224th AAS
Boston, MA – June, 2014
Meeting Abstracts

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Chair(s):
David Helfand (Quest University Canada)

101.01 – New Probes of Dark Energy

Dark energy seems to dominate today's universe. The talk will begin by reviewing the astronomical evidence for cosmic acceleration. This cosmic acceleration implies either that the dark energy is the primary component of our universe or that general relativity is not valid on cosmological scales. The talk will focus on new probes of dark energy with a focus on measurements by the WFIRST mission and observations of the cosmic microwave background.

Author(s): ***David Spergel (Princeton University)***

119 – LAD Posters Monday

Poster Session – Essex Ballroom and America Foyer – 02 Jun 2014 09:00 AM to 06:30 PM

119.01 – Transition Probabilities and Electron Impact Excitation Collision Strengths for Fe VII

Extensive calculations have been performed for electron impact excitation collision strengths and oscillator strengths for the Fe VII extreme ultraviolet lines of astrophysical importance. The collision strengths for fine-structure transitions are calculated in the B-spline Breit-Pauli R-matrix approach. The target wave\-functions have been calculated in the multi\-configuration Hartree-Fock method with term-dependent non-orthogonal orbitals. The close-coupling expansion includes 189 fine-structure levels of Fe VII belonging to terms of the ground $3p^63d^2$ and excited $3p^53d^3$, $3p^63d4l$, $3p^53d5s$, and $3p^63d5p$ configurations. The effective collision strengths are determined from the electron excitation collision strengths by integration over a Maxwellian distribution of electron velocities. The excitation rates are calculated for fine-structure transitions at electron temperatures from 10^4 to 10^7 K suitable for use in astrophysical plasma modeling. Our results normally agree with the previous R-matrix frame-transformation calculations. However, there are important differences for some transitions with the previous calculations. The corrections to the previous results are mainly due to more extensive expansions for the Fe VII target states. We were able to generate more accurate target states than those used in the previous collision calculations. In comparison with previous calculations, we included all $3p^43d^3nl$ correlation configurations which were found very important for accurate representation of the $3dnl$ states. We also found that correlation configuration with $3p-4f$ promotion are equally important and may considerably change the target CI expansions. This work was supported by NASA under grant NNX11AB62G from the Solar and Heliophysics program.

Author(s): ***Swaraj Tayal (Clark Atlanta University)***, Oleg Zatsarinny (Drake University)

119.02 – Comprehensive Analyses of the Spectra of Iron-group Elements

For many decades, the Atomic Spectroscopy Group at NIST has measured atomic data of vital use to astronomy and other fields using high resolution spectrometers that are found in few other places in the world. These now include the 2-m Fourier transform (FT) spectrometer covering the region 285 nm to 5500 nm, the FT700 vacuum ultraviolet (VUV) FT spectrometer covering the region 143 nm to 900 nm, and a 10.7-m normal incidence spectrograph (NIVS) covering 30 nm to 500 nm. Recent work focused on the measurement and analysis of wavelengths and energy levels of iron-group elements to provide extensive data for the analysis of astrophysical spectra. Our comprehensive linelist for Fe II from 90 nm to 5500 nm contains over 13 600 lines with order of magnitude improvements in the wavelengths compared to previous work [Nave & Johansson, ApJSS 204, 1(2013)]. The spectra were observed in high-current continuous and pulsed hollow cathode (HCL) discharges using FT spectrometers and our NIVS spectrograph. A similar analysis of Cr II contains over 5300 lines and extends the knowledge of this spectrum to the previously unobserved region between 731 nm at 5500 nm [Sansonetti, Nave, Reader & Kerber, ApJSS 202, 15 (2012); Sansonetti & Nave, ApJSS (in prep.)]. Our analysis of the Co III spectrum contains 750 lines observed in Penning discharge lamps and an additional 900 lines compiled from previous work, including Ritz wavelengths, optimized energy levels, and calculated log(gf) values [Smillie, Pickering, Nave & Smith, ApJSS (in prep.)]. NIST and ICL are currently collaborating to complete the measurement and analysis of wavelengths, energy levels, and hyperfine structure parameters for all singly-ionized iron-group elements of astrophysical interest, covering the wavelength range 80 nm to 5500 nm. This project uses archival data from FT spectrometers at NIST, ICL and Kitt Peak National Observatory, with additional spectra of HCL and Penning discharge sources taken using our FT and NIVS spectrometers. Current work includes the spectra of Mn I, Mn II, Ni II, Sc II, and Co III. This work was partially supported by NASA, the STFC and PPARC (UK), the Royal Society of the UK, and the Leverhulme Trust.

Author(s): ***Gillian Nave (NIST)***, Craig Sansonetti (NIST), Juliet Pickering (Imperial College London), Florence Liggins (Imperial College London)

119.03 – AtomPy: an open atomic-data curation environment

We present a cloud-computing environment for atomic data curation, networking among atomic data providers and users, teaching-and-learning, and interfacing with spectral modeling software. The system is based on Google-Drive Sheets, Pandas (Python Data Analysis Library) DataFrames, and IPython Notebooks for open community-driven curation of atomic data for scientific and technological applications. The atomic model for each ionic species is contained in a multi-sheet Google-Drive workbook, where the atomic parameters from all known public sources are progressively stored. Metadata (provenance, community discussion, etc.) accompanying every entry in the database are stored through Notebooks. Education tools on the physics of atomic processes as well as their relevance to plasma and spectral modeling are based on IPython Notebooks that integrate written material, images, videos, and active computer-tool workflows. Data processing workflows and collaborative software developments are encouraged and managed through the GitHub social network. Relevant issues this platform intends to address are: (i) data quality by allowing open access to both data producers and users in order to attain completeness, accuracy, consistency, provenance and currentness; (ii) comparisons of different datasets to facilitate accuracy assessment; (iii) downloading to local data structures (i.e. Pandas DataFrames) for further manipulation and analysis by prospective users; and (iv) data preservation by avoiding the discard of outdated sets.

Author(s): ***Manuel Bautista (Western Michigan University)***, Claudio Mendoza (Western Michigan University), Josiah Boswell (Western Michigan University), Chukwuemeka Ajoku (Western Michigan University)

119.04 – Revised Term Values for the *A–X* (*v*?=0-9, *v*?=0) Bands in $^{13}C^{16}O$ from High-resolution Fourier Transform Spectra

High-resolution spectra of the $A\ ^1? - X\ ^1?^+$ band system of $^{13}C^{16}O$ are presented. They were acquired with the vacuum ultraviolet (VUV) Fourier transform spectrometer installed on the DESIRS beamline at the SOLEIL synchrotron. We obtained revised term values that extend to higher *J*? values than previous VUV measurements for most *v*? levels and lower *J*? values for *v*?=0. Such data are needed to model the *A* – *X* bands in spectra of astronomical objects, including diffuse molecular clouds, circumstellar disks around newly formed stars, and comets. Previously observed perturbations of the rotational levels are confirmed, but are seen now in greater detail, and evidence is presented for new perturbations. The uncertainty in the line positions and term values of most CO transitions is on average within 0.01 cm^{-1}.

Author(s): ***Steven Federman (Univ. of Toledo)***, Lisseth Gavilan (Obs. de Paris), Jean Louis Lemaire (Obs. de Paris), Michele Eidelsberg (Obs. de Paris), Glenn Stark (Wellesley College), Alan Heays (Leiden Obs.), Jean-Hugues Fillion (UPMC Univ. Paris VI), James Lyons (ASU), Nelson de Oliveira (Synchrotron SOLEIL)

119.05 – Merged beam studies for astrobiology

The chain of chemical reactions leading towards life is thought to begin in molecular clouds when atomic carbon and oxygen are fixed into molecules. Reactions of neutral atomic C with H_3^+ is one of the first steps in the gas phase chemistry leading to the formation of complex organic molecules within such clouds. Water, believed to be vital for life, can form via a chain of gas-phase astrochemical reactions that begin with neutral atomic O reacting with H_3^+. Uncertainties in the thermal rate coefficient for these reactions hinder our ability to understand the first links in the chemical chain leading towards life. Theory and experiment have yet to converge in either the magnitude or temperature dependence. Theory provides little insight as fully quantum mechanical calculations for reactions involving four or more atoms are too complex for current capabilities. On the other hand, measurements of cross sections and rate coefficients for reactions of atoms with molecular ions are extremely challenging. This is due to the difficulty in producing sufficiently intense and well characterized beams of neutral atoms. We have developed a novel merged beam apparatus to study reactions of neutral atoms with molecular ions at the low collision energies relevant for molecular cloud studies. Photodetachment of atomic anion beams, with an 808-nm (1.53-eV) laser beam, is used to produce beams of neutral C and O, each in their ground term as occurs in molecular clouds. The neutral beam is then merged with a velocity matched, co-propagating H_3^+ beam, in order to study reactions of C and O on H_3^+. The merged beams method allows us to use fast beams (keV in the lab frame), which are easy to handle and monitor, while being able to achieve relative collision energies down to ?10 meV. Using the measured merged beams rate coefficient, we are able to extract cross sections which we can then convolve with a Maxwellian energy spread to generate a thermal rate coefficient for molecular cloud temperatures. Here we report recent results for reactions of C and O on H_3^+. This work was funded in part by the NSF.

Author(s): ***Nathalie De Ruette (Columbia University)***, Kenneth Miller (Columbia University), Aodh O'Connor (Columbia University), Julia Stuetzel (Columbia University), Xavier Urbain (Université catholique de Louvain), Daniel Savin (Columbia University)

119.06 – Analysis Of The Returned Samples From A Space Exposure Experiment: The ORGANIC Experiment on EXPOSE-R on the ISS

The ORGANIC experiment on the multi-user facility EXPOSE-R on the International Space Station investigated the chemical evolution, survival, destruction, and chemical modification of PAHs and fullerenes in space. Aromatic networks are among the most abundant organic material in space. PAHs and fullerenes have been identified in meteorites and are thought to be among the carriers for numerous astronomical absorption and emission features.Thin films of selected PAHs and fullerenes have been subjected to the low Earth orbit environment as part of the ORGANIC experiment. EXPOSE-R with its experiment inserts was mounted on the outside of the ISS for 682 days starting in 2009. The samples were returned to Earth and inspected in spring 2011. The period outside the ISS provided continuous exposure to the cosmic-, solar-, and trapped-particle radiation background and >2500 h of unshadowed solar illumination. All trays carry both solar-irradiation-exposed and dark samples shielded from the UV photons, enabling discrimination between the effects of exposure to solar photons and cosmic rays. The samples were analyzed before exposure to the space environment with UV-VIS and IR spectroscopy. Ground truth monitoring of additional sample carriers was performed through UV-VIS spectroscopy at regular intervals at NASA ARC (Bryson et al. 2011, Adv. Space Res. 48, 1980). The UV-VIS and IR spectroscopic measurements were collected for the returned flight samples. We report on the scientific experiment, the details of the ground control analysis, and returned flight sample results. We discuss how extended space exposure experiments allow to enhance our knowledge on the evolution of organic compounds in space.

Author(s): ***Kathryn Bryson (NASA ARC)***, Zan Peeters (Carnegie Institute of Washington), Farid Salama (NASA ARC), Bernard Foing (ESA), Pascale Ehrenfreund (Space Policy Institute), Andreas Elsaesser (Leiden Institute of Chemistry), Antonio Ricco (NASA ARC), Elmar Jessberger (Westfälische Wilhelms-Universität Münster), Addi Bischoff (Westfälische Wilhelms-Universität Münster), Michel Breitfellner (ESA), Werner Schmidt (PAH Research Institute), François Robert (Muséum National d'Histoire Naturelle)

119.07 – Dissociative Recombination of Molecular Ions for Astrochemistry

Dissociative recombination (DR) of molecular ions is a key chemical process in the cold interstellar medium (ISM). DR affects the composition, charge state, and energy balance of such environments. Astrochemical models of the ISM require reliable total DR cross sections as well as knowledge of the chemical composition of the neutral DR products. We have systematically measured DR for many astrophysically relevant molecular ions utilizing the TSR storage ring at the Max-Planck-Institute for Nuclear Physics (MPIK) in Heidelberg, Germany. We used the merged ion-electron beam technique combined with an energy- and position-sensitive imaging detector and are able to study DR down to plasma temperatures as low as 10 K. The DR count rate is used to obtain an absolute merged beams DR rate coefficient from which we can derive a thermal rate coefficient needed for plasma models. Additionally we determine the masses of the DR products by measuring their kinetic energy in the laboratory reference frame. This allows us to assign particular DR fragmentation channels and to obtain their branching ratios. All this information is particularly important for understanding DR of heteronuclear polyatomic ions. We will present DR results for several ions recently investigated at TSR. A new Cryogenic Storage Ring (CSR) is currently being commissioned at MPIK. With the chamber cooled down to ~10 K and a base pressure better than 10^{-13} mbar, this setup will allow internal cooling of the stored ions down to their rotational ground states, thus opening a new era in DR experiments. New technological challenges arise due to the ultracold, ultra-high vacuum environment of the CSR and thus the detection techniques used at TSR cannot be easily transferred to CSR. We will present new approaches for DR fragment detection in cryogenic environment. This work is supported in part by NASA and the NSF.

Author(s): ***Oldrich Novotny (Columbia University)***, A. Becker (Max-Planck-Institut für Kernphysik), H. Buhr (Weizmann Institute of Science), Andreas Fleischmann (Universität Heidelberg), Lisa Gamer (Universität Heidelberg), W. Geppert (Stockholm University), C. Krantz (Max-Planck-Institut für Kernphysik), H. Kreckel (Max-Planck-Institut für Kernphysik), D. Schwalm (Weizmann Institute of Science), K. Spruck (Justus-Liebig-Universität Giessen), A. Wolf (Max-Planck-Institut für Kernphysik), Daniel Savin (Columbia University)

119.08 – The Distribution, Excitation, and Abundance of CH^+ in Orion KL

The CH^+ ion was one of the first molecules identified in the interstellar gas more than 75 years ago, but its formation is still poorly understood. The high observed abundances of CH^+ are puzzling, because the main reaction proposed for the formation of CH^+, *viz.*, $C^+ + H_2$? $CH^+ + H$, is so endothermic (4640 K), that it is unlikely to proceed at the typical temperatures of molecular clouds. One way in which the high endothermicity may be overcome, is if a significant fraction of the H_2 is vibrationally excited, as is the case in dense molecular gas exposed to intense far-ultraviolet radiation fields. Elucidating the formation of CH^+ in molecular clouds requires characterization of its spatial distribution, as well as that of the key reactants in the chemical pathways yielding CH^+. Here we present high-resolution spectral maps of the two lowest rotational transitions of CH^+ and the fine structure transition of C^+ in a ~3?×3? region around the Orion Kleinmann-Low (KL) nebula, obtained with the Herschel Space Observatory's Heterodyne Instrument for the Far-Infrared (HIFI). We compare these maps to those of CH^+ and C^+ in the Orion Bar photodissociation region (PDR), and discuss the excitation and abundance of CH^+ toward Orion KL in the context of chemical and radiative transfer models, which have recently been successfully applied to the Orion Bar PDR.

Author(s): ***Harshal Gupta (California Institute of Technology)***, Patrick Morris (California Institute of Technology), Zsofia Nagy (University of Cologne), John Pearson (California Institute of Technology)

Contributing teams: HEXOS Team

119.09 – Formation of Water on a Warm Amorphous Silicate Surface

It is well established that reactions on interstellar dust grain surfaces are indispensable for water formation in space. Among all the intermediate products that lead to water formation, the OH radical is especially important because is a product of all the three main water formation surface routes, i.e., the hydrogenation of O, O_2, and O_3, and it also connects these three routes. The desorption energy of OH from dust grain surfaces, along with dust grain temperature, determines the availability OH for grain surface versus gas-phase reactions. We experimentally investigated water formation on the surface of a warm amorphous silicate via $H+O_3$?$OH+O_2$. The surface temperature was kept at 50 K so as to exclude the interference of O_2. It is found that OH has a significant residence time at 50 K. The OH desorption energy from amorphous silicate surface is calculated to be at least 1680 K, and possibly as high as 4760 K. Water is formed efficiently via OH+H and $OH+H_2$, and the product H_2O stays on the surface upon formation. Deuterium has also been used in place of hydrogen to check isotopic effects. This work is supported by NSF, Astronomy & Astrophysics Division (Grants No. 0908108 and 1311958) and NASA (Grant No. NNX12AF38G). We thank Dr. J.Brucato of the Astrophysical Observatory of Arcetri for providing the samples used in these experiments.

Author(s): ***Gianfranco Vidali (Syracuse Univ.)***, Jiao He (Syracuse Univ.)

119.10 – A TALE OF THREE GALAXIES: UNIQUE DUST PROPERTIES IN IRAS F10398+1455, IRAS F21013-0739 AND SDSS J0808+3948

On a galactic scale the 9.7 micrometer silicate emission is usually only seen in Type 1 active galactic nuclei (AGNs). They usually also display high 5--8 micrometer emission continua which are indicative of hot dust and the absence of the polycyclic aromatic hydrocarbon (PAH) emission bands. In contrast, starburst galaxies, luminous infrared galaxies (LIRGs), and ultra luminous infrared galaxies (ULIRGs) exhibit a low 5--8 micrometer emission continuum, a strong 9.7 micrometer silicate absorption feature, and strong PAH emission bands. Here we report the detection of anomalous dust properties by Spitzer/IRS in three galaxies (IRAS F10398+1455, IRAS F21013-0739 and SDSS J0808+3948) which are characterized by the simultaneous detection of a low 5--8 micrometer continuum, the 9.7 and 18 micrometer silicate emission features as well as strong PAH emission bands. The unique dust infrared emission spectra are modeled and discussed in terms of iron-poor silicate composition, amorphous carbon, small grain size and dust temperature in the young AGN phase of these three galaxies.

Author(s): ***Yanxia Xie (University of Missouri)***, Lei Hao (Shanghai Astronomical Observatory, Chinese Academy of Sciences), Aigen Li (University of Missouri)

119.11 – Laboratory Simulations of Space Weathering of Asteroid Surfaces by Solar Wind Ions.

Studies into the formation of the terrestrial planets rely on the analysis of asteroids and meteorites. Asteroids are solar system remnants from the planetary formation period. By characterizing their mineralogical composition we can better constrain the formation and evolution of the inner planets. Remote sensing is the primary means for studying asteroids. Sample return missions, such as Hayabusa, are complex and expensive, hence we rely on asteroid reflectance spectra to determine chemical composition. Links have been made and debated between meteorite classes and asteroid types [1, 2]. If such relationships can be confirmed, then meteorites would provide a low cost asteroid sample set for study. However, a major issue in establishing this link is the spectral differences between meteorite samples and asteroid surfaces. The most commonly invoked explanation for these differences is that the surfaces of asteroids are space weathered [2, 3]. The dominant mechanism for this weathering is believed to be solar-wind ion irradiation [2, 4, 5]. Laboratory simulations of space weathering have demonstrated changes in the general direction required to alter spectra from unweathered meteorite samples to asteroid observations [3, 6 -10], but many open questions remain and we still lack a comprehensive understanding. We propose to explore the alleged connection of ordinary chondrite (OC) meteorites to S-type asteroids through a series of systematic laboratory simulations of solar-wind space weathering of asteroid surface materials. Here we describe the issue in more detail and describe the proposed apparatus. [1] Chapman C. R. (1996) Meteorit. Planet. Sci., 31, 699-725. [2] Chapman C. R. (2004), Annu. Rev. Earth Planet. Sci., 32, 539-567. [3] Hapke B. (2001) J. Ge-ophys. Res., 106, 10039-10074. [4] Pieters C.M. et al. (2000) Meteorit. Planet. Sci., 35, 1101-1107. [5] Ver-nazza P. et al. (2009) Nature, 458, 993-995. [6] Stra-zulla G. et al. (2005) Icarus, 174, 31-35 (2005). [7] Brunetto R and Strazzulla G (2005) Icarus, 179, 265-273. [8] Marchi S et al. (2005) Astron. Astrophys., 443, 769-775. [9] Loeffler M. J. et al. (2009) J. Geo-phys. Res., 114, E03003. [10] Fu X. et al. (2012) Ica-rus, 219, 630-640

Author(s): ***Kenneth Miller (Columbia University)***, Nathalie De Ruette (Columbia University), George Harlow (American Museum of Natural History), Deborah Domingue (Planetary Science Institute), Daniel Savin (Columbia University)

119.12 – Hydrogen Implantation in Silicates: The role of solar wind in OH bond formation on the lunar surface

Airless bodies in space such as the Moon, asteroids and interplanetary dust particles are subject to bombardment from energetic electrons and ions, ultraviolet photons, micrometeorites and cosmic rays. These bombarding particles modify optical, chemical and physical characteristics of the ices and minerals that make up these bodies in a process known as space weathering. In particular, solar wind protons implanted in silicate materials can participate in hydroxylation reactions with the oxygen to form OH. This mechanism has been suggested to explain a reported 3-14% absorption signal identified as OH on the surface of lunar soil grains and present in decreasing magnitude from polar to equatorial latitudes. With the goal of determining a precise OH formation rate due to H^+ implantation in silicates, a series of experiments were carried out on terrestrial minerals as analogs to lunar and interstellar material. Experiments were carried out under UHV pressures ($<10^{-9}$ Torr) and irradiation was performed using a mass analyzed ion accelerator. The samples were first outgassed to ~200 °C for 12 hrs then directly transferred to the analysis position without exposure to laboratory air. In-situ transmission FTIR spectroscopy was used to determine the content of OH in thermally grown silicon oxide and San Carlos olivine, before and after irradiated with 1 - 5 keV H^+ ions. The increase in Si-OH content due to irradiation was determined by subtracting the unirradiated spectra from the irradiated spectra. The implanted protons induced OH stretch absorptions in the mid-infrared peaked at 3673 cm^{-1} for SiO2 and 3570 cm^{-1} for olivine. The initial yield (OH formed per incident ion) was ~90% and the OH absorption band was found to saturate at implantation fluences of ~$2x10^{17}$ H/cm^2. Irradiation also modified the Si-O stretch band at ~1090 cm^{-1} (9.2 ?m) causing an exponential decrease in the peak height with increasing fluence and the appearance of a silanol structure peaking at ~1030 cm^{-1}. These measurements allow constraints to be placed on stellar wind contribution to observational and theoretical models of water on the lunar surface and on interstellar dust grains.

Author(s): ***Micah Schaible (University of Virginia)***, Raul Baragiola (University of Virginia)

120 – Extrasolar Planet Posters

Poster Session – Essex Ballroom and America Foyer – 02 Jun 2014 09:00 AM to 06:30 PM

120.01 – Performance of Transit Model Fitting in Processing Four Years of Kepler Science Data

We present transit model fitting performance of the Kepler Science Operations Center (SOC) Pipeline in processing four years of science data, which were collected by the Kepler spacecraft from May 13, 2009 to May 12, 2013. Threshold Crossing Events (TCEs), which represent transiting planet detections, are generated by the Transiting Planet Search (TPS) component of the pipeline and subsequently processed in the Data Validation (DV) component. The transit model is used in DV to fit TCEs and derive parameters that are used in various diagnostic tests to validate planetary candidates. The standard transit model includes five fit parameters: transit epoch time (i.e. central time of first transit), orbital period, impact parameter, ratio of planet radius to star radius and ratio of semi-major axis to star radius. In the latest Kepler SOC pipeline codebase, the light curve of the target for which a TCE is generated is initially fitted by a trapezoidal model with four parameters: transit epoch time, depth, duration and ingress time. The trapezoidal model fit, implemented with repeated Levenberg-Marquardt minimization, provides a quick and high fidelity assessment of the transit signal. The fit parameters of the trapezoidal model with the minimum chi-square metric are converted to set initial values of the fit parameters of the standard transit model. Additional parameters, such as the equilibrium temperature and effective stellar flux of the planet candidate, are derived from the fit parameters of the standard transit model to characterize pipeline candidates for the search of Earth-size planets in the Habitable Zone. The uncertainties of all derived parameters are updated in the latest codebase to take into account for the propagated errors of the fit parameters as well as the uncertainties in stellar parameters. The results of the transit model fitting of the TCEs identified by the Kepler SOC Pipeline, including fitted and derived parameters, fit goodness metrics and diagnostic figures, are included in the DV report and one-page report summary, which are accessible by the science community at NASA Exoplanet Archive. Funding for the Kepler Mission has been provided by the NASA Science Mission Directorate.

Author(s): ***Jie Li (NASA Ames Research Center)***, Christopher Burke (NASA Ames Research Center), Jon Jenkins (NASA Ames Research Center), Elisa Quintana (NASA Ames Research Center), Jason Rowe (NASA Ames Research Center), Shawn Seader (NASA Ames Research Center), Peter Tenenbaum (NASA Ames Research Center), Joseph Twicken (NASA Ames Research Center)

120.02 – Revision of Earth-sized *Kepler* Planet Candidate Properties with High Resolution Imaging by *Hubble Space Telescope*

In this paper we present the first results of our HST GO/SNAP program GO-12893 and describe how our image analysis using STScI's DrizzlePac software combined with our own empirical point spread function definition were used to re-evaluate the habitability of some of the most interesting *Kepler* planet candidates. We used our high resolution imaging to calibrate Kp to the F555W and F775W filters on WFC3/UVIS, and spatially resolved the stellar multiplicity of KOI-1422, KOI-2626, and KOI-3049. We found KOI-1422 to be a tight binary star system with a projected separation of 0.217’’ (~90 AU). We found KOI-2626 to be a triple star system with a projected separation of 0.201’’ (~110 AU) between the primary and secondary components and 0.161’’ (~90 AU) between the primary and tertiary components. We found KOI-3049 to be a binary star system with a projected separation of 0.464’’ (~330 AU). Using theoretical isochrones from the Dartmouth Stellar Evolution Database, we performed hierarchical fitting using our derived photometry and the synthetic photometry from the isochrones. Revised stellar parameters for the individual components of the systems show that the stars in these systems range from early-K dwarf to early-M dwarf spectral types. We report with high confidence that all three systems are bound and co-eval based on the tight isochrone fitting and false positive analysis. Using our best-fit stellar parameters from the isochrone matches, we solved for the properties of the planets in the three systems and found that the planets range in size from ~2R_{Earth} to ~4 R_{Earth}, placing them in the Super Earth/mini-Neptune range. Some planets analyzed here are potentially habitable depending on their stellar host and greenhouse effect level.

Author(s): ***Kimberly Star (The Center for Exoplanets and Habitable Worlds)***, Ronald Gilliland (The Center for Exoplanets and Habitable Worlds)

120.03 – Characterizing the Transiting Planet Search of the Kepler Data Processing Pipeline

The Kepler Mission continuously observed a host of target stars, for over four years, in a 115 square-degree field of view to discover Earth-like planets transiting Sun-like stars through analysis of photometric data. The Kepler Science Operations Center at NASA Ames Research Center processes the data from the Kepler spacecraft with the Science Processing Pipeline, which is composed of several modules including the Transiting Planet Search (TPS). In order to accomplish the primary goal of the mission, computing the fraction of stars containing potentially habitable Earth-like planets, it is critical to understand any biases that the data processing imposes on the results. Currently, a massive effort to characterize this Science Processing Pipeline is underway. An infrastructure for characterizing TPS, through the injection of artificial signals, has been built and is being used to understand our detection probability on a large set of "quiet" targets. This infrastructure will enable us to understand the factors that affect detectability such as signal strength, orbital period, host-star type, galactic latitude, etc. Here we present the results of an initial study focused on a quiet set of targets, with hundreds of injections in each, using the first four years of data collected by Kepler.

Author(s): ***Shawn Seader (SETI)***, Peter Tenenbaum (SETI), Christopher Burke (SETI), Jon Jenkins (NASA Ames Research Center)

120.04 – Finding Every Planet We Can -- Removal of Transit-like False Triggers in Kepler Data.

With the Kepler data set now extant at 4 years, even greater pressure is placed on the processing pipeline to eke out every last transit signal in the data. Central to this end is the reduction of false positives during transit searching. A large fraction of the false positives are due to individual systematic spike events in the data. Various veto methods are utilized to remove these false positives but nevertheless, their presence risks to mask true planet signatures. A systematic spike remover has been developed in the Presearch Data Conditioning (PDC) component of the Kepler pipeline which removes short systematic spikes in the target light curves. This reduces false positives which not only increases the likelihood of detecting real transiting planets, but also improves the efficiency of running the pipeline and vetting of the results.

Author(s): ***Jeffrey Smith (NASA Ames Research Center)***, Joseph Catanzarite (NASA Ames Research Center), Shawn Seader (NASA Ames Research Center), Jon Jenkins (NASA Ames Research Center)

120.06 – Recent Developments in Kepler Pipeline Data Validation

Light curves for the vast majority of Kepler targets are searched for transiting planet signatures in the Transiting Planet Search (TPS) component of the Science Operations Center (SOC) Processing Pipeline. Targets for which the detection threshold is exceeded are subsequently processed in the Data Validation (DV) Pipeline component. The primary functions of DV are to (1) characterize planets identified in the transiting planet search, (2) search for additional transiting planet signatures in light curves after transit signatures have been removed, and (3) perform a comprehensive suite of diagnostic tests to aid in discrimination between true transiting planets and false positive detections. DV output products include extensive reports by target, one-page report summaries by planet candidate, and tabulated planet model fit and diagnostic test results. The Q1-Q16 Kepler data set was processed with TPS/DV (SOC release 9.1) in August 2013. Transiting planet detections and DV products were delivered to the Exoplanet Archive at the NASA Exoplanet Science Institute (NExScI). We describe developments in Data Validation that have been introduced in the Pipeline codebase subsequent to SOC 9.1. We have enhanced diagnostic test functionality to improve the performance of (human and automated) planet candidate vetting processes that rely on DV products; this necessarily increases the reliability of Kepler planet catalogs. We have also updated the report and summary products that are archived for the community and shall remain a significant part of the Kepler legacy. We illustrate the recent developments with examples from TPS/DV processing of the full Q1-Q17 Kepler data set. Some of the developments we describe were released with SOC 9.2 in March 2014; others have been introduced later into the SOC codebase and will be released with SOC 9.3. The Exoplanet Archive is located at exoplanetarchive.ipac.caltech.edu. Funding for the Kepler Mission has been provided by the NASA Science Mission Directorate.

Author(s): ***Joseph Twicken (NASA Ames Research Center)***, Bruce Clarke (NASA Ames Research Center), Forrest Girouard (NASA Ames Research Center), Jon Jenkins (NASA Ames Research Center), Todd Klaus (NASA Ames Research Center), Jie Li (NASA Ames Research Center), Sean McCauliff (NASA Ames Research Center), Elisa Quintana (NASA Ames Research Center), Shawn Seader (NASA Ames Research Center), Peter Tenenbaum (NASA Ames Research Center), Natalie Batalha (NASA Ames Research Center), Steve Bryson (NASA Ames Research Center), Christopher Burke (NASA Ames Research Center), Douglas Caldwell (NASA Ames Research Center), Jason Rowe (NASA Ames Research Center)

Contributing teams: Kepler Science Operations Center, Kepler Science Office

120.07 – Rolling Band Artifact Flagging in the Kepler Data Pipeline

Instrument-induced artifacts in the raw Kepler pixel data include time-varying crosstalk from the fine guidance sensor (FGS) clock signals, manifestations of drifting moiré pattern as locally correlated nonstationary noise and rolling bands in the images. These systematics find their way into the calibrated pixel time series and ultimately into the target flux time series. The Kepler pipeline module Dynablack models the FGS crosstalk artifacts using a combination of raw science pixel data, full frame images, reverse-clocked pixel data and ancillary temperature data. The calibration module (CAL) uses the fitted Dynablack models to remove FGS crosstalk artifacts in the calibrated pixels by adjusting the black level correction per cadence. Dynablack also detects and flags spatial regions and time intervals of strong time-varying black-level. These rolling band artifact (RBA) flags are produced on a per row per cadence basis by searching for transit signatures in the Dynablack fit residuals. The Photometric Analysis module (PA) generates per target per cadence data quality flags based on the Dynablack RBA flags. Proposed future work includes using the target data quality flags as a basis for de-weighting in the Presearch Data Conditioning (PDC), Transiting Planet Search (TPS) and Data Validation (DV) pipeline modules. We discuss the effectiveness of RBA flagging for downstream users and illustrate with some affected light curves. We also discuss the implementation of Dynablack in the Kepler data pipeline and present results regarding the improvement in calibrated pixels and the expected improvement in cotrending performance as a result of including FGS corrections in the calibration. Funding for the Kepler Mission has been provided by the NASA Science Mission Directorate.

Author(s): ***Bruce Clarke (SETI Institue)***, Jeffery Kolodziejczak (NASA MSFC), Douglas Caldwell (SETI Institue)

Contributing teams: Kepler Science Operations Center, Kepler Science Office

120.08 – Improving Kepler Pipeline Sensitivity with Pixel Response Function Photometry.

We present the results of our investigation into the feasibility and expected benefits of implementing PRF-fitting photometry in the Kepler Science Processing Pipeline. The Kepler Pixel Response Function (PRF) describes the expected system response to a point source at infinity and includes the effects of the optical point spread function, the CCD detector responsivity function, and spacecraft pointing jitter. Planet detection in the Kepler pipeline is currently based on simple aperture photometry (SAP), which is most effective when applied to uncrowded bright stars. Its effectiveness diminishes rapidly as target brightness decreases relative to the effects of noise sources such as detector electronics, background stars, and image motion. In contrast, PRF photometry is based on fitting an explicit model of image formation to the data and naturally accounts for image motion and contributions of background stars. The key to obtaining high-quality photometry from PRF fitting is a high-quality model of the system's PRF, while the key to efficiently processing the large number of Kepler targets is an accurate catalog and accurate mapping of celestial coordinates onto the focal plane. If the CCD coordinates of stellar centroids are known a priori then the problem of PRF fitting becomes linear. A model of the Kepler PRF was constructed at the time of spacecraft commissioning by fitting piecewise polynomial surfaces to data from dithered full frame images. While this model accurately captured the initial state of the system, the PRF has evolved dynamically since then and has been seen to deviate significantly from the initial (static) model. We construct a dynamic PRF model which is then used to recover photometry for all targets of interest. Both simulation tests and results from Kepler flight data demonstrate the effectiveness of our approach. Kepler was selected as the 10th mission of the Discovery Program. Funding for this mission is provided by NASA’s Science Mission Directorate. Kepler was selected as the 10th mission of the Discovery Program. Funding for this mission is provided by NASA’s Science Mission Directorate.

Author(s): ***Robert Morris (NASA Ames Research Center)***, Steve Bryson (NASA Ames Research Center), Jon Jenkins (NASA Ames Research Center), Jeffrey Smith (NASA Ames Research Center)

120.09 – Automatic Classification of Kepler Threshold Crossing Events

Over the course of its 4-year primary mission the Kepler mission has discovered numerous planets. Part of the process of planet discovery has involved generating threshold crossing events (TCEs); a light curve with a repeating exoplanet transit-like feature. The large number of diagnostics (~100) makes it difficult to examine all the information available for each TCE. The effort required for vetting all threshold-crossing events (TCEs) takes several months by many individuals associated with the Kepler Threshold Crossing Event Review Team (TCERT). The total number of objects with transit-like features identified in the light curves has increased to as many as 18,000, just examining the first three years of data. In order to accelerate the process by which new planet candidates are classified, we propose a machine learning approach to establish a preliminary list of planetary candidates ranked from most credible to least credible. The classifier must distinguish between three classes of detections: non-transiting phenomena, astrophysical false positives, and planet candidates. We use random forests, a supervised classification algorithm to this end. We report on the performance of the classifier and identify diagnostics that are important for discriminating between these classes of TCEs. Funding for this mission is provided by NASA's Science Mission Directorate.

Author(s): ***Sean McCauliff (NASA Ames Research Center)***, Joseph Catanzarite (Orbital Science Corporatin), Jon Jenkins (Orbital Science Corporatin)

120.10 – The NASA Exoplanet Archive: Data Inventory Service

We present here the latest addition to the NASA Exoplanet Archive - the Data Inventory Service, a tool aimed to provide the user with all the data available within the archive (exoplanet and stellar parameters, time series from ground-based transit surveys (such as Super WASP, XO, HAT-P, KELT), Kepler Pipeline products, CoRoT light curves, etc.) at or near the location of an astronomical object. The NASA Exoplanet Archive is an online service dedicated to compile and to serve public astronomical data sets involved in the search for and characterization of extrasolar planets and their host stars. The data in the archive include stellar parameters (e.g., positions, magnitudes, temperatures, etc.), exoplanet parameters (such as masses and orbital parameters) and discovery/characterization data (e.g., published radial velocity curves, photometric light curves, spectra, etc.). In support of the Kepler Extended Mission, the NASA Exoplanet Archive also hosts data related to Kepler Objects of Interest (KOI), Kepler Pipeline products such as Threshold Crossing Events (TCE) and Data Validation Reports, and Kepler Stellar parameters as used by the Kepler Pipeline. The archive provides tools to work with these data, including interative tables (with plotting capabilities), interactive light curve viewer, periodogram service, transit and ephemeris calculator, and application program interface. To access this information visit us at: http://exoplanetarchive.ipac.caltech.edu

Author(s): ***Solange Ramirez (Caltech)***, Rachel Akeson (Caltech), David Ciardi (Caltech), Xi Chen (Caltech), Jessie Christiansen (Caltech), Peter Plavchan (Caltech)

Contributing teams: NASA Exoplanet Archive Team

120.11 – What Can The Habitable Zone Gallery Do for You?

The Habitable Zone Gallery (www.hzgallery.org) has been online since August 2011 as a service to the exoplanet community to provide Habitable Zone (HZ) information for each of the exoplanetary systems with known planetary orbital parameters. The service includes a sortable table, a plot with the period and eccentricity of each of the planets with respect to their time spent in the HZ, a gallery of known systems which plots the orbits and the location of the HZ with respect to those orbits, and orbital movies. Recently, we have added new features including: implementation of both conservative and optimistic HZs, more user-friendly table and movies, movies for circumbinary planets, and a count of planets whose orbits lie entirely within the system's HZ. Here we discuss various educational and scientific applications of the site such as target selection, exploring planets with eccentric or circumbinary orbits, and investigating habitability.

Author(s): ***Dawn Gelino (NASA Exoplanet Science Institute, Caltech)***, Stephen Kane (San Francisco State University)

120.12 – Stellar Activity Masking and Mimicking Habitable Exoplanets

Future generations of precise radial velocity (RV) surveys aim to attain a sensitivity sufficient to detect Earth mass planets orbiting in their host star's habitable zones. The RV semi-amplitude of such a planet can be significantly smaller than RV variations caused by stellar "jitter". Some RV variations, in particular those caused by starspots rotating in and out of view and those caused by magnetic activity cycles can be periodic in nature and can mimic planetary RV signals. We calculate and compare the relative timescales and amplitudes of RV variations due to activity and habitable planetary companions as a function of stellar mass, and discuss the ramifications for RV surveys.

Author(s): ***Andrew Vanderburg (Harvard University)***, Peter Plavchan (Infrared Processing and Analysis Center), John Johnson (Harvard University)

120.13 – Characterization of the Performance of MANIC, a Monolithic Achromatic Nulling Interference Coronagraph

We present the characterization of the performance of a monolithic achromatic nulling interference coronagraph (MANIC). The primary scientific goal of this instrument is to directly image inner exoplanetary environments surrounding stars. The nulling performance of the instrument is optimized through use of wave front sensing and control. The measurement of the null and the instrument's limiting factors are presented with this poster.

Author(s): ***Kathleen Oram (University of Massachusetts Lowell)***, Timothy Cook (UMLCAR), Supriya Chakrabarti (UMLCAR), Brian Hicks (UMLCAR)

120.14 – ACCESS: The Arizona-CfA-Catolica Exoplanet Spectroscopy Survey

The Arizona-CfA-Catolica Exoplanet Spectroscopy Survey (ACCESS) is an international, multi-institutional consortium with members from the Harvard-Smithsonian CfA, the University of Arizona, Pontificia Universidad Catolica in Chile, MIT and UC Santa Cruz and the Carnegie Institution. ACCESS' goal is to observe about two dozen planets covering a wide range of mass, radius, atmospheric temperatures and energy irradiation levels, with two main scientific goals: 1) to obtain, for the first time, a uniform sample of visible transmission spectra of exoplanets, allowing the study of their atmospheric characteristics as a statistically significant sample, and 2) to mature the technique of ground-based observations of exoplanetary atmospheres for future observations of small planets. Here we describe ACCESS and its first science results.

Author(s): ***Mercedes Lopez-Morales (Harvard-Smithsonian CfA)***, Daniel Apai (University of Arizona), Andres Jordan (Pontificia Universidad catolica), Nestor Espinoza (Pontificia Universidad catolica), Benjamin Rackham (University of Arizona), Jonathan Fraine (Pontificia Universidad catolica), Florian Rodler (Harvard-Smithsonian CfA), Nikole Lewis (Massachusetts Institute of Technology), Jonathan Fortney (University of California, Santa Cruz), David Osip (Observatories of the Carnegie Institution for Science)

120.15 – The MEarth Project: Status Update and the Commissioning of a Brand New Telescope Array in the Southern Hemisphere

The MEarth Project is an ongoing all-sky survey for Earth-like planets transiting the closest, smallest M dwarfs. MEarth aims to find good targets for atmospheric characterization with JWST and the next generation of enormous ground-based telescopes. MEarth's yearly data releases, containing precise light curves of nearby mid-to-late M dwarfs, provide a unique window into the photometric variability of the stars that will forever be among the most interesting targets in the search for potentially habitable exoplanets. We present a status update on the MEarth Project, including a detailed map of the progress we’ve made so far with 8 telescopes in the Northern hemisphere and promising early results from our new installation of 8 more telescopes in the Southern hemisphere.

Author(s): ***Zachory Berta-Thompson (MIT)***, Jonathan Irwin (Smithsonian Astrophysical Observatory), David Charbonneau (Harvard University), Elisabeth Newton (Harvard University), Jason Dittmann (Harvard University)

120.16 – The Impact of Stellar Multiplicity on Planet Occurrence

The majority of searches for extrasolar planets have concentrated exclusively on single stars, actively avoiding close binary systems where the companion might complicate the observations and data analysis. However, the major ity of solar-type stars are found in binary systems. These binary companions should exert a strong dynamical influence on any planetary system, and hence this systematic bias leaves out knowledge of planet formation fundamentally incomplete. We will present the ongoing results of a high-resolution imaging survey to identify binary companions among a volume-limited sample of 600 Kepler planet hosts within 500 parsecs. This survey exploits nonredundant aperture-mask interferometry (NRM) to super-resolve binary companions down to 1/4 of the diffraction limit (15 mas; <5 AU at 300 pc), identifying the dynamically significant binary companions that are missed by standard imaging surveys. Our results show that binarity does indeed have a profound influence on planet occurrence, suppressing the planet frequency by a factor of 4 in 5-50 AU binaries. However, unexpected trends for planet survival also are starting to emerge.

Author(s): ***Adam Kraus (UT - Austin)***, Michael Ireland (ANU), Andrew Mann (UT - Austin), Daniel Huber (NASA Ames), Trent Dupuy (UT - Austin)

120.17 – Orbital Stability Analysis of GJ 581 and HD 10180

We present self-consistent orbital stability results over 10^7 years for GJ 581 for models including planets b, c, d, e, and g. We find substantial overlap between constraints on stability for planet e and its radial velocity-derived parameters. We find a smaller overlap between constraints of stability and RV fit for planet g, however not so small as to rule out planet g on stability requirements alone. We perform an F-test on RV fit results with and without planet g subject to the condition of orbital stability and do not find significant evidence for the existence of GJ 581 g given current radial velocity data. We also apply the process to HD 10180 to investigate the stability of 9 planets that have been reported in this system, and present results related to the stability of proposed planet HD 10180 i.

Author(s): ***David Joiner (Kean University)***, Cesar Sul (San Jose State University), Diana Dragomir (UC Santa Barbara), Stephen Kane (San Francisco State University), Monika Kress (San Jose State University), Kimberly Shanks (Kean University)

120.18 – Giant Planet Accretion in a Low-Turbulence Circumplanetary Disk

At least 5% of confirmed planets discovered by the Kepler Mission have a mass greater than Jupiter's. Gas giants more massive than Saturn account for at least 18% of all confirmed planets.The final stages of gas accretion of a giant planet occur in the presence of a circumplanetary disk (CPD). Recently, it was proposed that turbulence (and hence transport) in these disks is driven by MRI, possibly generating low-turbulence regions known as Dead Zones. It was thus suggested that gas accretion through a CPD and on the planet can be severely reduced by a Dead Zone. If CPDs create a bottleneck for the accretion of gas, then the growth of planets more massive than Jupiter may become problematic. We investigate how gas accretion on a Jupiter-mass planet is affected by a Dead Zone by means of global 3D hydrodynamics calculations. We model both the CPD and the protoplanetary disk. The accretion flow is resolved at a length scale smaller than Jupiter's radius, Rj, by using a nested-grid technique. We assume that the kinematic viscosity is constant and equal to nu=1e-5 Omega a^2, where a and Omega are respectively the planet's orbital radius and frequency. A Dead Zone around the planet is represented by a region of low viscosity (nu=1e-8 Omega a^2), extending out to ~60Rj and above and below the CPD mid-plane for a few local scale heights. We obtain an accretion rate of ~5e-5 Omega Sigma a^2, where Sigma is the unperturbed protoplanetary disk density. Calculations by D'Angelo et al. (2003) and Bate et al. (2003), which used nu=1e-5 Omega a^2 everywhere but applied a much coarser resolution and different accretion parameters, found an accretion rate of ~2e-4 Omega Sigma a^2. Accounting for variations of several tens of percent, arising from differences (between these and previous calculations) in numerical parameters and resolution, we argue that a CPD Dead Zone, as modeled here, does not significantly affect the gas accretion rate of a giant planet. This result is compatible with several previous studies, which found that the accretion flow involves mostly gas at and above the CPD surface. Continued accretion in the presence of a CPD is also consistent with observed exoplanets several times more massive than Jupiter.

Author(s): ***Gennaro D'Angelo (SETI Institure)***, Francesco Marzari (University of Padova)

120.19 – Visual Companions to Transiting Hot Jupiters

The known short period giant planets constitute a valuable statistical population. From the derived physical and orbital properties of this sample in conjunction with detailed studies of individual objects, we can investigate a wide array of topics, including the internal structures of giant planets, the conditions under which planets form, and their dynamical evolution. The success of such studies relies, of course, on the completeness and accuracy of the underlying data, but many of the known hot Jupiters have not been subjected to high resolution imaging in search of close stellar companions. The presence of a second star (whether physically bound or a chance alignment), can affect the derived stellar and planetary parameters. Moreover, the presence of bound companions can inform us about planetary formation and migration in binary systems. Here we present preliminary results from our adaptive optics survey of 94 transiting hot Jupiter host stars and discuss their significance in the context outlined above.

Author(s): ***Samuel Quinn (Georgia State University)***, Lars Buchhave (Harvard-Smithsonian Center for Astrophysics), Russel White (Georgia State University), Deepak Raghavan (Georgia State University)

120.20 – Untangling Planet Signals and Stellar Noise with Precision Radial Velocity Measurements

Radial velocity instrumental precision has improved to the degree that measurements are now partially limited by the noise intrinsic to the host star, or stellar ‘jitter’. Several different phenomena contribute to the observed jitter, including pressure waves, granulation, magnetic features caused by stellar activity, and solar-like magnetic cycles. The amplitude of these effects ranges from 10 to 400 cm/s, depending on stellar type, and pose a significant limitation to detecting Earth analogues. We analyze two years of radial velocity data from a survey of bright, quiet stars with the HARPS-N instrument, an ultra-stabilized R=115,000 cross-dispersed spectrograph located on the 3.6m Telescopio Nazionale Galileo on the island of La Palma. We look for correlations between these RV measurements and known activity indicators, including line bisector measurements and the CaII index. We also investigate the correlation between radial velocity measurements and other spectral variations, including equivalent widths of features selected by a blind search. By fitting for these effects simultaneously, we can improve the radial velocity precision, enabling the detection of low-mass planets.

Author(s): ***Sara Gettel (Harvard-Smithsonian Center for Astrophysics)***, David Charbonneau (Harvard-Smithsonian Center for Astrophysics)

Contributing teams: the HARPS-N Collaboration

120.21 – "Rare" Microlensing Events: how frequent are they? what can they teach us?

Today's microlensing teams discover roughly 2000 candidate microlensing events per year. Many of these exhibit the standard point-source/point-lens form, and are caused by distant lenses we cannot detect. In our poster we report on the preliminary results of a long term program of analysis designed to identify and study "rare" gravitational lensing events. We have focused on those rare events with light curve profiles that differ from the point-source/point-lens form. These unusual light curves provide additional information about the lens or source. We devote special effort to the study of a small set of events that appear to have been caused by nearby lenses. Nearby lenses are interesting, whatever the form of the light curve they generate. We show that some unusual events are common enough that their systematic study can be scientifically fruitful, allowing lensing programs to identify nearby (closer than a kiloparsec) compact objects and measure their masses, and to also identify and measure masses in nearby planetary systems. We have developed methods that should prove useful in a wide range of ground-based and space-based lensing studies.

Author(s): ***Rosanne Di Stefano (Harvard-Smithsonian CfA)***, William Bryk (Ramaz Upper School), Idan Ginsburg (Harvard-Smithsonian CfA), Jochen Greiner (MPE), Sebastien Lepine (Georgia State University), Antonia Oprescu (Harvard-Smithsonian CfA), Francis Primini (Harvard-Smithsonian CfA), Ben Tunbridge (Harvard-Smithsonian CfA)

120.22 – Open Source Cloud Computing for Transiting Planet Discovery

We provide an update on the development of the open-source software suite designed to detect exoplanet transits using high-performance and cloud computing resources (https://github.com/openEXO). Our collaboration continues to grow as we are developing algorithms and codes related to the detection of transit-like events, especially in Kepler data, Kepler 2.0 and TESS data when available. Extending the work of Berriman et al. (2010, 2012), we describe our use of the XSEDE-Gordon supercomputer and Amazon EMR cloud to search for aperiodic transit-like events in Kepler light curves. Such events may be caused by circumbinary planets or transiting bodies, either planets or stars, with orbital periods comparable to or longer than the observing baseline such that only one transit is observed. As a bonus, we use the same code to find stellar flares too; whereas transits reduce the flux in a box-shaped profile, flares increase the flux in a fast-rise, exponential-decay (FRED) profile that nevertheless can be detected reliably with a square-wave finder.

Author(s): ***Peter McCullough (Johns Hopkins)***, Scott Fleming (STScI), Andrea Zonca (San Diego Supercomputer Center), Jack Flowers (Reed College), Duy Cuong Nguyen (University of Toronto), Robert Sinkovits (San Diego Supercomputer Center), Pavel Machalek (Johns Hopkins Alumni)

120.23 – Structure and Dynamics of Cold Water Super-Earths: The Case of Occluded CH4 and its Outgassing

In this work we study the transport of methane in the external water envelopes surrounding water-rich super-Earths. We investigate the influence of methane on the thermodynamics and mechanics of the water mantle. We further explore the dynamics of possible tectonic modes active in these planets and derive overturn and resurfacing time scales as a function of ice mass fraction. We propose a mechanism for methane release into the atmosphere and formulate the relation between the outgassing flux and the tectonic mode dynamical characteristics. We give numerical estimates for the global outgassing rate of methane into the atmosphere. We suggest a qualitative explanation for how the same outgassing mechanism may result in either a stable or a runaway volatile release, depending on the specifics of a given planet.

Author(s): ***Amit Levi (Harvard-Smithsonian Center for Astrophysics)***, Dimitar Sasselov (Harvard-Smithsonian Center for Astrophysics), Morris Podolak (Tel-Aviv University)

120.24 – Implications of CME Deflections on the Habitability of Planets Around M Dwarfs

Solar coronal mass ejections (CMEs) are known to produce adverse space weather effects at Earth. These effects include geomagnetically induced currents and energetic particles accelerated by CME-driven shocks. Significant non-radial motions are observed for solar CMEs with the CME path deviating as much as 30 degrees within 20 solar radii. We have developed a model, Forecasting a CME's Altered Trajectory (ForeCAT), which predicts the deflected path of a CME according to the magnetic forces of the background solar wind. In Kay et al (2013), we show that these magnetic forces cause CMEs to deflect towards the region of minimum magnetic field strength. For the Sun, this magnetic minimum corresponds to the Heliospheric Current Sheet (HCS). We predict that the Earth is most likely to be impacted by a deflected CME when its orbit brings it near the HCS. M dwarfs can have magnetic field strengths several orders of magnitude larger than the Sun which will strongly affect CME deflections. We explore stellar CME deflections with ForeCAT. We present results for M4V star V374 Peg. We determine potential impacts caused by CME deflections for a planet located within the habitable zone of V374 Peg (~20-40 solar radii). We discuss future extensions as including variations in solar cycle, capturing small structures such as active regions, and extensions for other M dwarf stars.

Author(s): ***Christina Kay (Boston Univ.)***, Merav Opher (Boston Univ.)

120.25 – Road Testing Asterodensity Profiling using Flicker as an Input

Asterodensity Profiling (AP) is a young but powerful tool for studying transiting exoplanets. A transit light curve directly reveals the mean stellar density, under various idealized assumptions such as circular orbits and no blended light. By comparing this observed density to some independent measure, differences (or lack there-of) can be used to extract useful information on particular systems, such as the orbital eccentricity and the amount of blended light. In a previous paper, we were able to use AP to infer a high false rate for the KOIs of giant stars (Sliski & Kipping 2014) by using asteroseismology as the independent measure. Recently, the analysis of brightness variations on an 8-hour timescale ("flicker") has emerged as a less precise but more widely applicable alternative method for deriving a star's density. Here, we road-test the flicker technique on the 41 KOIs studied previously, to test whether our previous conclusion of a high giant star false positive rate can be recovered using flicker alone. Secondly, we explore the possibility of extending AP to hundreds of Kepler targets, where generally flicker remains viable but asteroseismology does not. Finally, we discuss the impact of this technique to future missions such as TESS and PLATO missions, with a view to both planet validation and extracting the eccentricity distribution of different planet populations.

Author(s): ***David Sliski (Harvard-Smithsonian Center for Astrophysics)***, David Kipping (Harvard-Smithsonian Center for Astrophysics)

120.26 – Reconnaissance of Stars within Twenty-Five Parsecs: Red Dwarfs Rule the Galaxy

The REsearch Consortium On Nearby Stars (RECONS, www.recons.org) team has been mapping the solar neighborhood for 20 years. We continue to collect original astrometric, photometric, and spectroscopic data for the nearest stars and their companions, with significant effort concentrated in the southern hemisphere at the CTIO 0.9m telescope, operated by RECONS for the SMARTS Consortium. These new data are combined with carefully vetted data from classic surveys to paint the most complete portrait to date for the nearby stars. The combined data from RECONS and others have been organized into the RECONS 25 Parsec Database, which as of January 1, 2014 includes 3074 stars, brown dwarfs, and exoplanets in 2168 systems. All of these systems have accurate trigonometric parallaxes in the refereed literature placing them closer than 25.0 parsecs, i.e. parallaxes greater than 40 mas with errors less than 10 mas. Statistical results from this comprehensive Database are outlined, allowing us to make an unprecedented census of the Galaxy's stellar population, of which more than three-quarters are red dwarfs. Fewer than twenty of these red dwarfs are currently known to harbor planets, indicating that a great deal of work remains to be done in the search for the nearest worlds outside our Solar System. It is virtually certain that most planets in the Galaxy are orbiting red dwarfs, and the nearest examples should be among the prime targets in our search for life elsewhere. This effort has been supported by the NSF through grants AST-0908402 and AST-1109445, and via observations made possible by the SMARTS Consortium.

Author(s): ***Todd Henry (RECONS)***, Wei-Chun Jao (Georgia State University), Tiffany Pewett (Georgia State University), Adric Riedel (Hunter College/AMNH), Justin Rodriguez (Georgia State University), Michele Siverstein (Georgia State University), Kenneth Slatten (RECONS), Jennifer Winters (Georgia State University)

Contributing teams: RECONS

121 – Pulsars, Neutron Stars, and Supernovae Posters

Poster Session – Essex Ballroom and America Foyer – 02 Jun 2014 09:00 AM to 06:30 PM

121.01 – Low Mach Number Simulations of Nuclear Flames Using Spectral Deferred Corrections

Many phenomena in Astrophysics are largely subsonic and require special techniques for long-time integration. MAESTRO is a low Mach number stellar hydrodynamics code that can be used to simulate long-time, low-speed flows that would be extremely time consuming to simulate using traditional compressible codes. MAESTRO filters sound waves while retaining both local and large-scale compressibility which gives increased accuracy and efficiency. In this project we describe the results of applying MAESTRO to thermonuclear flames (thin propagating thermonuclear fusion fronts) as well as the convective layer of a nova. The nova is a carbon-oxygen white dwarf with a hydrogen-helium envelope in tight hydrostatic equilibrium. As the envelope increases in mass, the pressure and temperature increase at the base of the accreted layer. When the pressure and temperature are sufficiently high, nuclear fusion (burning) occurs. To capture this burning, we use the extensive reaction network of the Modules for Experiments in Stellar Astrophysics (MESA) code to model the reactions in the flow. We apply a spectral deferred corrections (SDC) algorithm to couple the reactions to the hydrodynamics. We present the results of applying the SDC temporal integration strategy in low Mach number simulations of thermonuclear flames. The SDC approach provides a better coupling between the various physical processes with greater accuracy and reduced computational cost as compared to a Strang splitting approach. This work was supported in part by a DOE/Office of Nuclear Physics grant No. DE-FG02-06ER41448 to Stony Brook.

Author(s): ***Ryan Orvedahl (University of Colorado at Boulder)***, Michael Zingale (Stony Brook University), Ann Almgren (Lawrence Berkeley National Laboratory), John Bell (Lawrence Berkeley National Laboratory), Andrew Nonaka (Lawrence Berkeley National Laboratory)

121.02 – The Earliest Type Oe Stars: Shattering the Record for the Be Phenomenon

Oe stars are massive and likely evolved stars that may be key to understanding aspects of massive star evolution. These are rapidly rotating stars that may have spun up during main sequence evolution and are believed to have formed decretion disks. A decretion disk forms when stellar material is spun out of a star as it rotates near break-up velocity. Oe stars are extremely rare in the Milky Way (MW), where the earliest known Oe star has a spectral type of O7.5. Because weaker stellar winds prevent O stars from losing angular momentum, this model of Oe disk formation predicts that, in low metallicity environments, the weak winds allow larger numbers and frequencies of early-type Oe stars. We test this scenario in the low-metallicity, Small Magellanic Cloud (SMC), where we have identified approximately 30 field Oe stars from RIOTS4, a spatially complete, spectroscopic survey of field OB stars. To date, the earliest reported Oe star in any galaxy is type O7.5. However, here we find seven Oe stars of types O5 to O7, thus yielding much earlier type Oe stars than ever before. Therefore, the increase in the frequency of early-type Oe stars in the SMC compared to the MW supports the decretion disk model because the weaker winds in low-metallicity environments allow earlier type O stars to form decretion disks. Funding for this project was provided by NSF grant AST-0907758.

Author(s): ***Jesse Golden-Marx (University of Michigan)***, M. Oey (University of Michigan), Joel Lamb (Nassau Community College), Andrew Graus (University of California, Irvine)

121.03 – Infrared Spectral Energy Distributions of Nearby Dwarf Carbon Stars

The discovery of G77?61 (Dahn et al. 1977) -- a star with a carbon-rich spectrum a mere 58 pc away and therefore of relatively low luminosity -- led to the recognition that _dwarf_ carbon (dC) stars exist. As more dCs are now known, the accepted paradigm of the presence of atmospheric carbon is that dCs must contain a white dwarf secondary. While the white dwarf companion was going through an AGB stage, it deposited carbon-rich material in the atmosphere of the lower-mass (and now brighter) dwarf star. Indeed, a handful of the dC's have exhibited radial velocity signatures consistent with this picture. To allow for the carbon to still be present in the atmosphere past the AGB stage, a replenishing outer shell or disk has been proposed. Current understanding of the formation and evolution of a dC is, however, limited by the small number of objects and observations. We present a full range of fluxes and flux limits from 1 - 160 um including 2MASS, WISE, Spitzer, and Herschel observations for a list of the nearest carbon dwarfs. We reconstruct the spectral energy distribution exploring the mid-infrared region where any residual debris disks would be detectable. The carbon dwarfs have been historically studied in the visible, and these new infrared observations provide a picture of the circumstellar dust.

Author(s): ***Patrick Lowrance (Spitzer Science Center/Caltech)***

121.04 – Atomic Hydrogen in the Extended Circumstellar Envelope of the Carbon Star IRC+10216

IRC+10216 (CW Leo) is the nearest and best-known carbon star. It is currently undergoing a high rate of mass loss (~10^{-5} M? yr^{-1}) and is believed to be approaching the end of its lifetime on the asymptotic giant branch. Mass loss from IRC+10216 has led to the formation of an extensive circumstellar envelope (CSE) that spans more than half a degree (>1.3 parsecs) across and is both structurally and chemically complex. While the CSE of IRC+10216 has been widely studied through emission from dust and molecular lines, the properties of the predominant CSE constituent —hydrogen gas—have remained poorly known, including the total mass and extent of the circumstellar hydrogen and the ratio of atomic to molecular hydrogen throughout the envelope. I will present new insights into these questions based on a study of IRC+10216 in the HI 21-cm line using the Very Large Array and the Robert C. Byrd Green Bank Telescope. I will also highlight the value of HI line emission as a probe of the interface between the circumstellar and interstellar environment of the star.

Author(s): ***Lynn Matthews (MIT Haystack Observatory)***

121.05 – Soft X-ray Emission from the Central Star of the Dumbbell Nebula

The hot central star of the well-studied planetary nebula M 27 (a.k.a. Dumbbell Nebula) is a strong source of soft X-ray photons. As part of the Chandra Planetary Nebulae Survey (ChanPlaNS), the central star was targeted with the back-illuminated (S3) chip of the Chandra ACIS-S array. All of the central star photons detected in this observation have photon energies below 0.3 keV, where the calibration of Chandra is not well-constrained. Assuming the X-ray spectrum emerges from the hot photosphere, we used the X-ray spectrum and the well-known central star properties to constrain the relevant calibration functions (effective area curve and response matrix) below 0.3 keV. In this poster, we present our methodology, results, and guidelines that will enable the use of the central star as a soft X-ray calibration source.

Author(s): ***Rodolfo Montez (Vanderbilt University)***, Phillip Cargile (Vanderbilt University)

121.06 – What are the progenitors of Galactic Bulge Planetary Nebulae?

CLOUDY photoionization models of galactic bulge planetary nebulae are computed with the goal of simultaneously determing the luminosity and temperature of the planetary nebulae central stars and the abundances of He, C, N, O, Ne, S, Cl, and Ar in the nebulae. A synthetic stellar evolution model is employed to determine the zero age main sequence mass and composition of the planetary nebulae progenitor. The implications for stellar populations and the chemical evolution of the bulge are discussed.

Author(s): ***James Buell (Alfred State College)***

121.07 – Observations Of Planetary Nebula NGC 3242 Using STIS From HST19 GO 12600

During HST Cycle 19, we obtained long-slit spectra using STIS of the planetary nebula NGC 3242 with higher spatial resolution than previously published. The full wavelength range is around 1100-10200Å, covering many nebular lines for determining numerous ionic abundances and electron densities and temperatures. In this work, we first analyze the low- and moderate-resolution UV emission lines of carbon, nitrogen and oxygen. In particular, the resolved lines of C_III] 1907 and C_III] 1909 have yielded a direct measurement of one of the dominant ionic species for carbon and a determination of the density occupied by doubly-ionized carbon and other similar ions. Next, the spatial emission profile of these lines reveals variations in the inferred density along the line of sight from about 2800-11500 cm^{-3}, compared with a value ~3800 cm^{-3}, when averaged over the entire slit. Similarly, the electron temperature is around 12000K for the entire slit and ranges from about 11400-14000K when the slit is divided into smaller sub-regions. Lastly, these sub-regions of the nebula have been modeled in detail with the photoionization code CLOUDY. This modeling will assess the density profile that produces the observed density variation, reproduce the temperature fluctuations, and constrain the central star temperature. We acknowledge the gracious support from HST and the University of Oklahoma.

Author(s): ***Timothy Miller (University of Oklahoma-Norman)***, Reginald Dufour (Rice University), Richard Henry (University of Oklahoma-Norman), Karen Kwitter (Williams College), Richard Shaw (NOAO), Bruce Balick (University of Washington), Romano Corradi (IAC)

121.08 – Abundances in Eight M31 Planetary Nebulae

As part of a continuing project using planetary nebulae (PNe) to study the chemical evolution and formation history of M31 (see accompanying poster by Balick et al.), we obtained spectra of eight PNe in the fall of 2013 with the OSIRIS spectrograph on the GTC. All of these PNe are located outside M31's inner disk and bulge. Spectral coverage extended from 3700-7800Å with a resolution of ~6 Å. Especially important in abundance determinations is the detection of the weak, temperature-sensitive auroral line of [O III], at 4363Å, which is often contaminated by Hg I 4358Å from streetlights; the remoteness of the GTC eliminated this difficulty. We reduced and measured the spectra using IRAF, and derived nebular diagnostics and abundances with ELSA, our in-house five-level-atom program. Here we report the chemical abundances determined from these spectra. The bottom line is that the oxygen abundances in these PNe are all within a factor of 2-3 of the solar value, (as are all the other M31 PNe our team has previously measured) despite the significant range of galactocentric distance. Future work will use these abundances to constrain models of the central star to estimate progenitor masses and ages. In particular we will use the results to investigate the hypothesis that these PNe might represent a population related to the encounter between M31 and M33 ~3 Gy ago. We gratefully acknowledge support from Williams College.

Author(s): ***Kerry Hensley (Williams College)***, Karen Kwitter (Williams College), Romano Corradi (Instituto de Astrofísica de Canarias), R. Galera-Rosillo (Instituto de Astrofísica de Canarias), Bruce Balick (University of Washington), Richard Henry (University of Oklahoma)

121.09 – First Results from HST19 GO12600: CNO Abundances in Seven Milky Way Planetary Nebulae

In HST Cycle 19 we observed 10 Milky Way planetary nebulae (PNe) from 1150–10270Å with STIS to obtain accurate abundances of carbon, nitrogen and oxygen. The ultimate goal of the project is to assess carbon production in the low-to-intermediate-mass (LIMS) progenitors of PNe with near-solar metallicity (~0.5-1.2 x solar), but varying N/O (~0.1-3), comparing observational data with theoretical models of carbon yields. Seven of our objects had data of sufficient quality to allow good empirical abundance determinations: IC2165, IC3568, NGC2440, NGC3242, NGC5315, NGC5882, and NGC7662. Each PN was observed with seven grating setting combinations with identical slit positions and slit sizes across the entire UV-optical spectral region. We created one-dimensional spectra from the two-dimensional STIS spectral images, taking care to extract the identical spatial region from each spectrum for a given object. This was done to produce one-dimensional spectral lines integrated along the slit, resulting in the highest signal-to-noise measurements for analysis. We measured line fluxes with IRAF and calculated nebular diagnostics and abundances with ELSA. The crucial value in using STIS is the ability to observe the ultraviolet lines of important CNO ions with higher signal-to-noise than in previous studies. In all objects we detected lines of C^{+}, C^{+2}, and C^{+3}. We also detected N^{+} and N^{+4} in all objects; in four of the seven we also detected N^{+2} and N^{+3}. We will present these data and compare them with previous determinations and analyses (largely from the old IUE datasets and studies). We gratefully acknowledge support from HST and from Williams College.

Author(s): ***Karen Kwitter (Williams College)***, Reginald Dufour (Rice University), Richard Shaw (NOAO), Richard Henry (University of Oklahoma), Bruce Balick (University of Washington), Romano Corradi (IAC)

121.10 – Kinetic Simulations of the Electrically Charged Current Sheet of a Pulsar

The pulsar magnetosphere is believed to comprise a volume of low-lying, closed field about the magnetic equator, bounded by polar open-field regions in which the pulsar wind flows into space. In the standard global-scale models, a magnetic discontinuity (electric current sheet) of nonneutral plasma separates these opposite-polarity open fields. We use the particle-in-cell Plasma Simulation Code, PSC, to examine the dynamics of a self-consistent model for the internal structure of this sheet, in which the charge-neutral Vlasov/Maxwell equilibria of Harris (1962) and Hoh (1966) are generalized to allow a net electric charge. PSC accommodates both Maxwell (nonrelativistic) and Jüttner/Synge (relativistic) distribution functions for the electrons and positrons. Numerical equilibrium solutions to the 1D Maxwell equations are initialized on the 2D PSC grid, supplemented by periodic boundary conditions in the direction parallel to the sheet and insulating-wall boundary conditions remote from the sheet in the perpendicular direction. As is typical in kinetic studies of pair plasmas, the particle thermal energy and the relative drift velocity driving the current are assumed to be of order the rest energy and the speed of light, respectively. In this limit, the Debye length, skin depth, and Harris/Hoh current-sheet width are all comparable to each other, rather than widely separated and arranged in order of increasing size as generally occurs in nonrelativistic plasmas. The qualitatively new feature of our pulsar simulations is the equilibrium electric field, whose strength can be comparable to that of the magnetic field in the relativistic limit. We expect its presence to have profound consequences for the linear stability and nonlinear evolution of charged pulsar current sheets, substantially modifying the tearing and reconnection of the magnetic field. Exploratory PSC simulations of magnetic reconnection in representative electrified Harris/Hoh equilibria will be presented. The derivation, solution, and analysis of the equilibrium Vlasov/Maxwell equations are discussed in a companion paper at this conference (C. R. DeVore et al. 2014). This work was supported by NASA GSFC’s Science Innovation Fund.

Author(s): ***Carrie Black (CUA)***, C. DeVore (NASA/GSFC), Spiro Antiochos (NASA/GSFC), Alice Harding (NASA/GSFC), Demosthenes Kazanas (NASA/GSFC), Constantinos Kalapotharakos (NASA/GSFC), Andrey Timokhin (UMD)

121.11 – A Model for the Electrically Charged Current Sheet of a Pulsar

Global-scale electromagnetohydrodynamic solutions for the magnetosphere of a pulsar consist of a region of low-lying, closed magnetic field near the star bounded by opposite-polarity regions of open magnetic field along which the pulsar wind flows into space. Separating these open-field regions is a magnetic discontinuity – an electric current sheet – consisting of nonneutral plasma. We have developed a self-consistent model for the internal structure of this sheet by generalizing the charge-neutral Vlasov/Maxwell equilibria of Harris (1962) and Hoh (1966) to allow a net electric charge. The resulting equations for the electromagnetic field are identical for Maxwell (nonrelativistic) and Jüttner/Synge (relativistic) distribution functions of the particles. The solutions have a single sign of net charge everywhere, with the minority population concentrated near the current sheet and the majority population completely dominant far from the sheet. As the fractional charge imbalance at the sheet increases, for fixed relative drift speed and total thermal pressure of the particles, both the electric- and magnetic-field strengths far from the sheet increase. The electrostatic force acts to disperse the charged particles from the sheet, so the magnetic force must increase proportionately, relative to the charge-neutral case, to pinch the sheet together and maintain the equilibrium. The charge imbalance in the sheet that can be accommodated has an upper bound, which increases monotonically with the relative drift speed. Implications of the model for the steady-state structure of pulsar magnetospheres will be discussed. The model also provides a rigorous starting point for investigating electromagnetohydrodynamic and kinetic instabilities that could lead to magnetic reconnection and current-sheet disruption in pulsars. Exploratory particle-in-cell simulations of representative equilibria are presented in a companion paper at this conference (C. E. Black et al. 2014). This work was supported by NASA GSFC's Science Innovation Fund.

Author(s): ***C. DeVore (NASA GSFC)***, Spiro Antiochos (NASA GSFC), Carrie Black (NASA GSFC), Alice Harding (NASA GSFC), Constantinos Kalapotharakos (NASA GSFC), Demosthenes Kazanas (NASA GSFC), Andrey Timokhin (NASA GSFC)

121.12 – X-Ray Observations of Two Remarkable Millisecond Pulsars: PSR J0337+1715 and PSR J0636+5129

PSR J0337+1715 is a fast, bright, and so-far unique millisecond pulsar (MSP) in a hierarchical triple system with two white dwarf (WD) companions. PSR J0636+5129 is an MSP in a 96-min orbit with a companion with a mass of approx. 8 M,J,. Here we report recent observations of these systems with the XMM-Newton X-ray telescope. We have analyzed X-ray spectroscopy and optical/ultraviolet photometry. The X-ray data for each seem largely consistent with expectations for most MSPs. The optical/ultraviolet data help us determine the extinction and size of the inner WD companion to J0337 as well as the effects of the outer, more massive WD. We discuss the implications of these data and prospects for the future.

Author(s): ***Renée Spiewak (University of WI - Milwaukee)***, David Kaplan (University of WI - Milwaukee), Kevin Stovall (University of New Mexico), Duncan Lorimer (West Virginia University), Maura McLaughlin (West Virginia University), Ingrid Stairs (University of British Columbia), Ryan Lynch (McGill University), Scott Ransom (NRAO), Jason Hessels (ASTRON), Anne Archibald (ASTRON)

Contributing teams: The GBT Driftscan Collaboration

121.13 – Host Galaxy Environments of Superluminous Supernovae

One of the most unexpected results from Pan-STARRS and other untargeted time-domain surveys is the discovery of super-luminous supernovae (SLSNe), with bolometric luminosities up to 100 times that of normal core-collapse, Type Ia SNe, and even GRB-SNe and with spectra that do not match any known SN classes. These SLSNe represent a new challenge to our understanding of the death of massive stars, the standard core-collapse picture, and the mechanism for powering optical emission in SNe. Progress in our understanding will come from both studying the properties of the SNe themselves, as well as studying their galactic and sub-galactic environments. We will present results from an extensive survey of ~30 SLSN host galaxies, spanning a redshift range of $0.1 < z < 1.6$. Our data includes optical and NIR photometry and optical spectroscopy, allowing us to determine stellar masses, star formation rates and metallicities, as well as HST imaging allowing us to study the host morphologies and the locations of the SLSNe in the overall host light distribution. We will compare the SLSN host properties to core-collapse SN host galaxies and long-duration GRB host galaxies in the same redshift range, shedding light on the possible progenitors of these extreme explosions.

Author(s): ***Ragnhild Lunnan (Harvard University)***, Ryan Chornock (Harvard University), Edo Berger (Harvard University)

Contributing teams: Pan-STARRS1 CfA Transients Group

121.14 – Using PNe to Explore the History of M31's Extended Disk

The results of O/H abundances derived from PNe in M31 (accompanying poster by Hensley et al.) have extended the radius coverage of our previous gradient studies out to projected disk distances of 100 kpc. The PNe are drawn from the peak of the [OIII] PNLF which suggests that their progenitor stars are more massive than about 1.5 M_sun with evolution lifetimes less than ~2 billion years. However, many of the PNe in this sample are located in regions without gas and other signatures of recent star formation. Here we investigate how the measured O/H abundances of PNe beyond the classical disk of M31 correlate within stellar groupings that are defined in various ways (region, disk radius, kinematic deviations from a thin disk model, and proximity to known stellar streams). The goal is to determine the relationships of the M31 PN sample to any HI and the other stellar populations associated with the evolution of M31's outer environment.

Author(s): ***Bruce Balick (Univ. of Washington)***, Karen Kwitter (Williams College), Romano Corradi (IAC), Kerry Hensley (Williams College), Richard Henry (Univ. of Oklahoma)

121.15 – SweetSpot Data Release 1: 70 Type Ia Supernovae in the Near Infrared in the Nearby Hubble Flow

SweetSpot is an NOAO Survey program from 2012B-2015A that is observing 150 Type Ia supernovae (SNe Ia) in the Hubble flow to obtain reliable NIR luminosities free from peculiar-velocity confusion and the uncertainties of dust. Our full SweetSpot program will (1) extend the NIR Hubble diagram past currently available samples; (2) quantitatively demonstrate the degree to which SNeIa are robust standard candles in the NIR; (3) provide key insights about the color evolution and intrinsic properties of SNeIa and their host galaxies; and (4) establish a well-calibrated low-redshift anchor for future NIR supernova surveys from JWST, Euclid, and WFIRST/NEW. By the end of the survey we will have measured the relative distance to a redshift of z~0.05 to 1%. Nearby Type Ia supernova (SN Ia) observations such as these will test the standard nature of SNe Ia in the restframe NIR, allow insight into the nature of dust, and provide a critical anchor for future cosmological SN Ia surveys at higher redshift. We here present a first look at our Data Release 1 which includes 70 supernovae observed from 2012B-2013B.

Author(s): ***W. Wood-Vasey (University of Pittsburgh)***, Anja Weyant (University of Pittsburgh), Lori Allen (NOAO), Peter Garnavich (Notre Dame), Nabila Jahan (University of Pittsburgh), Saurabh Jha (Rutgers University), Kara Ponder (University of Pittsburgh), Richard Joyce (NOAO), Thomas Matheson (NOAO), Armin Rest (STScI)

121.16 – The Supernova Spectropolarimetry Project: Photometric Followup in the Optical and Near-Infrared by the Mount Laguna Supernova Survey

The SuperNova SpectroPOLarimetry project (SNSPOL) is a recently formed collaboration between observers and theorists that focuses on decoding the complex, time-dependent spectropolarimetric behavior of supernovae (SNe) of all types. Photometric followup of targeted SNe is provided by the MOunt LAguna SUpernova Survey (MOLASUS), which is carried out using Mount Laguna Observatory's 1-meter telescope. Here we present optical and near-infrared (NIR) photometric observations of three recent SNe that were observed as part of this coordinated effort: SN 2013ej, SN 2013dy, and SN 2014J. We discuss the multi-band light curves of these three SNe, with a particular focus on the use of NIRIM (Meixner et al. 1999), our NIR camera used to obtain the J, H, and K' data. SN 2013ej is a Type II supernova in M74, discovered by the Lick Observatory Supernova Search (LOSS) on 2013 July 25.45 (UT; UT dates are used throughout). Our monitoring of this object began 2013 August 07.88 and continued until 2013 December 13.74. The data provide evidence for a photospheric phase lasting roughly 70 days from our first observation, with SN 2013ej then declining by about 3 magnitudes in H-band over the following 50 days. SN 2013dy is a Type Ia supernova in NGC 7250 discovered by LOSS on 2013 July 10.45. We monitored SN 2013dy from July 19.89 until 2013 December 13.62. Our observations show a characteristic type Ia light curve that declines in brightness by about 3 magnitudes in H through the course of our monitoring. Lastly, SN 2014J is a Type Ia-HV [High Velocity] (Takaki et. al (2014) - ATEL 5791) in M82, discovered on 2014 January 21.81, and the closest Type Ia supernovae in over three decades. Our monitoring of SN 2014J began on 2014 January 30.67. We acknowledge support from NSF grants AST-1009571 and AST-1210311, under which part of this research was carried out.

Author(s): ***Harish Khandrika (San Diego State University)***, Douglas Leonard (San Diego State University), Chuck Horst (San Diego State University), Alisa Rachubo (San Diego State University), Nhieu Duong (San Diego State University), G. Grant Williams (MMT Observatory), Paul Smith (Steward Observatory), Nathan Smith (Steward Observatory), Peter Milne (Steward Observatory), Jennifer Hoffman (U. Denver), Leah Huk (U. Denver), Luc Dessart (Universite de Nice)

121.17 – SN 2014J and the Harvard Observing Project

A chance discovery on January 21, 2014 by Steve Fossey et al. of University College London during an undergraduate telescope training session revealed the closest type Ia supernova in the past 42 years. The bright SN 2014J was observed by undergraduates and graduate students alike in the Harvard Observing Project (see poster by A. Bieryla) with the Clay Telescope at Harvard University. Observations were obtained in multiple filters starting January 24, 2014, prior to the supernova reaching its peak brightness, and monitoring will continue as the supernova fades in brightness. We will present multiple band light curve photometry and color RGB images of SN 2014J and its host galaxy M82.

Author(s): ***Melissa McIntosh (Harvard University)***, Allyson Bieryla (Harvard University), Elisabeth Newton (Harvard University), John Lewis (Harvard University), Andrew Vanderburg (Harvard University), Kate Alexander (Harvard University), Peter Blanchard (Harvard University)

121.18 – SN 1993J - The X-ray Story of a Supernova Slowly Transitioning to a Remnant

Supernova 1993J in the nearby galaxy M81 is one of the best observed supernovae (SNe) in X-rays, with better long-term X-ray time-sampling than any other SN. We re-analysed most of the available archival data on SN 1993J, combined with a 79ks Chandra observation obtained by our group in Aug 2010. Together, the data constitute a veritable history of a Type IIb SN from its explosion, through its outward journey into the surrounding medium, and on its way to becoming a remnant. The X-ray emission probes the characteristics of the surrounding medium, and the kinematics of the SN shock wave(s). In this project we explore the evolution of these quantities in SN 1993J, together with the evolution of its X-ray spectrum.

Author(s): ***Vikram Dwarkadas (Univ. of Chicago)***, Franz Bauer (Space Science Institute)

121.19 – The Curious Case of SN 2011dn: Was It A Peculiar Type Ia Supernova?

Type Ia supernovae (SNe Ia) are excellent cosmological distance indicators due to the uniformity in their light curves. This led to the major discovery of the accelerated expansion of the universe (Riess et al. 1998, Perlmutter et al. 1999). However, SNe Ia are not so uniform as one may expect, as there are many ‘peculiar’ SNe Ia that exhibit differences in photometry and spectroscopy from normal SNe Ia. One of the goals of supernova cosmology today is to produce a cleaner sample of SNe Ia by removing the peculiar SNe Ia from the sample. A useful parameter for identifying peculiar SNe Ia based on photometry is ?m15(B), which measures the decrease in B-band magnitude 15 days after the peak of the light curve (Phillips et al. 1993). For typical SNe Ia the standard value is ?m15(B) = 1.1. Peculiar SNe Ia of the overluminous type show a slower decline, with its prototypical member SN 1991T having ?m15(B) = 0.80 (Hicken et al. 2009), while peculiar SNe Ia of the subluminous type show a faster decline, with its prototypical member SN 1991bg having ?m15(B) = 1.87 (Hicken et al. 2009). Here we present optical photometry and spectroscopy of SN 2011dn, which were obtained as part of the MOunt LAguna SUpernova Survey (MOLASUS). Based on its pre-maximum spectrum, which showed strong absorption lines of Fe III ?4404 and Fe III ?5129, along with a weak Si II ?6355 absorption line, SN 2011dn was classified as a SN 1991T-like event (Koff et al. 2011). However, in an earlier preliminary analysis of the light curves – based on point-spread-function photometry – we proposed that SN 2011dn might have had a higher than expected ?m15(B) value of 1.08 (Salvo et al. 2012). Since SN 2011dn is embedded in its host galaxy UGC 11501, it is possible that some of the light from the host galaxy was measured, which may have influenced the measured ?m15(B) value. Here, we employ galaxy-subtraction techniques to isolate the supernova light from its host galaxy, and generate more precise light curves. We derive an updated value of ?m15(B), in order to verify or refute the claimed peculiarity of SN 2011dn. We acknowledge support from NSF grants AST-0850564, AST-1009571 and AST-1210311, under which part of this research was carried out.

Author(s): ***Alisa Rachubo (San Diego State University)***, Chris Salvo (University of California, Riverside), Douglas Leonard (San Diego State University), Nhieu Duong (San Diego State University), Chuck Horst (San Diego State University), Harish Khandrika (San Diego State University), Julienne Sumandal (San Diego State University), John Moustakas (Siena College)

121.20 – Photometry of the Supernova SN 2011dh in the Whirlpool Galaxy

Supernovae are categorized by the presence (Type II) or absence (Type I) of hydrogen lines in their spectra. Our object of interest, SN 2011dh is categorized by its early hydrogen lines and dominated by helium lines in the later phases, indicating a type IIb supernova (Ergon et al. 2013). Here, we present optical photometry of the SN 2011dh, which was obtained as part of the MOunt LAguna SUpernova Survey (MOLASUS) over a period of almost two years capturing the entire lifespan in four different filters (BVRI). All photometric measurements were made using IRAF, and employing point-spread-function fitting technique. We discuss and analyze the light curves produced. We acknowledge support from NSF grants AST-0850564, AST-1009571 and AST-1210311, under which part of this research was carried out.

Author(s): ***Nhieu Duong (San Diego State University)***, Julienne Sumandal (San Diego State University), Douglas Leonard (San Diego State University), Alisa Rachubo (San Diego State University), Harish Khandrika (San Diego State University), Chris Salvo (university of california riverside), Chuck Horst (San Diego State University)

121.21 – Evidence for Accelerated Radioactive Decay (ARD) Models of Type I Supernova Lightcurves in the Low Redshift Universe

Forty years ago Van Hise [*ApJ* **192** (1974) 657-659] observed that the post peak light curve for the Type I supernova SN1937C is well represented by a sum of two exponentials with half lives which are ~ 0.75 of the terrestrial half lives of ^{56}Ni and ^{56}Co in the beta decay chain ^{56}Ni ? ^{56}Co ? ^{56}Fe. Thirty nine years ago Leventhal and McCall [*Nature* **255** (1975) 690-692] proposed a fully convective, radioactive white dwarf model to account for the observed accelerated decay. Thirty eight years ago ARD models were tested by Rust, et al. [*Nature* **262** (1976) 118-120] on the data from the 15 fragmentary light curves available at that time. The results offered significant but not overwhelming support for ARD models. In this paper we present a new mathematical model for Type I lightcurves and fit that model, using only 6 free parameters, to an extensive collection of higher quality lightcurves that have been measured over the last 38 years. The fits all capture more than 99% of the total variance in the measured data, thus establishing the reality of an ARD lightcurve model. These new results provide a much improved Phillips relation for calibrating the extragalactic distance scale and testing other cosmological relations.

Author(s): ***Bert Rust (NIST)***, Marvin Leventhal (University of Maryland)

121.22 – Numerical Verification of the White and Long SNR Model

In 1991 White and Long derived a similarity solution that described the evolution of supernova remnants expanding into an interstellar medium uniformly populated by dense clouds. While this solution marked a great advance in modeling the IR, optical, and X-ray emissions of supernova remnants, it was constrained by a set of limiting assumptions; namely, a homogeneous and uniform inter-cloud medium, clouds that are uniformly distributed and much denser than the surround inter-cloud medium, and no significant acceleration or heating of the clouds by the shock. While many of these assumptions are reasonable, they limit the range of simulations to a subset of all possible supernova remnant scenarios. In this work we have devised a numerical simulation of a supernova remnant expanding into an interstellar medium using the FLASH MHD code. We first test a simulation with conditions similar to that of the White and Long model to test the validity of the simulation. We then vary parameters of the clouds, such as the distribution and density ratios with respect to the inter-cloud medium, to determine which parameters play an important role in SNR observational signatures.

Author(s): ***Henry Winter (SAO)***, Randall Smith (SAO), Adam Foster (SAO)

122 – Instrumentation Posters

Poster Session – Essex Ballroom and America Foyer – 02 Jun 2014 09:00 AM to 06:30 PM

122.01 – Twelve Years of the HST Advanced Camera for Surveys : Calibration Update

The Advanced Camera for Surveys (ACS) has been a workhorse HST imager for over twelve years, subsequent to its Servicing Mission 3B installation. The once defunct ACS Wide Field Channel (WFC) has now been operating longer since its Servicing Mission 4 repair than it had originally operated prior to its 2007 failure. Despite the accumulating radiation damage to the WFC CCDs during their long stay in low Earth orbit, ACS continues to be heavily exploited by the HST community as both a prime and a parallel detector. Conspicuous examples include the recently completed HST Multi-cycle Treasury programs, and the ongoing HST Frontier Fields (HFF) program. We review recent developments in ACS calibration that enable the continued high performance of this instrument, with particular attention the to the Wide Field Channel. Highlights include: 1) the refinement of the WFC geometric distortion solution and its time dependency; 2) the efficacy of both pixel-based and catalog-based corrections for the worsening WFC charge-transfer efficiency (CTE); 3) the extension of pixel-based CTE correction to the WFC 2K subarray mode; and 4) a novel "self-calibration" technique appropriate for large-number stacks of deep WFC exposures (such as the HFF targets) that provides superior reductions compared to the standard CALACS reduction pipeline.

Author(s): ***Norman Grogin (Space Telescope Science Institute)***

Contributing teams: the ACS Calibration Team

122.02 – Revised ACS/WFC Geometric Distortion and Its Linear Time Dependency

We present a new geometric distortion model and its time dependency for the Wide Field Channel (WFC) of the HST Advanced Camera for Surveys (ACS). The primary goal of this study is to derive a new Instrument Distortion Correction (IDC) table to provide calibration reference files for superior alignment and combination of WFC images. These new calibration files will allow the STSDAS and DRIZZLEPAC software to properly align and combine ACS images as well as cross-combine them with other HST images with very high accuracy. The calibration observations of globular cluster 47Tuc taken through the ACS/WFC F435W, F606W and F814W filters before and after Servicing Mission 4 over a wide range of telescope roll angles have been used for astrometric calibration with accuracy to the level of 0.1 pixels. From these observations, a 5th order polynomial fit was derived with respect to the standard astrometric catalog in the vicinity of 47Tuc. After transforming the filter-specific distortion polynomials into the HST focal-plane coordinate system (V2V3), we found a highly significant, filter independent, linear trend in the coefficients over the lifetime of the WFC. AstroDrizzle itself has been slightly modified to handle properly the time-dependency. Our extensive testing suggests that WFC geometric distortions are now corrected to a level of <=0.1 pixels across the entire field of view.

Author(s): ***David Borncamp (Space Telescope Science Institute)***, Vera Kozhurina-Platais (Space Telescope Science Institute), Warren Hack (Space Telescope Science Institute), Colin Cox (Space Telescope Science Institute)

122.03 – WFC3: Improvements to WFC3 UVIS Photometric Calibration

The Wide Field Camera 3 (WFC3) is a fourth-generation imaging instrument installed on the Hubble Space Telescope (HST) in May 2009. It contains both an IR and a UVIS channel. The latter, which covers the 200-1000nm spectral range, consists of two 2K x 4K CCD chips along with 62 spectral elements and one grism. The two CCD chips were manufactured on different wafers. As a result, there are differences in the two chips' properties and behaviors, such as their lithography imprint patterns, their sensitivity responses, and their measured quantum efficiency (QE), particularly in the UV. Therefore, the WFC3 team developed a chip-dependent approach to the photometric calibration, where each chip now has its own separate calibration. We discuss the impacts of this new approach and its implementation in the calibration pipeline, presenting the new zero points and header keywords, as well as the new flat fields. We also present the latest trends in the contamination monitoring, which obtains regular imaging and grism spectroscopy of the white dwarf, GRW+70, in key filters F218W, F225W, F336W, F814W, and F606W. No contamination effects have been detected, though there is evidence for a small photometric drift (<1% over 3 years). We anticipate that these efforts will improve UV imaging with WFC3.

Author(s): ***Catherine Gosmeyer (Space Telescope Science Institute)***, Sylvia Baggett (Space Telescope Science Institute), Ariel Bowers (Space Telescope Science Institute), Tomas Dahlen (Space Telescope Science Institute), Susana Deustua (Space Telescope Science Institute), Derek Hammer (Space Telescope Science Institute), Jennifer Mack (Space Telescope Science Institute)

122.04 – WFC3: UVIS Dark Calibration

Wide Field Camera 3 (WFC3), a fourth-generation imaging instrument on board the Hubble Space Telescope (HST), has exhibited excellent performance since its installation during Servicing Mission 4 in May 2009. The UVIS detector, comprised of two e2v CCDs, is one of two channels available on WFC3 and is named for its ultraviolet and visible light sensitivity. We present the various procedures and results of the WFC3/UVIS dark calibration, which monitors the health and stability of the UVIS detector, provides characterization of hot pixels and dark current, and produces calibration files to be used as a correction for dark current in science images. We describe the long-term growth of hot pixels and the impacts that UVIS Charge Transfer Efficiency (CTE) losses, postflashing, and proximity to the readout amplifiers have on the population. We also discuss the evolution of the median dark current, which has been slowly increasing since the start of the mission and is currently ~6 e-/hr/pix, averaged across each chip. We outline the current algorithm for creating UVIS dark calibration files, which includes aggressive cosmic ray masking, image combination, and hot pixel flagging. Calibration products are available to the user community, typically 3-5 days after initial processing, through the Calibration Database System (CDBS). Finally, we discuss various improvements to the calibration and monitoring procedures. UVIS dark monitoring will continue throughout and beyond HST's current proposal cycle.

Author(s): ***Matthew Bourque (STScI)***, John Biretta (STScI), Jay Anderson (STScI), Sylvia Baggett (STScI), Heather Gunning (STScI), John MacKenty (STScI)

Contributing teams: The WFC3 Team

122.05 – WFC3/UVIS Charge-Transfer-Efficiency Losses: Mitigation and Correction

WFC3/UVIS was installed on HST in 2009 and has been subjected to the harsh radiation environment of space for the past five years. One consequence of radiation damage is charge-transfer-efficiency (CTE) losses, and these losses became apparent much more quickly than expected for WFC3/UVIS because of its low dark current and the low backgrounds in the ultraviolet. Several years ago, we developed a pixel-based model to describe the WFC3/UVIS charge-transfer process, similar to the model that was developed for ACS/WFC. This model showed us that a low-level of post-flash (12 electrons) significantly improves CTE, and many observations now take advantage of this preventative strategy. We have recently taken some calibration data to allow us to improve the pixel-based CTE-correction model in anticipation for the model's inclusion in the WFC3 pipeline. This poster will report on the latest model and CTE-losses.

Author(s): ***Jay Anderson (STScI)***

Contributing teams: WFC3 Team

122.06 – WFC3: News Regarding IR Backgrounds, Spatial Scans, and Cycle 22 Phase 2 Advice

We report on recent developments in the characterization and calibration of the Hubble Space Telescope's Wide Field Camera 3. Installed in 2009 during HST Servicing Mission 4, WFC3 continues as the most used instrument on the observatory with stable performance and steady improvements in its photometric, flat field, dark current, and astrometric calibrations. An important recent development is the recognition of the impact of the Helium 1.083 micron emission line from the upper atmosphere. This sometimes results in significant background variations of factors of 3 to 5 higher than the nominal zodiacal light background in the F105W, F110W, G102, and G141 spectral elements. We also report on progress in using observatory level spatial scans to achieve higher dynamic range observations, to obtain higher precision and more efficient photometric measurements of bright sources, to improve our knowledge of the flat fields, and to increase the precision of astrometric measurements. Suggestions to aid Cycle 22 Phase 2 proposers will also be presented.

Author(s): ***John MacKenty (STScI)***

Contributing teams: Wide Field Camera 3

122.07 – Advanced Time-domain Calibrations and Data-reductionTechniques with HST/COS.

The Hubble Space Telescope/Cosmic Origins Spectrograph (HST/COS) detectors have a time-tag mode of observation in which the arrival time of each photon is recorded individually. Although the COS calibration pipeline (CalCOS) makes use of this capability in many aspects of routine processing, there remains a number other ways that this information can be used to improve the calibration for specific science cases. This has led to the development of tools and techniques to perform additional calibrations that are not part of the standard data products output by CalCOS, but have been made available to the user. Here we demonstrate a few of these techniques including day/night filtering, extracting spectra on sub-exposure timescales, producing photometric light-curves, and performing additional dark-count screening.

Author(s): ***Justin Ely (Space Telescope Science Institute)***, K. Bostroem (Space Telescope Science Institute), John Debes (European Space Agency), Svea Hernandez (Space Telescope Science Institute), Philip Hodge (Space Telescope Science Institute), Robert Jedrzejewski (Space Telescope Science Institute), Kevin Lindsay (Space Telescope Science Institute), Derck Massa (Space Science Institute), Cristina Oliveira (European Space Agency), Steven Penton (Space Telescope Science Institute), Charles Proffitt (Space Telescope Science Institute), Julia Roman-Duval (European Space Agency), David Sahnow (Space Telescope Science Institute), Hugues Sana (European Space Agency), Paule Sonnentrucker (European Space Agency), Joanna Taylor (Space Telescope Science Institute)

122.08 – Moving COS FUV Spectra to the Third COS FUV Lifetime Position

In the fall of 2014, the location of COS FUV spectra on the detector is expected to be moved from the second COS FUV Lifetime Position (LP2) to the third COS FUV Lifetime Position (LP3). This move is needed to mitigate the continuing effects of gain sag in the microchannel plate detectors. With the LP2 move (July 2012) spectra were shifted perpendicularly to the dispersion direction by the equivalent of +3.5", or about 41 pixels, from the original LP1 location. With the LP3 move, spectra will be shifted below the original LP1 position by about -2.5", which maximizes resolution and the detector area available for future lifetime positions. The modes with the widest profiles perpendicular to the dispersion, G130M 1055 and 1096, will remain at LP2, while all other modes will be moved to LP3. Improved extraction techniques are being developed to ensure that the gain sagged regions near LP1 do not affect the spectral quality of point source observations at LP3. We will present results from preliminary tests near LP3 and discuss the implications for science observations. Typical spectral resolving power (?/??) for the modes that are moved to LP3 may decline by about 15% relative to the performance at LP2. Observations of spatially extended sources may also be slightly impacted by the proximity to the gain sagged regions near the original LP1 location and care may be needed not to confuse gain sag artifacts with real spectral features for such sources. Instrument performance is otherwise expected to be similar to that seen during Cycle 21.

Author(s): ***Charles Proffitt (Space Telescope Science Institute)***, K. Bostroem (Space Telescope Science Institute), John Debes (European Space Agency), Justin Ely (Space Telescope Science Institute), Svea Hernandez (Space Telescope Science Institute), Philip Hodge (Space Telescope Science Institute), Robert Jedrzejewski (Space Telescope Science Institute), Kevin Lindsay (Space Telescope Science Institute), Derck Massa (Space Science Institute), Cristina Oliveira (European Space Agency), Steven Penton (Space Telescope Science Institute), Julia Roman-Duval (European Space Agency), David Sahnow (Space Telescope Science Institute), Hugues Sana (European Space Agency), Paul Sonnentrucker (European Space Agency), Joanna Taylor (Space Telescope Science Institute)

122.09 – Planetary Imaging Concept Testbed Using a Recoverable Experiment - Coronagraph

We present the design and expected performance of PICTURE-C, a new suborbital mission designed to image debris disks around stars hosting exoplanets. We present the mission design, expected capabilities, and status. Potential targets, observing scenarios, and expected results are also discussed.

Author(s): ***Timothy Cook (UMass Lowell)***, Kerri Cahoy (MIT), Nikole Lewis (MIT), Mark Swain (JPL), Susanna Finn (UMass Lowell), Christopher Mendillo (UMass Lowell), Supriya Chakrabarti (UMass Lowell), Jason Martel (UMass Lowell), Ewan Douglas (Boston University)

122.10 – Status of the PICTURE Sounding Rocket to Image the Epsilon Eridani Circumstellar Environment

The PICTURE (Planetary Imaging Concept Testbed Using a Rocket Experiment) sounding rocket will use a visible nulling interferometer to characterize the exozodiacal dust disk of Epsilon Eridani (K2V, 3.22 pc) in reflected visible light to an inner radius of 1.5 AU (0.5") from the star. Launch is scheduled for Fall 2014 and the PICTURE payload is currently undergoing re-integration. The first launch of PICTURE suffered a science telemetry failure and the primary mirror was shattered upon landing, the second launch will fly a new SiC primary mirror and onboard data storage. PICTURE visible light observations will constrain scattering properties of the Epsilon Eridani exozodiacal dust disk from 600nm to 750 nm, measuring the background brightness which must be overcome for future exoplanet observations. Additionally, PICTURE will demonstrate operation of a MEMS deformable mirror and a visible nulling coronagraph in space. We will present the latest measurements of integrated telescope and interferometer performance.

Author(s): ***Ewan Douglas (Boston University)***, Christopher Mendillo (University of Massachusetts Lowell), Brian Hicks (NASA GSFC), Timothy Cook (University of Massachusetts Lowell), Jason Martel (University of Massachusetts Lowell), Susanna Finn (University of Massachusetts Lowell), Ronald Polidan (Northrop Grumman Aerospace Systems), Supriya Chakrabarti (University of Massachusetts Lowell)

122.11 – High Precision Pointing Stability and Control for Exoplanet Missions

Exoplanet imaging and characterization space observatories require high precision pointing stability and stability. We have developed a toolbox of sensors, actuators and algorithms along with a systems approach to meet the demanding needs of these missions. Grown from developments and experience gained from high precision Earth remote sensing missions such as the WorldView satellites, as well as high performance astrophysics missions such as Kepler and JWST, these capabilities are enabling for a wide range of future missions. The approaches take advantage of highly flexible software architectures; Enhanced ground simulation capabilities for system tuning and verification and validation; Testing capabilities to verify our modelling; High precision sensors including sub-arc-second star trackers and fine guidance sensors; High bandwidth fast steering mirrors for optical path control; and high precision reaction wheels and control moment gyros for overall observatory control. Many of these capabilities coupled with innovative thinking have been applied to the recent Kepler mission to enable the K2 extended mission concept.

Author(s): ***Arnold Barnes (Ball Aerospace)***, John Troeltzsch (Ball Aerospace), Doug Wiemer (Ball Aerospace)

122.12 – Modeling Exoplanet Transmission Spectra with Solar System Objects

Light transmitted through the atmosphere of an extrasolar planet during a transit becomes encoded with information about the composition and structure of the exoplanet's atmosphere. Transit transmission spectroscopy aims to extract this information through observations of the exoplanet's wavelength-dependent transit depth. However, this practice often yields results with degenerate interpretations. For instance, a featureless transmission curve could suggest an atmosphere with a large mean molecular weight, high-altitude clouds, or it could simply suggest that the instruments making the measurements are not sensitive enough to detect any subtle spectral features. As the number of known exoplanets continues to grow, so does the importance of our ability to accurately characterize these exoplanets using methods such as transit transmission spectroscopy. Fortunately, the bodies in our own solar system can serve as laboratories to understand extrasolar planetary systems. We present a model that can transform solar occultation data into transmission spectra of the atmospheres of various bodies within our solar system. Using this model, we can improve our current interpretations of exoplanetary transmission spectra through observations well-studied solar system objects, as if they were exoplanets. The transformation from occultation to transit presents several challenges including those due to refraction, viewing geometry, and limb darkening. However, we show that it is possible to extract a wavelength-dependent, star-planet radius ratio and therefore a transmission spectrum from occultation data. This model is originally intended for use on Saturn and Titan utilizing occultations observed by the Visual and Infrared Mapping Spectrometer (VIMS) onboard the Cassini Spacecraft. However, it has the potential to be applied to other planets and satellites, even those exhibiting thin atmospheres such as Mars. As future missions such as TESS and JWST continue to emphasize the importance of exoplanet characterization, it is critical that we understand the potential of transit transmission spectroscopy.

Author(s): ***Paul Dalba (Boston University)***, Philip Muirhead (Boston University), Matthew Hedman (University of Idaho), Jonathan Fortney (University of California, Santa Cruz), Philip Nicholson (Cornell University)

122.13 – The Effects of Orbital Environment on X-ray CCD Performance

X-ray telescopes, such as NASA's Chandra X-ray Observatory and Japan's Suzaku, have flown in space for several decades, however the effects of this hostile environment on sensitive astrophysics instruments are still not completely documented. Both observatories use CCD cameras for imaging spectroscopy of the X-ray sky. The CCDs themselves are similar in design, being fabricated at MIT's Lincoln Laboratory. We compare the on-orbit performance evolution of the Chandra ACIS and Suzaku XIS, to better understand the effect of the radiation environment in low- and high-Earth orbit. After more than a combined twenty years in space, both instruments have suffered performance degradation due to radiation damage, but comparison must take into consideration the operational differences, such as the presence of charge injection and the warmer focal plane temperature of the XIS. The low-Earth orbit of Suzaku has the advantage of a lower and stable particle background during observations, while the Chandra particle background during observations is higher and subject to variations due to the solar cycle and solar storms. This is in contrast to the rate of radiation damage accumulation, which is about four times higher for Suzaku, even after correcting for operational differences. We present models of the particle environments for both Suzaku and Chandra which can explain the apparent discrepancy. While the choice of orbit for future missions is obviously dependent on many factors beyond radiation environment, we hope this study will be useful for better informing that choice.

Author(s): ***Catherine Grant (MIT)***, Beverly LaMarr (MIT), Eric Miller (MIT), Mark Bautz (MIT)

122.14 – An X-ray Grating Spectrometer for the ISS

We present the design approach for a X-ray grating spectrometer mission to be deployed on the International Space Station. The baseline design uses sub-apertured X-ray optics feeding into off-plane gratings to achieve both high spectral resolution with a large effective area; the read out is by high-TRL CCDs in the focal plane. The mission will use a pointing system with a novel technology to reduce vibrations from the ISS propagating into the telescope, and would be ready to be attached to the ISS in 2021. The mission parameters are similar to those of the IXO X-ray Grating Spectrometer of R=3000 and ~1000 sq. cm at 0.5 keV, with a bandpass from ~0.3-1 keV, enabling a wide range of science objectives.

Author(s): ***Jay Bookbinder (Smithsonian Astrophysical Obs.)***, Randall McEntaffer (U. Iowa), Peter Daigneau (Smithsonian Astrophysical Obs.), Randall Smith (Smithsonian Astrophysical Obs.), Mark Bautz (MIT), David Burrows (Penn State), Richard Willingale (Univ. of Leicester), Robert Petre (GSFC), Jörn Wilms (Friedrich-Alexander Universitaet), Abraham Falcone (Penn State), Nancy Brickhouse (Smithsonian Astrophysical Obs.), Andrew Ptak (GSFC), Adam Foster (Smithsonian Astrophysical Obs.), Joel Bregman (U. Michigan)

122.15 – Micro-X X-ray Imaging Spectrometer

Micro-X is a NASA funded, rocket borne X-ray imaging spectrometer utilizing Transition Edge Sensors (TESs) to perform high resolution microcalorimetry in the soft X-ray band on astronomical sources. The TESs utilize the 50 mK stage of an Adiabatic Demagnetization Refrigerator (ADR) as a heat sink – one of the biggest challenges in payload design and calibration is to maintain the temperature of the detectors. To achieve the best thermal environment and therefore the best possible resolution of the detectors, we combine software modeling of heat flow within the instrument with data from laboratory tests of thermal connections between the Front End Assembly and ADR. We present a brief overview of the instrument design, recent lab results and modeling, and an update of ongoing progress with the preparations for launch.

Author(s): ***David Goldfinger (Massachusetts Institute of Technology)***

Contributing teams: Micro-X Collaboration

122.16 – From ProtoEXIST to HREXI

The ProtoEXIST program was initiated for the creation of a highly scalable, cost effective, CdZnTe (CZT) detector plane architecture. Two separate prototype coded-aperture telescopes, (ProtoEXIST1 and ProtoEXIST2) each with a detector plane consisting of an 8 × 8 array of pixelated 2 cm × 2 cm, 5 mm thick CZT detectors with anode pixel pitches of 2.5 mm (P1) and 0.6048 mm (P2) and a focal length of ~900 mm have been successfully integrated and flown on high-altitude (39 km) balloon flights in 2009 and 2012 demonstrating operation in space-like conditions while conducting observations of X-ray sources. We review the performance of the P1 and P2 detectors and telescopes before, during and after flight and discuss forthcoming upgrades to the detector plane architecture. We then describe our follow-on High Resolution Energetic X-ray Imager (HREXI) program intended for eventual deployment as a large area (>1m^2) low cost coded-aperture telescope to conduct a wide-field hard X-ray imaging survey and transient monitor optimize over 3-200 keV band. With sensitivities and resolution (both spatial and spectral) ~5-10X better than Swift/BAT, HREXI will be proposed for a future Explorer class mission.

Author(s): ***Branden Allen (Harvard-Smithsonian CfA)***, JaeSub Hong (Harvard-Smithsonian CfA), Jonathan Grindlay (Harvard-Smithsonian CfA), Scott Barthelmy (Goddard Space Flight Center), Robert Baker (Goddard Space Flight Center), Peter Mao (Caltech), Fiona Harrison (Caltech), Hiromasa Miyasaka (Caltech), Jill Burnham (Caltech), William Cook (Caltech)

122.17 – Optical All-Sky Camera for the Large Synoptic Survey Telescope

The Large Synoptic Survey Telescope (LSST) is a wide-field 8.4 meter telescope that will repeatedly survey the southern sky in 6 passbands over a period of 10 years. To maximize the survey efficiency under variable atmospheric conditions (especially with changing cloud cover and variable sky brightness) , we are implementing an all-sky optical wavelength camera and associated image analysis pipeline. This camera will take photos of the sky every minute and return quantitative information about cloud cover to be used in informing the LSST scheduler. In the nearer term the all-sky data will inform the image and scheduler simulations that are being used to plan the project. We present results from calibration and characterization of a Canon 5D Mark III camera in a laboratory setting, as well as preliminary results from sites in Chile and Hawaii.

Author(s): ***Michael Coughlin (Harvard University)***, Chuck Claver (National Optical Astronomy Observatory), Christopher Stubbs (Harvard University), John Tonry (University of Hawaii)

122.18 – Polarimetric analysis of the Thirty Meter Telescope (TMT) for modeling instrumental polarization characteristics

Because a polarimetric observing capability is an important function that the Thirty Meter Telescope (TMT) will be called upon to support, many different observing programs covering a range of different science areas are being considered for the TMT and a model of the overall polarization characteristics is being developed. The instrument development program will provide a means for polarimetric instruments to be developed, however the telescope itself and the AO system must be able to support polarimetric instruments. As a first step to defining the necessary polarimetric technical requirements we have created an international working group to carry out a study in which technical and cost implications will be balanced with scientific impact; new requirements will be generated with supporting science cases. We present here initial results of the instrumental polarization sensitivity of TMT with NFIRAOS, the first-light adaptive optics system.

Author(s): ***Warren Skidmore (Thirty Meter Telescope Observatory Corp.)***, Jenny Atwood (National Research Council Canada), Ramya Manjunath (Indian Institute of Astrophysics), Krishna Reddy (ARIES), G. Anupama (Indian Institute of Astrophysics), Asoke Sen (Assam University)

Contributing teams: The TMT Polarimetry and Time Resolved Working Group

122.19 – Early science performance and upcoming changes at Lowell Observatory's Discovery Channel Telescope

Science operations began in 2013 on Lowell Observatory's Discovery Channel Telescope (DCT). The DCT is a 4.3m telescope designed and constructed for astronomical observations in the optical and near infrared. The f/6.1 RC focus has an instrument cube with integrated wave front sensing and guider systems, capable of carrying five instruments. The first instrument, currently in use, is the Large Monolithic Imager, a 6Kx6K optical CCD camera. Three spectrographs are under construction or modification and are expected to commission on the telescope later in 2014. The spectrographs are (1) the low to mid-resolution optical DeVeny spectrograph, being modified now in the Lowell shop, (2) the Near IR High Throughput Spectograph (NIHTS), which is a low resolution spectrograph that will cover J through K bands in one observation and (3) the Rapid IMager-Spectrometer (RIMAS) being built by the Goddard Space Flight Center and the University of Maryland. The on-sky pointing and tracking performance of the telescope, have proven to be stable and repeatable. The active optics support system has also proven to be a reliable performer. The first implementation of an open loop model of the optical aberrations, combined with the tracking are giving image quality in line with our hopes based on the original site survey. Key milestones defining the transition from commissioning to full operations are expected to be complete by the end of 2014.

Author(s): ***Stephen Levine (MIT)***

Contributing teams: DCT Engineering Team, Lowell Instrument Group

122.20 – Photometry and Spectroscopy with the SMARTS Consortium Telescopes

We present recent results from the SMARTS Consortium Telescopes located at Cerro Tololo, designed to highlight the capabilities of the telescopes and instruments. We will report astrometry from the 0.9m+2KCCD obtained for the RECONS project (Dieterich et al. 2014 and Riedel et al. 2014), optical/IR photometry obtained with the 1.3m+ANDICAM for studies of X-ray binaries (e.g. MacDonald et al. 2014) and the SMARTS/Fermi blazar project (Bonning et al. 2012), and high-resolution spectroscopy obtained with the 1.5m+Chiron for exoplanet studies (Tokovinin et al. 2013). We note that time is available to new private partners on all these telescope/instrument combinations.

Author(s): ***Charles Bailyn (Yale Univ.)***, Michelle Buxton (Yale Univ.), Victoria Misenti (Yale Univ.), Debra Fischer (Yale Univ.), Todd Henry (Georgia State), Nicole Van Der Bliek (CTIO)

122.21 – Faster, Better, Cheaper: A ZERODUR® low-expansion, light-weight present path toward affordable spaceborne telescopes

For competed missions, payload costs are often the discriminate of whether or not outstanding science can be selected to fly. Optical Telescope Assemblies (OTAs) encompass a significant fraction of the payload cost, and mirror aperture and stability are usually are key to the science merit. The selection of the primary mirror approach drives architecture decisions for the rest of the OTA and even payload. We look at the ways OTA architecture is affected by the PM selection, and specifically at the benefits of selecting a low expansion material. We will also review recent advances in ZERODUR® fabrication which make this low-expansion material relevant in situations where affordable, lightweight mirrors can enable the apertures needed for science merit. Extreme Lightweight ZERODUR® Mirrors (ELZM) are available in apertures from 0.3m to over 4m. SCHOTT has recently demonstrated a relevant 1.2m ELZM substrate.

Author(s): ***Anthony Hull (University of New Mexico)***, Thomas Westerhoff (SCHOTT AG)

122.22 – Computational modeling of Radioisotope Thermoelectric Generators (RTG) for interplanetary and deep space travel

This research project is part of Narsis Nejat Master of Science thesis project that it is done at Shiraz University. The goals of this research are to make a computer model to evaluate the thermal power, electrical power, amount of emitted/absorbed dose, and amount of emitted/absorbed dose rate for static Radioisotope Thermoelectric Generators (RTG)s that is include a comprehensive study of the types of RTG systems and in particular RTG's fuel resulting from both natural and artificial isotopes, calculation of the permissible dose radioisotope selected from the above, and conceptual design modeling and comparison between several NASA made RTGs with the project computer model pointing out the strong and weakness points for using this model in nuclear industries for simulation. The heat is being converted to electricity by two major methods in RTGs: static conversion and dynamic conversion. The model that is created for this project is for RTGs that heat is being converted to electricity statically. The model approximates good results as being compared with SNAP-3, SNAP-19, MHW, and GPHS RTGs in terms of electrical power, efficiency, specific power, and types of the mission and amount of fuel mass that is required to accomplish the mission.

Author(s): ***Cyrus Nejat (University of Southern California)***, Narsis Nejat (Shiraz University), Najmeh (Setareh) Nejat (Shiraz University)

122.23 – The PockeQube T-LogoQube: a Prototype Approach for Future Spaced Based Astronomy Experiments

T-LogoQube is a first generation 3P (size 5 cm x 5 cm x 15 cm) ~500 gram PocketQube which flies instrumentation. The project is a collaboration between undergraduate universities Morehead State (MSU) in Kentucky and Sonoma State (SSU) in California. The purpose of this project is to develop a platform for future space-based science experiments including astronomy. This first 3P satellite is one of the smallest, stand-alone satellites to send both a radio beacons and instrumentation telemetry. T-LogoQube successfully reached orbit on November 21 in a sun synchronous polar low-earth orbit. A Russian DNEPR-1 rocket from Dombarovsky Cosmodrome at Yasny, Russia carried an Italian micro-satellite called Unisat-5 which actually released the T-LogoQube satellite into space. Flight software is written in the programming language microLogo (ulogo) which makes this satellite a platform for future spaced-based astronomy experiments. The T-LogoQube team is comprised of about fifty people (professional mentors, faculty, and students).

Author(s): ***Aaron Owen (Sonoma State University)***, Kevin Zack (Sonoma State University), J. Jernigan (Little H-Bar Ranch), Bob Twiggs (Morehead State Univerisity), Lynn Cominsky (Sonoma State University), Benjamin Malphrus (Morehead State Univerisity), B. Silverman (PICO), S. McNeil (Little H-Bar Ranch), W. Roach-Barrette (Little H-Bar Ranch)

Contributing teams: and the T-LogoQube Team

123 – SPD Posters 1

Poster Session – Essex Ballroom and America Foyer – 02 Jun 2014 09:00 AM to 06:30 PM

123.01 – Absolute Abundance Measurements in Solar Flares

We present measurements of elemental abundances in solar flares with EVE/SDO and EIS/Hinode. EVE observes both high temperature Fe emission lines Fe XV-XXIV and continuum emission from thermal bremsstrahlung that is proportional to the abundance of H. By comparing the relative intensities of line and continuum emission it is possible to determine the enrichment of the flare plasma relative to the composition of the photosphere. This is the first ionization potential or FIP bias (F). Since thermal bremsstrahlung at EUV wavelengths is relatively insensitive to the electron temperature it is important to account for the distribution of electron temperatures in the emitting plasma. We accomplish this by using the observed spectra to infer the differential emission measure distribution and FIP bias simultaneously. In each of the 21 flares that we analyze we find that the observed composition is close to photospheric. The mean FIP bias in our sample is F=1.17+-0.22. Furthermore, we have compared the EVE measurements with corresponding flare observations of intermediate temperature S, Ar, Ca, and Fe emission lines taken with EIS. Our initial calculations also indicate a photospheric composition for these observations. This analysis suggests that the bulk of the plasma evaporated during a flare comes from deep in the chromosphere, below the region where elemental fractionation in the non-flaring corona occurs.

Author(s): ***Harry Warren (Naval Research Lab.)***

123.02 – Pre-Impulsive Flares and Chromospheric Heating/Evaporation Mechanisms with RHESSI and AIA

We present an investigation of RHESSI flares with a distinct "early rise" or "pre-impulsive" phase in which low-energy X-ray flux (6-12 keV) increases ~minutes before more energetic (25-50 keV), impulsive emission. It is currently unclear what the dominant heating mechanism is for this class of events; studies have claimed chromospheric heating by non-thermal electron beams or by conduction (see e.g. Siarkowski et al. 2009, Battaglia et al 2009). We use AIA data in conjunction with the data analysis technique outlined in Brosius & Holman 2012 to distinguish between chromospheric heating/evaporation mechanisms. This technique involves the temporal analysis of AIA lightcurves in the passbands sensitive to flare temperatures; a simultaneous increase in all channels is interpreted as beam-driven chromospheric heating, whereas an early increase in hotter channels can indicate a hot coronal source and conductive heating. RHESSI imaging and spectroscopy is performed to determine flare parameters such as temperature, density, and power-law index (if a detectable non-thermal component is present). We also perform a search for early phase, non-thermal coronal sources similar to those observed in some strong events such as 2002 July 23.

Author(s): ***Andrew Marsh (UC Santa Cruz)***, David Smith (Space Sciences Laboratory, UC Berkeley), Lindsay Glesener (Space Sciences Laboratory, UC Berkeley), Amir Caspi (Laboratory for Atmospheric and Space Physics, Univ. of CO)

123.04 – Study of Two Successive Three-ribbon Solar Flares Using BBSO/NST Observations

We studied two rarely observed three-ribbon flares (M1.9 and C9.2) on 2012 July 6 in NOAA AR 11515, which we found using H? observations of 0.1 arcsec resolution from the New Solar Telescope and Ca II H images from Hinode. The flaring site is characterized by an intriguing "fish-bone-like" morphology evidenced by both Halpha images and a nonlinear force-free field (NLFFF) extrapolation, where two semi-parallel rows of low-lying, sheared loops connect an elongated, parasitic negative field with the sandwiching positive fields. The NLFFF model also shows that the two rows of loops are asymmetric in height and have opposite twists, and are enveloped by large-scale field lines including open fields. The two flares occurred in succession within half an hour and are located at the two ends of the flaring region. The three ribbons of each flare run parallel to the magnetic polarity inversion line, with the outer two lying in the positive field and the central one in the negative field. Both flares show surge-like flows in Halpha apparently toward the remote region, while the C9.2 flare is also accompanied by EUV jets possibly along the open field lines. Interestingly, the 12-25 keV hard X-ray sources of the C9.2 flare first line up with the central ribbon then shift to concentrate on the top of the higher branch of loops. These results are discussed in favor of reconnection along the coronal null line, producing the three flare ribbons and the associated ejections.

Author(s): ***Haimin Wang (NJIT)***, Chang Liu (NJIT), Na Deng (NJIT), Zhicheng Zeng (NJIT), Yan Xu (NJIT), Ju Jing (NJIT), Wenda Cao (NJIT)

123.05 – Magnetic Field Changes in SDO/HMI Line-of-sight Magnetograms during Large Solar Flares

Photospheric magnetic fields are often used to study the topology of a flaring active region as well as to predict when a flare will happen. We examined SDO/HMI line-of-sight magnetograms for forty flares (M5.0 or larger) from 2010 to 2013. Using the full-resolution (0.5 arcsecond/pixel) and high time cadence (45-second), observations, we identified three types of changes in line-of-sight magnetic flux near the flaring region during large solar flares: First, discreet jumps or steps in the line-of-sight magnetic flux are often observed when examining magnetograms before and after the flare. Second, spikes or rapid and transient changes lasting just a few minutes occur during the rise of the flare, coinciding with the impulsive phase. Finally, in a few flares, moderate-scale waves in magnetograms, similar to Moreton or EIT waves, are seen propagating away from the flaring region. In this study, we provide statistics on these different apparent magnetic flux changes as well as offer possible physical explanations.

Author(s): ***K. Balasubramaniam (USAF/AFRL)***, Rachel Hock (USAF/AFRL)

123.06 – Magnetic Energy Dissipation in 200 Solar Flares Measured with SDO

We present the first statistical study of magnetic energetics in solar flares. The amount of dissipated magnetic energy during solar flares provides the fundamental limit on the flare energy budget that is partitioned into the kinetic and potential energy of CMEs, acceleration of nonthermal particles, and radiation in soft X-rays, EUV, UV, and bolometric luminosity. The determination of the dissipated magnetic energy requires the calculation of nonlinear force-free field (NLFFF) solutions during flares, which can quantify the nonpotential E_N(t), the potential E_P(t), and the free magnetic energy E_{free}(t)=E_N(t)-E_P(t), which itself represents an upper limit on the magnetic energy dE_diss that can be dissipated during a flare. Here we developed a NLFFF forward-fitting code that fits a nonpotential field in terms of vertical currents with helically twisted field lines to automatically traced coronal loops from 7 AIA wavelength filters and apply it to 200 M- and X-class flares that have been observed during the first 4 years of the Solar Dynamics Observatory (SDO) mission. We cacluate the free energy with a cadence of 6 minutes during all 200 flares, and find significant magnetic energy decreases dE_diss in almost all flares, in the order of E_diss ~ 10(31)-10(32) erg, which amounts to a fraction of dE_diss/E_P ~ 0.01-0.3 of the potential magnetic energy E_P. We find that the dissipated energy dE_diss cannot simply be determined by an energy difference before and after the flare, because the hydrodynamic evolution causes brightenings and dimmings of helically twisted loops (sigmoids) in the flare core region, which acts as a time-dependent illumination effect of nonpotential loop structures.

Author(s): ***Markus Aschwanden (Lockheed Martin ATC)***

Contributing teams: AIA/SDO

123.07 – The Multi-Instrument, Comprehensive Differential Emission Measure (DEM) of the Solar Corona During Flares and Quiescent Periods

Thermal plasma in the solar corona, while often modeled as isothermal for ease of analysis, is in fact decidedly multi-thermal, ranging from ~1-2 MK in the quiescent corona to ~30-50 MK in intensely flaring loops. It has proven difficult to obtain a well-constrained differential emission measure (DEM) from a single instrument, as the wavelength ranges of individual instruments, even those with broadband coverage, provide sensitivity to only a limited range of plasma temperatures. Recently, we developed a new technique using combined extreme ultraviolet (EUV) and soft and hard X-ray (SXR, HXR) data from the EUV Variability Experiment (EVE) onboard the Solar Dynamics Observatory (SDO) and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI), respectively, to obtain a self-consistent DEM that is strongly constrained across the full range of coronal plasma temperatures (<2 to >50 MK). An accurate, precise determination of the plasma temperature distribution enables not only studies of plasma heating and thermal plasma evolution, but can also provide strong constraints on the non-thermal accelerated electron population, including the low-energy cutoff which is typically determined only as a loose upper limit. We present EVE+RHESSI DEM results from selected intense (X-class) flares from solar cycle 24, including determining the non-thermal low-energy cutoff and examining how this evolves with the temperature distribution. We also apply this technique to combine EUV data from EVE with SXR data from the GOES X-ray Sensor (XRS) and the X123, a new SXR spectrometer flown on two recent SDO/EVE calibration sounding rockets, to examine the DEM during quiescent (non-flaring) times with varying activity levels; the X-ray data provide crucial constraints on the high-temperate extent of the DEM and any potential non-thermal emission. We compare these results with those from a parallel technique to derive DEMs from imaging data from the Atmospheric Imaging Assembly (AIA) onboard SDO, and we discuss the implications for plasma heating, both during flares and in the quiescent corona. This research is supported by NASA contracts NAS5-98033 and NAS5-02140, and NASA Heliophysics Guest Investigator Grant NNX12AH48G.

Author(s): ***Amir Caspi (University of Colorado)***, James McTiernan (University of California), Harry Warren (Naval Research Laboratory), Thomas Woods (University of Colorado)

123.08 – Searching for narrow-band oscillations in solar flares in the presence of frequency-dependent noise

A common feature of solar flare emission is the appearance of short timescale fluctuations, often interpreted in terms of oscillatory signatures, and often referred to as quasi-periodic pulsations (QPPs) or quasi-periodic oscillations (QPOs). These fluctuations are an important diagnostic of solar plasma, as they are linked to the flare reconnection and particle acceleration sites. However, it has recently become clear that solar flare time series, like many astrophysical objects, are often dominated by frequency-dependent 'red' noise, rather than white noise. This frequency-dependent red-noise is commonly not taken into account when analyzing flare time-series for narrow-band oscillations. We demonstrate the application of a Bayesian method of searching for narrow-band oscillations in flares (based on Vaughan 2010) that fully accounts for frequency-dependent noise. We apply this method to the recent flares of 2011 February 15 and 2011 June 7, utilizing high-cadence EUV and X-ray data from the Proba-2/LYRA and Fermi/GBM instruments. While emphasizing that the observed fluctuations are a very real effect, we show that the emission from the selected events can be well described by a frequency-dependent noise model, without the need to invoke an explicit oscillatory mechanism. This presents a challenge to our current understanding of flare fluctuations, and suggests that narrow-band oscillations in flare emission may be much less prevalent than previously believed.

Author(s): ***Andrew Inglis (NASA Goddard Space Flight Center)***, Jack Ireland (NASA Goddard Space Flight Center)

123.09 – A FLARE OBSERVED IN CORONAL, TRANSITION REGION AND HELIUM I 10830 Å EMISSIONS

On June 17, 2012, we observed the evolution of a C-class flare associated with the eruption of a filament near a large sunspot in the active region NOAA 11504. We obtained high spatial resolution filtergrams using the 1.6 m New Solar Telescope at the Big Bear Solar Observatory in TiO broad-band (bandpass: 10 Å)and He I 10830 Å narrow-band (bandpass: 0.5 Å, centered 0.25 Å to the blue). We analyze the spatio-temporal behavior of the He I 10830 Å data, which were obtained over a 90×90 arcsends field of view with a cadence of 10 sec. We also analyze simultaneous data from the Atmospheric Imaging Assembly and Extreme Ultraviolet Variability Experiment instruments on board the Solar Dynamics Observatory spacecraft, and data from Reuven Ramaty High Energy Solar Spectroscopic Imager and GOES spacecrafts. Several quantitative aspects of the data, as well as models derived using the “0D” Enthalpy-Based Thermal Evolution of Loops model (EBTEL: Klimchuk et al. 2008) code, indicate that the 10830 Å multiplet is formed primarily by photoionization of chromospheric plasma followed by radiative recombination. Surprisingly, the He II 304 Å line is reasonably well matched by standard emission measure calculations, along with the C IV emission which dominates the AIA 1600 Å channel during flares. This work lends support to some of our previous work combining X-ray, EUV and UV data of flares to build models of energy transport from corona to chromosphere.

Author(s): ***Zhicheng Zeng (Big Bear Solar Observatory)***, Jiong Qiu (Montana State University), Wenda Cao (Big Bear Solar Observatory), Philip Judge (High Altitude Observatory)

123.10 – Sub-arcsecond Structure and Dynamics of Flare Ribbons Observed with New Solar Telescope

Emission of solar flares across the electromagnetic spectrum is often observed in the form of two expanding ribbons. The standard flare model explains the flare ribbons as footpoints of magnetic arcades, emitting due to the interaction of energetic particles with the chromospheric plasma. However, the physics of this interaction and properties of the accelerated particles are still unknown. We present results of multiwavelength observations of C2.1 flare of August 15, 2011, observed with the 1.6-meter New Solar Telescope of Big Bear Solar Observatory. These unique data are characterized by the great spatial resolution reaching the telescope diffraction limit with good spectral scanning of H-alpha line, and photospheric imaging. The observations reveal previously unresolved sub-arcsecond structure of the flare ribbons in regions of strong magnetic field. We discuss the fine structure of the flare ribbons, their dynamics, and possible mechanisms of the energy release and transport, using also data from SDO, GOES and FERMI spacecraft.

Author(s): ***Ivan Sharykin (Space Research Institute of RAS)***, Alexander Kosovichev (Stanford University)

123.11 – Helioseismic and Magnetic Imager Observations of Linear Polarization from a Loop Prominence System

White-light observations by the Solar Dynamics Observatory's Helioseismic and Magnetic Imager of a loop-prominence system occurring in the aftermath of an X-class flare on 2013 May 13 near the eastern solar limb show a linearly polarized component, reaching up to 20% at an altitude of 33 Mm, about the maximal amount expected if the emission were due solely to Thomson scattering of photospheric light by the coronal material. The mass associated with the polarized component was 8.2x10^14 g. At 15 Mm altitude, the brightest part of the loop was 3(+/-0.5)% linearly polarized, only about 20% of that expected from pure Thomson scattering, indicating the presence of an additional unpolarized component at wavelengths near Fe I (617.33 nm), probably thermal emission. We estimated the free electron density of the white-light loop system to possibly be as high as 1.8x10^12 cm^-3.

Author(s): ***Pascal Saint-Hilaire (University of California, Berkeley)***, Jesper Schou (Max-Planck-Institut fur Sonnensystemforschung), Juan Carlos Martinez Oliveros (University of California, Berkeley), Hugh Hudson (University of Glasgow), Sam Krucker (University of Applied Sciences and Arts Northwestern Switzerland), Hazel Bain (University of California, Berkeley), Sebastien Couvidat (Stanford University)

123.12 – Acceleration Regions Jointly Observed with Microwave and X-Ray Imaging Spectroscopy in a Number of Solar Flares

Detection of acceleration regions in solar flares has proved challenging for many reasons, in particular, because the X-ray emission is weighted by denser regions of the flare volume, although the acceleration can take place in a tenuous region, while the microwave emission, which can be significant even from the tenuous regions, is often dominated by a (looptop) trapped population, rather than the acceleration region itself. For these reasons we undertook a systematic database search to identify events that do not show a significant trapped component and at the same time show evidence of the source uniformity, which simplifies the data analysis greatly. Initially, we identified a subset of more than 20 radio bursts with a relatively narrow spectrum, having the low- and high-frequency spectral indices larger than 3 by the absolute value. That steep low-frequency spectrum implies that the emission is nonthermal (for the thermal emission the spectral index is supposed to be 2 or flatter), and the source is reasonably dense and uniform. The steep high-frequency spectrum implies that no significant electron trapping occurs; otherwise a progressive spectral flattening would be observed. Roughly half of these radio bursts have RHESSI data, which allows for a detail joint diagnostics of the source parameters and evolution. Based on the studied radio-to-X-ray spatial relationships, timing, and spectral fits we do conclude that we deal here with emission from directly the acceleration regions. We discuss the implications of these observations for the acceleration mechanism involved. We also discuss further strategy of how to detect the acceleration region with the currently available observational means. This work was supported in part by NSF grants AGS-1250374, and NASA grants NNX11AB49G and NNX14AC87G to New Jersey Institute of Technology.

Author(s): *Gregory Fleishman (NJIT)*, Eduard Kontar (University of Glasgow), Gelu Nita (NJIT), Dale Gary (NJIT)

123.13 – Heating Rate in Reconnection Formed Flare Loops

High-resolution ultraviolet (UV) and extreme ultraviolet (EUV) images of solar flares have revealed that flare loops are formed by magnetic reconnection events successively and heated separately. Our recent work (Qiu et al. 2012) suggests that the heating rate in individual flare loops could be inferred from the rapid rise of UV brightness at the foot-points of these loops. The heating rate is further restricted by comparing the observed coronal radiation and the synthetic one from plasma in all these loops computed by the Enthalpy-Based Thermal Evolution of Loops (EBTEL, Klimchuk et al. 2008, Cargrill et al. 2012) model. Therefore, the method uses observations to constrain the heating rates from both the input and output of the loop heating model. In this study, we apply this method to three flares of different magnitude, respectively. Comparison of the results from the three events show that the synthetic coronal radiation compares reasonable well with observations from plasma with temperature in the range of 3-10MK. This experiment provides another independent constraint to determination of the heating rates. Furthermore, using RHESSI hard X-ray observations, we also infer the fraction of non-thermal beam heating in the total heating rate of flare loops, and discuss its effect on plasma evolution. For the 2005 May 13 M8.0 flare that exhibits significant thick-target hard X-ray emissions, the lower limit of the total energy used to heat the flare loops is 1.2e31 ergs, out of which, less than 20% is carried by beam-driven upflows during the impulsive phase.

Author(s): *Wenjuan Liu (Montana State University)*, Jiong Qiu (Montana State University), Dana Longcope (Montana State University), Amir Caspi (University of Colorado)

123.14 – Relationship between unusual features in umbrae and flares

The influence of photospheric and chromospheric dynamics and morphologies on flare activity are still unclear. We present a study of two flaring active regions (ARs) with complementary instruments (DST/IBIS, Hinode/SOT-SP, SDO/HMI and SDO/AIA) to investigate the temporal evolution of the sunspots and their magnetic and thermodynamic properties. In spite of vast differences in flare occurrence and flare magnitudes, both ARs show similar features in the lower solar atmosphere during flares. We investigate common magnetic topologies and dynamics, which may favor flare activity.

Author(s): *Alberto Sainz Dalda (Stanford-Lockheed Institute for Space Research)*, Lucia Kleint (BAER Institute)

123.15 – Decay-phase Cooling and Inferred Heating of M- and X-class Solar Flares

Hydrodynamic modelling is a well established and important field in understanding the evolution of solar flares. However, in order to be of greatest use the results of such models must be compared to statistically significant samples of flare observations. In this talk we observationally investigate the hydrodynamic decay phase evolution of 72 M- and X-class flares using GOES/XRS, SDO/EVE and Hinode/XRT and quantify their cooling rates. The results are then compared to the predictions of an analytical zero-dimensional hydrodynamic model. We find that the model does not fit the observations well, but does provide a well-defined lower limit on a flare's total cooling time. The discrepancy between observations and the model is then assumed to be primarily due to heating during the decay phase. The decay-phase heating necessary to account for the discrepancy is quantified and found be ~50% of the total thermally radiated energy, as calculated with GOES/XRS. This suggests that the energy released during the decay phase may be as significant as that released during the rise phase.

Author(s): ***Daniel Ryan (Trinity College Dublin)***, Phillip Chamberlin (NASA Goddard Space Flight Center), Ryan Milligan (Catholic University of America), Peter Gallagher (Trinity College Dublin)

123.16 – A study of sympathetic eruptions using the Heliophysics Events Knowledgebase

Over the past few decades there have been a number of papers investigating the connection between flares occurring in succession. Statistically, any connection that affects the timing of successive flares that exists is found to be weak. However, the majority of previous investigations has been limited by only considering the causal connection between soft X-ray flares. More recent case studies have shown convincing evidence that large eruptions cause a global reorganization of overlying magnetic fields that can result in the eruption of both flares and filaments at large distances from the original event. In this work, the connection between GOES X-ray flares (C-, M-, and X-class) and filament eruptions occurring in succession in two different active regions is considered statistically. The filament eruptions are recorded in the Heliophysics Events Knowledgebase by observers using SDO/AIA data. A significant causal connection is found between the two event types, such that large flares are followed by filament eruptions within 24 hours much more often than they are preceded by filament eruptions. This stipulates that the flares either cause the filaments to erupt or affect the eruption timing such that the filament eruptions follow the flares more closely in time.

Author(s): ***Paul Higgins (Lockheed Martin)***, Carolus Schrijver (Lockheed Martin), Alan Title (Lockheed Martin), D. Shaun Bloomfield (Trinity College Dublin), Peter Gallagher (Trinity College Dublin)

123.17 – Different Temperature Evolution In Magnetic Flux Rope and Near-Surface Flare Loop Source In A Failed Solar Eruption

Solar eruption is a transient energetic phenomenon that involves sophisticated kinematic, morphological and thermal evolution. The observed evolution bears the knowledge on the physical mechanism of solar eruptions. Here we report a detailed study of a failed solar eruption occurred on January 05, 2013, which generated an M1.7 X-ray flare and a giant "fire ball" that likely represent a magnetic flux rope. The flux rope, a well-organized structure in the corona, was initially impulsively accelerated to a speed of $\sim$400 km/s in the first minute, then decelerated and came to a complete stop in two minutes. The failed eruption resulted in a large-size high-lying ($\sim$100 Mm above the surface) high-temperature ``fire ball" sitting in the corona for more than two hours. The time evolution of the thermal structure of the flux rope was revealed through the differential emission measure analysis technique, which produced temperature maps using observations of the Atmospheric Imaging Assembly on board \textit{Solar Dynamic Observatory}. The average temperature of the flux rope steadily increased from $\sim$5 MK to $\sim$10 MK during the first nine minutes of the evolution. On the other hand, the temperature increase of the near surface flare loop source lasted only three minutes, similar to the rise time of the associated soft X-ray flare. We suggest that the flux rope is heated by the thermal energy release of the continuing magnetic reconnection in the high corona, which is different from the heating of the low-lying flare loops. The low-lying loops are likely heated by chromospheric plasma evaporation during the flare main phase. The large ambient loops overlying the flux rope was pushed up by $\sim$10 Mm during the attempted eruption. The pattern of the velocity variation of the ambient loops strongly suggests that the failure of the eruption is caused by the strapping effect of the overlying loops.

Author(s): ***Jie Zhang (George Mason Univ.)***, Hong-qiang Song (George Mason Univ.)

123.18 – The Study of Solar Energetic Protons Associated with EUV Waves

We studied the relationship between solar energetic protons (SEPs) and extreme ultraviolet (EUV) wave properties between 2010 August and 2013 May observed by STEREO, SOHO and SDO. We determined the onset times, peak times and peak fluxes of the SEPs in SOHO ERNE and STEREO LET proton channel (6 – 10 MeV). Full Sun heliographic images created by combining STB 195Å, SDO 193Å, and STA 195Å were used for the analysis of the EUV waves. EUV wave arrival times at the spacecraft connecting points and their speed on the low corona were determined by space-time plots. It is noted that there is a significant correlation between the EUV wave arrival times and SEP onset times (r=0.73) but no SEP peak times. SEP peak fluxes increase with EUV wave speed (r=0.69) and the power law spectral index become harder with the EUV wave speed. This suggests that energetic protons are strongly associated with EUV waves, which is considered as the signature of CME shock in the low corona.

Author(s): ***Jinhye Park (Kyung Hee University)***, Davina Innes (Max Planck Institute), Radoslav Bucik (Max Planck Institute), Yong-Jae Moon (Kyung Hee University), Stephen Kahler (Air Force Research Laboratory)

123.20 – IRIS Observations of the Solar Atmospheric Response to Flares

The Interface Region Imaging Spectrograph (IRIS) is a NASA Small EXplorer mission to observe the sun. It observes high resolution images and spectra in the chromospheric C II and Mg II lines, the transition region Si IV and O IV lines, and the coronal XXI line. Since its launch on June 27 2013, IRIS has observed several solar flares. The high spatial resolution of IRIS, and its range of spectral lines allow a detailed analysis of the flare energy deposition and flare dynamics in the lower solar atmosphere, especially in conjunction with complementary observations from SDO, Hinode, and RHESSI. We present initial IRIS observations of the solar flare response in a broader observational context and discuss how IRIS can provide new insight into the flare process.

Author(s): ***Jean-Pierre Wuelser (Lockheed Martin ATC)***

Contributing teams: The IRIS team

123.21 – Chromospheric Magnetic Fields in the X1.2 Flare of January 7, 2014

Measurements of magnetic fields in chromospheric flares are scarce and many basic magnetic properties of flares are uncertain. A four-ribbon X1.2 flare occurred near disk center on January 7, 2014. It was observed at the time of peak soft X-ray emission with the NSO SOLIS vector spectromagnetograph using the 854.2 nm line of Ca II. A full vector modulator for this wavelength is under construction, but for this observation only intensity (I) and circularly polarized (V) spectral line profiles were obtained. Given the large variations of physical properties along sight lines through the chromosphere, especially in a flare, it is difficult to measure the magnetic field. We apply three simple techniques to estimate chromospheric and photospheric average flux densities. One method uses the wavelength difference between selected portions of the I±V line profiles. A second method integrates |V/I| over portions of the line profile. A third method uses the simple weak-field approximation, V ? dI/d?, but with modifications to the observed I profile to better match the V profile. As is well known in flares, there are asymmetry and line width variations in the emission and absorption line profiles indicating complicated mass motions along lines of sight. A tentative conclusion is that in most areas of the flare the average magnetic flux density along the line of sight is very similar to the underlying photosphere but usually weaker. Obtaining more robust measurements and conclusions requires exploration by forward modeling of the observations with realistic model atmospheres. Useful inversions may someday be possible if the atmosphere model parameters to be fit can be restricted enough to match the information content of the observed spectra.

Author(s): ***J. Harvey (National Solar Obs.)***

Contributing teams: SOLIS Team

123.22 – The Formation of Accelerated Electron Distributions in Solar Flares

Driven by RHESSI observations of dense compact coronal hard X-ray sources in solar flares, we study electron acceleration in such regions. We consider the acceleration of electrons by a stochastic process that is characterized by a diffusion coefficient D_turb ~ 1/v in a collisional medium of finite length. If electron escape can be neglected, the electron distribution function is determined by a balance between stochastic acceleration and collisional friction. Such a scenario admits a stationary solution for the electron distribution function that takes the form of a kappa-distribution. We show how the growth toward this stationary distribution can be described as a "wave"' propagating forwards in velocity space, so that electrons of higher energy E are accelerated later than lower-energy ones; quantitatively, the acceleration time ? scales with E according to ? ~ E^{3/2}. Since such an approach towards a stationary kappa distribution becomes progressively slower at high energies, escape from the acceleration region (of finite length L) will, at sufficiently high energies, eventually dominate over collisions, and a different stationary solution, corresponding to a balance between diffusive acceleration and particle escape, is applicable in this energy range. Using a numerical treatment, we derive the time evolution toward the stationary solution for a range of parameters appropriate to the solar flare situation.

Author(s): ***A. Emslie (Western Kentucky University)***, Nicolas Bian (University of Glasgow), Eduard Kontar (University of Glasgow)

123.23 – Element Abundances in High-temperature Solar Flare Plasma from MESSENGER SAX Observations

X-ray spectral measurements of many solar flares made with the MESSENGER SAX instrument have been used to determine the abundances of Fe, Ca, Ar, S, and Si in the high temperature plasma. All available data from launch in 2004 to date have been used to obtain spectral fits to the SAX data from 2.3 to 8.5 keV for all time intervals with a detectable count rate in the Fe-line complex at 6.7 keV. For each time interval, OSPEX, our object-oriented IDL spectral analysis program, is used to obtain values of the emission measure, temperature distribution, and abundances that give the best-fit of the corresponding CHIANTI photon spectrum folded through the instrument response matrix to the measured count-rate spectrum above background. Distributions will be presented of element abundances for each flare and for all flares detected during each year of observations. Variations in measured abundances will be discussed as to whether they reflect real differences from the mean or differences due to statistical and/or systematic uncertainties. Comparisons will be made with abundance measurements made from other data sets, in particular by Phillips and Dennis (2012) using data from the Ramaty High Energy Solar Spectroscopic Imager (RHESSI), and by Warren et al. (2013) using data from the EUV Variability Experiment (EVE) on the Solar Dynamics Observatory (SDO). Phillips, K. J. H. and Dennis, B. R., “The Solar Flare Iron Abundance,” 2012, ApJ, 748, 52. Warren, H. “Measurements of Absolute Abundances in Solar Flares,” 2013, arXiv, 2013arXiv1310.4765W

Author(s): ***Brian Dennis (NASA's GSFC)***, Larry Nittler (Carnegie Institution of Washington), Kenneth Phillips (Natural History Museum), Richard Schwartz (The Catholic University of America), Richard Starr (NASA's GSFC), Anne Tolbert (The Catholic University of America)

123.24 – Modeling the response of the lower atmosphere to flare reconnection

It has long been recognized that energy release in a solar flare gives rise to ablation of material from the chromosphere (more commonly called evaporation). The prevailing view is that energy is initially transformed from stored magnetic energy by the process of magnetic reconnection. In some models reconnection accelerates electrons, either directly or indirectly, and these non-thermal electrons carry energy to the chromospheric footpoints. In others the reconnection converts magnetic energy into heat in the corona and thermal conduction carries that heat to the chromosphere. While no comprehensive, self-consistent model yet exists for the conversion of magnetic energy to non-thermal electron energy, models of the conversion to heat, via slow magnetosonic shocks, have been available since Petschek's 1964 paper. We present a numerical model encompassing the conversion of magnetic energy to shocks, to heat, and then to conduction-driven evaporation. We compare its results to those of more traditional conduction-driven models where reconnection is replaced by an ad hoc plasma heating. We consider, in particular, observable signatures such as doppler shifts and formation of flare ribbons. This work was supported by the NASA SR&T program.

Author(s): ***Dana Longcope (Montana State Univ.)***, Jiong Qiu (Montana State Univ.), James Klimchuk (NASA GSFC, Code 671)

123.25 – Long Duration Flare Emission by Sequential Reconnection and Heating

Long duration flare emissions lasting for a few hours are likely produced by magnetic reconnection that continuously forms flare loops and heats plasma inside. In this study, we demonstrate that this process leads to the long duration emission in a C2.9 flare on 2011 September 13. Observed by AIA, the flare exhibits an organized pattern of evolution with UV brightenings in flare ribbons spreading along the polarity inversion line, followed by sequential formation of post-flare loops seen in EUV emissions. The spatially resolved observation of flare ribbons can be used to infer heating rates in sequentially formed and heated flare loops, with which we synthesize flare emission in these loops with hydrodynamic models. The 0d EBTEL model (Klimchuk et al. 2008) efficiently computes mean properties of thousands of flare loops identified from flare ribbon signatures, and the synthetic tempo-spatial evolution of the total emission is in reasonable agreement with EUV observations. The 1d model applied on a few selected loops reveals physics of the heating mechanism and along-the-loop dynamics, particularly during the impulsive heating phase. During the four hours of this event, the estimated total energy in the heating amounts to 2e30 erg, with the total reconnection flux about 1e21 Mx.

Author(s): ***Jiong Qiu (Montana State University)***, Dana Longcope (Montana State University), James Klimchuk (NASA Goddard Space Flight Center)

123.26 – Formation and Properties of Magnetic Island Plasmoids in Large-Scale Current Sheets During CME Eruptions

We present the continued analysis of the high-resolution 2.5D MHD simulations of sympathetic magnetic breakout eruptions from a pseudostreamer source region. We examine the generation of X- and O-type null points during the current sheet tearing and their evolution as reconnection progresses. There are three large-scale current sheets that we investigate in detail over the course of the simulation. We examine the properties of reconnection occurring within these current sheets including evolution of the current sheet lengths, Lundquist number, and reconnection rates. We also quantify the statistical and spectral properties of the fluctuations in the current sheets resulting from the resistive tearing and magnetic island plasmoid formation including the distribution of magnetic island width, flux content, and mass. We show that the temporal evolution of the spectral index of the magnetic energy density in our current sheets appears to reflect the transition from the linear to non-linear phase of the instability. Our results are in excellent agreement with recent dedicated reconnection simulations even though our current sheets’ formation, growth, and dynamics are both dictated by and in turn, govern the global evolution of sequential, sympathetic CME eruptions.

Author(s): ***Benjamin Lynch (Univ. of California-Berkeley)***, Justin Edmondson (Univ. of Michigan)

123.27 – White-Light Observations of Major Flares Compared to Total Solar Irradiance and Short-Wavelength Observations

The NSO’s GONG network produces “white light” (WL) continuum intensity images from one-minute integrations averaged across a 0.7~\AA\ wide band pass centered at 6768~\AA\ at one minute cadence using six sites worldwide. Clear WL signatures of solar flares are present in GONG intensity data for only the largest flares because of low spatial resolution (2.5 arcsec pixel size). For six major flares (GOES class X6.5 - X28) observed by GONG, we compare integrated GONG full-disk WL intensity curves with SORCE/TIM total solar irradiance (TSI) measurements. Distinctive p-mode signatures are evident in both GONG and SORCE time series, though the correlation between GONG and SORCE data varies from flare to flare. In some cases a clear TSI peak and an interruption of the GONG p-mode pattern accompany the flare. The flare signature is generally weaker in the GONG data, suggesting that most of the TIM flare signal arises from wavelengths shorter than the GONG band pass. The flare kernels nevertheless are clear and last many minutes in the spatially resolved GONG image time series. We also compare the GONG active region intensity observations with shorter-wavelength data. In one case observed by TRACE, the GONG and TRACE WL curves are very similar and the TRACE 1600~\AA\ curve shows a significant precursor and a long tail. In most cases the GONG WL and RHESSI 25-100 keV counts appear well correlated in time. This work utilizes GONG data obtained by the NSO Integrated Synoptic Program (NISP), managed by the National Solar Observatory, which is operated by AURA, Inc. under a cooperative agreement with the National Science Foundation.

Author(s): ***Gordon Petrie (NSO)***, Greg Kopp (University of Colorado), J. Harvey (NSO)

123.28 – Relating photospheric magnetic field changes and hard X-ray emission during flares

We study the correlation between abrupt permanent changes of magnetic field during strong flares observed by GONG and HMI instruments, and the location of hard X-ray (HXR) emission observed by RHESSI to relate the field changes to the reconnection processes in the corona and investigate the origin of the field changes. The chromospheric HXR emission in solar flares is generally regarded as the footprints of magnetic field lines newly reconnected in the corona. Also, the footpoint motions traveling away from the neutral lines are considered to be indicative of the reconnection occurring in arcade magnetic fields of increasing heights. Our analysis of six flares shows that the early HXR emission corresponds well to locations of the strong field changes. The later HXR emission does not correspond to significant field changes as the footpoint is moving away from the neutral line in later stages of the flare. The field changes and HXR emission are spatio-temporally related, but not simultaneous. The field changes start earlier and end later than the detectable HXR signal. The strongest X-class flares in our analysis show a well-defined peak in the field changes a few minutes earlier than the peak in the HXR emission. The timing relationship between the HXR and the largest photospheric field changes may indicate an indirect physical relationship between these phenomena. Tracing of the field changes at the footpoints' locations shows that in most of the flares the field changes propagated at a speed similar to that of the HXR footpoint moving away from the neutral line. However most of the field changes occurred earlier in time. O.B., G.P. and A.P. are partially supported by NASA grant NNX14AE05G.

Author(s): ***Gordon Petrie (NSO)***, Olga Burtseva (NSO), Juan Carlos Martinez Oliveros (UC Berkeley), Alexei Pevtsov (NSO)

123.29 – Investigating a Complex X-class Solar Flare Using Magnetic Field Modeling

We will present the investigation of a complex X-class flare occurred in NOAA Active Region 11283 on 2011 September 6. This flare is associated with two filament eruptions and a coronal mass ejection (CME) with speed of 575 km/s. AR11283 contains mainly two bipoles, a large decaying bipole and a small "L" shape emerging bipole with sunspots. The main eruption initiated and occurred in the small bipolar region. Multiple flare ribbons are observed during the eruption. We studied the structure and dynamics of the erupting filaments and flare ribbons observed by SDO/AIA and Hinode/XRT as well as the dynamics of the photospheric magnetic fields observed by SDO/HMI. We also constructed magnetic field models using the flux rope insertion method, in order to understand how the eruption is triggered and how the flare ribbons are formed during the eruption.

Author(s): ***Yingna Su (Harvard-Smithsonian Center for Astrophysics)***, Blake Forland (Harvard-Smithsonian Center for Astrophysics), Adriaan Van Ballegooijen (Harvard-Smithsonian Center for Astrophysics), Li Feng (Purple Mountain Observatory, CAS), Haisheng Ji (Purple Mountain Observatory, CAS)

123.30 – Distinguishing Between Supra-Arcade Downflows and Plasmoids

Supra-arcade downflows (SADs) observed above flaring active regions during long-duration events are theorized to be signatures of magnetic reconnection. Observations of SADs strongly indicate an association with shrinking reconnected flux tubes characterized by a specific magnetic topology. Plasmoids comprise another proposed group of obserational reconnection signatures. While some plasmoids occur under nearly the same conditions as SADs, the magnetic configuration of the two phenomena are quite incongruous, yet they are often categorized together. We present distinguishing characteristics between SADs and plasmoids and indicate how their respective observations may yield insight into the conditions within the current sheet above eruptive active regions.

Author(s): ***Sabrina Savage (NASA/MSFC)***

123.31 – Chromospheric and Coronal HMI Flare Sources

We present observations of white-light features in the low corona, for three flares SOL20110308T1935, SOL20110308T0230 and SOL2013-05-13T16:01, using data from the Helioseismic and Magnetic Imager (HMI) of the Solar Dynamics Observatory. At least two distinct kinds of sources appear (chromospheric and coronal) in the early and later phases of flare development, in addition to the white-light footpoint sources commonly observed in the lower atmosphere. The gradual emissions have a clear identification with the classical loop-prominence system, with emission contributions from electron scattering and from the free-free continuum (as seen in soft X-rays). These sources may also contain other continuum and/or line emissions and lead clearly to coronal rain in some cases observed

Author(s): ***Juan Carlos Martinez Oliveros (University of California Berkeley)***, Pascal Saint-Hilaire (University of California Berkeley), Sebastien Couvidat (Stanford University), Hugh Hudson (University of Glasgow), Sam Krucker (University of Applied Sciences North Western Switzerland)

123.32 – Observation of 2011-02-15 X2.2 solar flare in Hard X-ray and microwave

Previous studies have shown that the energy release mechanism of some solar flares follow the Standard magnetic-reconnection model, but the detailed properties of high-energy electrons produced in the flare are still not well understood. We conducted a unique, multi-wavelength study that discloses the spatial, temporal and energy distributions of the accelerated electrons in the X2.2 solar flare on Feb. 15, 2011. We studied the source locations of the observed seven temporal peaks in hard X-ray (HXR) and microwave (MW) lightcurves using the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) in 50-75 keV channels and Nobeyama Radioheliograph (NoRH) in 34 GHz, respectively. We confirmed that peak emissions were coming from two spatially distinct sites in HXR and MW, and in HXR we observed a sudden change between these sites over the second and the third peak. Comparison between the HXR lightcurve and the temporal variations in MW source kernel intensity also confirmed that seven peak emissions were actually coming from two sources, each with their own multiple peaks.

Author(s): ***Natsuha Kuroda (New Jersey Institute of Technology)***, Haimin Wang (New Jersey Institute of Technology), Dale Gary (New Jersey Institute of Technology)

123.33 – Can return-current losses explain a strong break in RHESSI spectra?

We fit the RHESSI (Ramaty High Energy Solar Spectoscopic Imager) spectra from two flares with the 1D return-current model in OSPEX, as well as with models containing a broken power law and/or a sharp, low-energy cutoff. Based on previous studies, we know that the flattening of these flares' spectra is unlikely to be due to albedo or non-uniform ionization. Both flares show compact RHESSI sources, which makes imaging spectroscopy difficult or impossible. We verify whether the time evolution of the fitted parameters is consistent with the return-current model. We look for signatures specific to return currents, such as the "bump" on higher energy non-thermal light curves. We also show whether the RHESSI spectra are consistent with a 1D numerical model based on solving the energy loss and the continuity equations for return current and Coulomb collisions in a partially ionized atmosphere. This model is more comprehensive than the model currently in OSPEX which takes into account the effect of return currents in a fully ionized solar atmosphere.

Author(s): ***Meriem Alaoui (GSFC/NASA)***, Gordon Holman (GSFC/NASA)

123.34 – Case Study of a Magnetic Transient in NOAA 11429 Observed by SDO/HMI During the M7.9 Flare on 13 March 2012

NOAA 11429 was the source of an M7.9 X-ray flare at the western solar limb (N18° W63°) on 2012 March 13 at 17:12 UT. Observations of the line-of-sight magnetic flux and the Stokes I and V profiles from which it is derived were carried out by the Solar Dynamics Observatory Helioseismic and Magnetic Imager (SDO/HMI) with a 45 s cadence over the full disk, at a spatial sampling of 0.''5. During flare onset, a transient patch of negative flux can be observed in SDO/HMI magnetograms to rapidly appear within the positive polarity penumbra of NOAA 11429. We present here a detailed study of this magnetic transient and offer interpretations as to whether this highly debated phenomenon represents a "real" change in the structure of the magnetic field at the site of the flare, or is instead a product of instrumental/algorithmic artifacts related to particular SDO/HMI data reduction techniques.

Author(s): ***Brian Harker (National Solar Observatory)***, Alexei Pevtsov (National Solar Observatory)

123.35 – Study of super-hot plasma in the solar flare of August 9, 2011: Neupert effect, acceleration of electrons and energy balance.

We investigated plasma heating during the impulsive phase of GOES X6.9 flare occurred in August 9, 2011. This event is characterized by large flux of soft X-ray radiation in the GOES short-wavelength channel that indicates high temperature of emitting plasma estimated as T~33 MK. The main goal of the work is to study plasma heating and to determine role of nonthermal electrons in the energy release for the selected event. We analyze observational data of the RHESSI, GOES and SDO spacecrafts and discuss spatial structure of the flare region and Neupert effect for plasmas of different temperatures. Fitting of soft X-ray spectra measured by RHESSI is made in the frame of two-temperature approach: emission of hot (T~20 MK) and super-hot (T~45 MK) plasmas. Fitting of hard X-ray spectra is made with a power-law function. To interpret the data we use model of the flare region consisting of two separate zones with hot and super-hot temperatures, with super-hot region being located in the highest coronal part of the flare loops where electron acceleration most probably took place. In the frame of the applied model the estimated changes of internal plasma energy and radiation heat losses are comparable with kinetic power of nonthermal electrons, assuming additional heat flux from the super-hot region of the flare loops.

Author(s): ***Ivan Sharykin (New Jersey Institute of Technology)***, Alexei Struminsky (Moscow Institute of Physics and Technology), Ivan Zimovets (Space Research Institute of RAS)

123.37 – The Compatibility of Flare Temperatures Observed with AIA, GOES, and RHESSI

In this talk we compare multi-thermal flare DEM peak temperatures determined with SDO/AIA with those determined by GOES/XRS and RHESSI using the isothermal assumption. In a set of 149 M- and X-class flares, AIA finds an average DEM peak temperature at the time of the GOES long channel peak of 12.0±2.9 MK and Gaussian DEM widths of log10(?T) = 0.50±0.13. From GOES observations of the same 149 events, a mean temperature of 15.6±2.4 MK is inferred, which is higher by a factor of TGOES/TAIA = 1.4±0.4. We demonstrate that this discrepancy results from the isothermal assumption in the inversion of the GOES filter ratio. From isothermal fits to photon spectra at energies of 6–12 keV of 61 of these events, RHESSI finds the temperature to be higher (TRHESSI/TAIA = 1.9±1.0). We find that this is partly a consequence of the isothermal assumption. However, RHESSI is not sensitive to the low-temperature range of the DEM peak, and thus only samples the DEM's high-temperature tail. This is expected to be the cause of further discrepancies. We conclude that self-consistent flare DEM temperatures require simultaneous fitting of EUV and SXR fluxes.

Author(s): ***Daniel Ryan (NASA Goddard Space Flight Center)***, Markus Aschwanden (Lockheed Martin Advanced Technology Cente), Aidan O'Flannagain (Trinity College Dublin), Peter Gallagher (Trinity College Dublin)

Contributing teams: Catholic University of America

123.38 – Energetic analysis of the white light emission associated to seismically active flares in solar cycle 24

Solar flares are explosive phenomena, thought to be driven by magnetic free energy accumulated in the solar corona. Some flares release seismic transients, "sunquakes", into the Sun's interior. Different mechanisms are being considered to explain how sunquakes are generated. We are conducting an analysis of white-light emission associated with those seismically active solar flares that have been reported by different authors within the current solar cycle. Seismic diagnostics are based upon standard time-distance techniques, including seismic holography, applied to Dopplergrams obtained by SDO/HMI and GONG. The relation between white-light emissions and seismic activity may provide important information on impulsive chromospheric heating during flares, a prospective contributor to seismic transient emission, at least in some instances. We develop a method to get an estimation of Energy associated whit white-light emission and compare those results whit values of energy needed to generate a sunquake according with holographic helioseismology techniques.

Author(s): ***Juan Camilo Buitrago-Casas (Space Sciences Lab - UC Berkeley)***, Juan Carlos Martinez Oliveros (Space Sciences Lab - UC Berkeley), Lindsay Glesener (Space Sciences Lab - UC Berkeley), Sam Krucker (Space Sciences Lab - UC Berkeley)

123.39 – F-CHROMA. Flare Chromospheres: Observations, Models and Archives

F-CHROMA is a collaborative project newly funded under the EU-Framework Programme 7 "FP7-SPACE-2013-1", involving seven different European research Institutes and Universities. The goal of F-CHROMA is to substantially advance our understanding of the physics of energy dissipation and radiation in the flaring solar atmosphere, with a particular focus on the flares' chromosphere. A major outcome of the F-CHROMA project will be the creation of an archive of chromospheric flare observations and models to be made available to the community for further research. In this poster we describe the structure and milestones of the project, the different activities planned, as well as early results. Emphasis will be given to the dissemination efforts of the project to make results of these activities available to and usable by the community.

Author(s): ***Gianna Cauzzi (INAF)***, Lyndsay Fletcher (University of Glasgow), Mihalis Mathioudakis (Queen's University Belfast), Mats Carlsson (University of Oslo), Petr Heinzel (Academy of Sciences of the Czech Republic), Arek Berlicki (University of Wroclaw), Francesca Zuccarello (University of Catania)

123.40 – Coronal Type II Radio Bursts Associated with Helmet Streamers and Electron Acceleration in a Streamer-Shock System

Two solar type II radio bursts, separated by about 24 hours in time, are examined together. We find several common observational features of the two events. Firstly, both events are associated with coronal mass ejections (CMEs) erupting from the same active region (NOAA 11176) beneath a well-observed helmet streamer. Secondly, the radio-emitting heights obtained by fitting the type II dynamic spectra are in agreement with those measured from the CME fronts. Thirdly, the type II emissions ended once the CME/shock fronts passed the white-light streamer tip, which is presumably the magnetic cusp of the streamer. These observations lead us to propose that the closed magnetic arcades of the streamer play an important role in electron acceleration and type II excitation at coronal shocks. To examine such a scenario, we conduct a test-particle simulation for electron dynamics within a large-scale partially-closed streamer magnetic configuration swept by a coronal shock. We find that electrons can be trapped within the magnetic arcades and gain energy multiple times at the shock. Low energy electrons with an initial energy of 300 eV can be accelerated to tens of keV, energetic enough to excite Langmuir waves and radio bursts. The results suggest that the scenario may be important to the generation of metric type IIs considering the fact that most solar eruptions originate from closed field regions. This scenario also provides an explanation to the long-standing issue of the disconnection between metric and interplanetary type II bursts.

Author(s): ***Xiangliang Kong (Shandong University, Weihai)***, Yao Chen (Shandong University, Weihai), Fan Guo (Los Alamos National Laboratory), Gang Li (University of Alabama in Huntsville)

123.41 – Towards Characterizing Early-stage SEP Fluxes with High-Cadence EUV Coronal Shock Observations

Recent advances in space-based solar observing have enabled unprecedented access to high-cadence, high-resolution observations of the coronal dynamics. This is extremely important, since transient phenomena in the corona usually cover multiple scales - from the current spatial resolution limit in the case of reconnection, to several solar radii in the case of coronal waves and mass ejections. The latter are also thought to drive shocks in the corona, which in turn have been shown capable of accelerating protons, electrons, and other species up to GeV energies in a matter of tens of minutes. These solar energetic particles (SEPs) are a prime source of space weather. Historically, it has been notoriously difficult to extract information about energetic particle spectra in the corona, due to the lack of in situ measurements. It is possible, however, to use remote observations in order to deduce coronal shock dynamics and related particle spectra, with some reasonable assumptions. We present an effort towards building a framework for estimating coronal SEP spectra in the early stages of real CME events, based on a combination of fast-cadence extreme ultraviolet imaging (from the SDO/AIA instrument), potential coronal magnetic field models, and differential emission measure models. The ultimate goal for this framework is to give predictions for early-stage SEP spectra for various source populations and coronal turbulence levels. It is designed in a modular fashion, and may be adapted for near real time use. This system can be applied for early warning and predicting the severity of the impulsive early stages of SEP events.

Author(s): ***Kamen Kozarev (Harvard-Smithsonian, CfA)***, John Raymond (Harvard-Smithsonian, CfA), Michael Hammer (Cornell University)

123.42 – Forecast of daily solar flare peak flux using regressive and neural network methods

We have developed a set of daily solar flare peak flux forecast models using the multiple linear regression, auto regression, and artificial neural network methods. We consider input parameters as solar activity data from January 1996 to December 2013 such as sunspot area, X-ray flare peak flux, weighted total flux Tf=1*Fc+10*Fm+100*Fx of previous day, mean flare rates of a given McIntosh sunspot group (Zpc), and a Mount Wilson magnetic classification. The hitting rate is defined as the fraction of events whose absolute differences between the observed and predicted fluxes in a logarithm scale are ? 0.5. The best three input parameters related to the observed flare peak flux are weighted total flare flux of previous day, Mount Wilson magnetic classification, and sunspot area. The hitting rates of flares stronger than M5 class, which is regarded to be significant for space weather forecast, are as follows: 0% for the multiple linear regression method, 30% for the auto regression method, and 69% for the neural network method. Especially, we note that for the forecast of strong flares, the neural network method is much more effective than the other methods.

Author(s): ***Seulki Shin (KyungHee University)***, Jin-Yi Lee (KyungHee University), Yong-Jae Moon (KyungHee University)

123.43 – Rates of Large Flares in Old Solar-like Stars in Kepler Clusters NGC 6811 and 6819 With Implications for the Sun

We hope to better estimate the rate of very strong (Carrington event-type) flares in the Sun by studying flares of stars in several open clusters with well determined ages using Kepler data. Here we derive white light flare distributions for a sample of near-solar-mass (G0-G5) dwarfs in NGC 6811 (age ~ 1 Gyr) and NGC 6819 (~ 2.5 Gyr). We compare these with solar white light flare rates and, by estimating X-ray emission from the same flares using a solar-based relationship, we compare the Kepler results to other solar and stellar X-ray flare data. We explore implications of our results for the rates of large solar flares. This research was supported by Kepler grant NNX13AC29G.

Author(s): ***Steven Saar (Harvard-Smithsonian, CfA)***, Paul Wright (University of Southhampton), Soren Meibom (Harvard-Smithsonian, CfA), Vinay Kashyap (Harvard-Smithsonian, CfA), Jeremy Drake (Harvard-Smithsonian, CfA)

123.44 – H2 Emission in the Sun and Stars: A New Window on Spots and Flares

Molecular H2 is likely important for the formation of sun and starspots, but has been difficult to observe in the past. H2 emission has been seen in solar FUV spectra of sunspots and flares, where it produced by fluorescent excitation driven (primarily) by Si IV and O IV. New observations with IRIS show that the emission is strong in flares, and in loops connected to pores or the boundaries of umbrae. We find evidence for H2 emission in the HST spectra of several magnetically active, flaring, spotted stars. Once the excitation process is better understood, observations of H2 emission should permit new insight into spot formation on the Sun and active stars.

Author(s): ***Steven Saar (Harvard-Smithsonian, CfA)***, Sarah Jaeggli (Montana State Univ.)

123.45 – Transient Small-Scale Magnetic Flux Emergence and Atmospheric Response Observed with New Solar Telescope and SDO

State-of-the art solar instrumentation is now revealing the activity of the Sun at the highest temporal and spatial resolution. Granular-scale magnetic flux emergence and the response of the solar atmosphere is one of the key topics. Observations with the 1.6m aperture New Solar Telescope (NST) at Big Bear Solar Observatory (BBSO) are making next steps in our understanding of the solar surface structure. On August 7, 2013, NST observed active region NOAA 11810 in different photospheric and chromospheric wavelengths. The region displays a group of solar pores, in the vicinity of which we detected a site of emerging magnetic flux accompanied by intense and very confined abnormal granulation dynamics, observed in the photospheric TiO 7057 A with a resolution of 0.034 “/pix. Following the expansion of exploding granules in this site, we observed a sudden appearance of an extended surge in the HeI 10830A data (bandpass of 0.05 A). The SDO/HMI data used to study the evolution of the magnetic field and Doppler velocities reveal a short-lived emerging loop-like structure with strong upflows. We used the SDO/AIA data to investigate the response of the transition region and corona to the transient emerging flux phenomenon. We compare the results with previous observations, and propose a scenario for the production of plasma surges by the transient magnetic flux emergence events.

Author(s): ***Santiago Vargas Domínguez (Big Bear Solar Observatory)***, Alexander Kosovichev (Stanford University)

123.46 – On Hemispheric Rule of Magnetic Helicity in Solar Active Regions

The sign of magnetic helicity in solar active regions has been found to have a hemispheric preference: negative in the northern hemisphere and positive in the southern. The strength of this preference reported in previous studies was in a range of 58% -- 82%. These studies were based on examining proxies of magnetic helicity, such as magnetic twist or current helicity density in the photosphere. Recently Liu et al. (2014) found that the strength of the hemisphere rule, tested by examining magnetic twist using HMI vector magnetic field data, differs substantially between the groups of active regions with the same sign of magnetic twist and writhe (56%) and with the opposite signs (93%). They further speculated that origin of magnetic twist, dynamo process versus emergence process, causes this difference. In this presentation, we directly calculate magnetic helicity in active regions, and examine it with the hemisphere rule. This test helps evaluate property of magnetic helicity generated by the dynamo process, and help understand intrinsic difference between those two groups of active regions.

Author(s): ***Yang Liu (Stanford Univ.)***

123.47 – RADMHD2S: A Global 3D Radiative-MHD Model of the Upper Convection Zone-to-Corona System

We present the latest results from a new, global radiative-MHD model of the upper convection zone-to-corona system, RADMHD2S. The numerical methods build upon those of the RADMHD model of Abbett (2007) and Abbett & Fisher (2012), and significantly extend the capabilities of that code to allow for large-scale, sufficiently resolved, global calculations over a non-uniform, 3D curvilinear (spherical) mesh. RADMHD2S utilizes a high-order, non-dimensionally split, semi-implicit finite volume formalism to update the system of conservation equations in a way that properly propagates discontinuities in off-axis directions, while simultaneously preserving the 3D solenoidal constraint on the magnetic field. In addition, we will discuss improvements in the treatment of energetics, radiative transport, and cross-field diffusion that allow for more realistic data-driven modeling of the model's photosphere and chromosphere.

Author(s): ***William Abbett (University of California, Berkeley)***, David Bercik (University of California, Berkeley)

123.48 – Active Region Lorentz Force: A CGEM Data Product Based on HMI Vector Magnetic Field

We describe a new data product from the CGEM (Coronal Global Evolution Model) collaboration that estimates the Lorentz force in active regions (ARs) based on HMI vector magnetogram patches. Following Fisher et al. (2012), we compute three components of the integrated Lorentz force over the outer solar atmosphere every 12 minutes throughout an AR's disk passage. These estimates, differenced during solar eruptive events, can provide valuable diagnostics on dynamic processes. We perform a preliminary survey on the major events with HMI's four-year data archive. We explore and characterize some of the systematic uncertainties associated with these estimates.

Author(s): ***Xudong Sun (Stanford University)***

Contributing teams: the CGEM Team

123.49 – Relationship between the photospheric Poynting flux and the active region luminosity

How does energy radiated by active regions compare with magnetic energy that propagates lower across the photosphere? This is a fundamental question for energy storage and release in active regions, yet it is presently poorly understood. In this work we quantify and compare both energy terms using SDO observations of the active region (AR) 11520. To quantify the magnetic energy crossing the photosphere, or the Poynting flux, we need to know both the magnetic field vector B and electric field vector E as well. Our current electric field inversion technique, PDFI, combines the Poloidal-Toroidal-Decomposition method with information from Doppler measurements, Fourier local correlation tracking (FLCT) results, and the ideal MHD constraint, to determine the electric field from vector magnetic field and Doppler data. We apply the PDFI method to a sequence of Helioseismic and Magnetic Imager (HMI/SDO) vector magnetogram data, to find the electric-field and hence the Poynting-flux evolution in AR 11520. We find that most of the magnetic energy in this AR is injected in the range of 10^7 to 10^8 $ergs/{cm^2 s}$, with the largest fluxes reaching 10^{10} $ergs/{cm^2 s}$. Integrating over the active region this yields a total energy of order 10^{28} ergs/s. To quantify the active region luminosity, we use EUV Variability Experiment (EVE) and Atmospheric Imaging Assembly (AIA) spectrally resolved observations. We find the active region luminosity of order 10^{28} ergs/s. We compare derived magnetic and radiated energy fluxes on different temporal and spatial scales and estimate their uncertainties. We also discuss the roles that potential/non-potential and emerging/shearing terms play in the total magnetic energy budget.

Author(s): ***Maria Kazachenko (UC Berkeley)***, Richard Canfield (Montana State University), George Fisher (UC Berkeley), Hugh Hudson (UC Berkeley), Brian Welsch (UC Berkeley)

123.50 – Gravity waves in magnetized solar atmospheres from MHD simulations.

The solar atmosphere is believed to be a region where gravity waves are generated and propagate, but a variety of effects makes observations of them rather difficult. Measurements of gravity wave properties could, however, show how they play an important role in the upper photosphere and chromosphere and even deposit energy there. Here we show how analysis of gravity waves from detailed numerical simulations can be used to study magnetic fields and energy deposition in the atmosphere, and how mode conversion to slow magneto-acoustic waves changes their observable properties.

Author(s): ***Jason Jackiewicz (New Mexico State University)***, Vigeesh Gangadharan (New Mexico State University)

123.51 – Understanding Measurements Returned by the Helioseismic and Magnetic Imager

The Helioseismic and Magnetic Imager (HMI) aboard the Solar Dynamics Observatory (SDO) observes the Sun at the FeI 6173 Å line and returns full disk maps of line-of-sight observables including the magnetic field flux, FeI line width, line depth, and continuum intensity. To properly interpret such data it is important to understand any issues with the HMI and the pipeline that produces these observables. At this aim, HMI data were analyzed at both daily intervals for a span of 3 years at disk center in the quiet Sun and hourly intervals for a span of 200 hours around an active region. Systematic effects attributed to issues with instrument adjustments and re-calibrations, variations in the transmission filters and the orbital velocities of the SDO were found while the actual physical evolutions of such observables were difficult to determine. Velocities and magnetic flux measurements are less affected, as the aforementioned effects are partially compensated for by the HMI algorithm; the other observables are instead affected by larger uncertainties. In order to model these uncertainties, the HMI pipeline was tested with synthetic spectra generated through various 1D atmosphere models with radiative transfer code (the RH code). It was found that HMI estimates of line width, line depth, and continuum intensity are highly dependent on the shape of the line, and therefore highly dependent on the line-of-sight angle and the magnetic field associated to the model. The best estimates are found for Quiet regions at disk center, for which the relative differences between theoretical and HMI algorithm values are 6-8% for line width, 10-15% for line depth, and 0.1-0.2% for continuum intensity. In general, the relative difference between theoretical values and HMI estimates increases toward the limb and with the increase of the field; the HMI algorithm seems to fail in regions with fields larger than ~2000 G. This work is carried out through the National Solar Observatory Research Experiences for Undergraduate (REU) site program, which is co-funded by the Department of Defense in partnership with the NSF REU Program. The National Solar Observatory is operated by the Association of Universities for Research in Astronomy, Inc. (AURA) under cooperative agreement with the National Science Foundation.

Author(s): ***Daniel Cohen (National Solar Observatory - Sacramento Peak)***, Serena Criscuoli (National Solar Observatory - Sacramento Peak)

123.52 – Tracked Active Region Patches for MDI and HMI

We describe tracked active-region patch data products that have been developed for HMI (HMI Active Region Patches, or HARPs) and for MDI (MDI Tracked Active Region Patches, or MDI TARPs). Both data products consist of tracked magnetic features on the scale of solar active regions. The now-released HARP data product covers 2010-present (>2000 regions to date). Like the HARPs, the MDI TARP data set is a catalog of active regions (ARs), indexed by a region ID number, analogous to a NOAA AR number, and time. The TARPs contain 6170 regions spanning 72000 images taken over 1996-2010, and will be available in the MDI resident archive (RA). MDI TARPs are computed based on the 96-minute synoptic magnetograms and intensitygrams. As with the related HARP data product, the approximate threshold for significance is 100G. Use of both image types together allows faculae and sunspots to be separated out as sub-classes of activity, in addition to identifying the overall active region that they are in. After being identified in single images, the magnetically-active patches are grouped and tracked from image to image. Merges among growing active regions, as well as faint active regions hovering at the threshold of detection, are handled automatically. Regions are tracked from their inception until they decay within view, or transit off the visible disk. For each active region and for each time, a bitmap image is stored containing the precise outline of the active region. Also, metadata such as areas and integrated fluxes are stored for each AR and for each time. Because there is a cross-calibration between the HMI and MDI magnetograms (Liu et al. 2012), it is straightforward to use the same classification and tracking rules for the HMI HARPs and the MDI TARPs. We show results demonstrating region correspondence, region boundary agreement, and agreement of flux metadata using the approximately 140 regions in the May 2010-October 2010 time period. We envision several uses for these data products, including data subsetting and per-active-region studies such as the relation between AR structure and energetic events like flares. Also, the combined HARP/MDI-TARP catalog can enable extended studies, such as solar irradiance, across cycles 23 and 24, and allow analyses that had been confined to just a handful of ARs to be extended to a larger set.

Author(s): ***Michael Turmon (JPL/Caltech)***, J. Todd Hoeksema (Stanford Univ.), Monica Bobra (Stanford Univ.)

123.54 – A New Ground-Based Network for Synoptic Solar Observations: The Solar Physics Research Integrated Network Group (SPRING)

SPRING is a project to develop a geographically distributed network of instrumentation to obtain synoptic solar observations. Building on the demonstrated success of networks to provide nearly-continuous long-term data for helioseismology, SPRING will provide data for a wide range of solar research areas. Scientific objectives include internal solar dynamics and structure; wave transport in the solar atmosphere; the evolution of the magnetic field over the activity cycle; irradiance fluctuations; and space weather origins. Anticipated data products include simultaneous full-disk multi-wavelength Doppler and vector magnetic field images; filtergrams in H-Alpha, CaK, and white light; and PSPT-type irradiance support. The data will be obtained with a duty cycle of around 90% and at a cadence no slower than one minute. The current concept is a multi-instrument platform installed in at least six locations, and which will also provide context information for large-aperture solar telescopes such as EST and the DKIST. There is wide support for the idea within the EU and the US solar research communities. The project is in the early planning stages, and we are open to and looking for participants in the science and instrument definition.

Author(s): ***Frank Hill (National Solar Obs.)***, Markus Roth (Kiepenheuer-Institut für Sonnenphysik), Michael Thompson (NCAR), Sanjay Gusain (Kiepenheuer-Institut für Sonnenphysik)

123.55 – An Improved Periodogram Technique for 2-D PSF Equalization

The Multi-Order Extreme Ultraviolet Spectrograph (MOSES) forms images of the transition region at HE II 30.4 in three spectral orders. Subtle differences between these images encode line profile information. However, differences in instrument point-spread function (PSF) in the three orders lead to non-negligible systematic errors in the retrieval of the line profiles. We describe an improved periodogram technique for equalizing the PSFs, and provide numerical verification of the technique's validity.

Author(s): ***Shane Atwood (Montana State University)***, Charles Kankelborg (Montana State University)

123.56 – An Airborne Infrared Telescope and Spectrograph for Solar Eclipse Observations

The solar infrared spectrum offers great possibilities for direct spatially resolved measurements of the solar coronal magnetic fields, via imaging of the plasma that is constrained to follow the magnetic field direction and via spectro-polarimetry that permits measurement of the field strength in the corona. Energy stored in coronal magnetic fields is released in flares and coronal mass ejections (CME) and provides the ultimate source of energy for space weather. The large scale structure of the coronal field, and the opening up of the field in a transition zone between the closed and open corona determines the speed and structure of the solar wind, providing the background environment through which CMEs propagate. At present our only direct measurements of the solar magnetic fields are in the photosphere and chromosphere. The ability to determine where and why the corona transitions from closed to open, combined with measurements of the field strength via infrared coronal spectro-polarimetry will give us a powerful new tool in our quest to develop the next generation of forecasting models. We describe a first step in achieving this goal: a proposal for a new IR telescope, image stabilization system, and spectrometer, for the NCAR HIPER GV aircraft. The telescope/spectrograph will operate in the 2-6micron wavelength region, during solar eclipses, starting with the trans-north American eclipse in August 2017. The HIAPER aircraft flying at ~35,000 ft will provide an excellent platform for IR observations. Our imaging and spectroscopy experiment will show the distribution and intensity of IR forbidden lines in the solar corona.

Author(s): ***Edward DeLuca (Harvard-Smithsonian, CfA)***, Peter Cheimets (Harvard-Smithsonian, CfA), Leon Golub (Harvard-Smithsonian, CfA)

123.57 – Performance Measurements of an Intensified APS Detector for SPICE on Solar Orbiter

The Spectral Imaging of the Coronal Environment (SPICE) instrument for the Solar Orbiter mission will make spectroscopic observations of the Sun's low corona to characterize the plasma properties of the source regions of the solar wind. The detector package for SPICE, provided by the NASA Goddard Space FLight Center, consists of two microchannel-plate (MCP) intensified Active Pixel Sensor (APS) detectors covering the short (702-792 Angstroms) and long (972-1050 Angstroms) wavelength bandpasses. The long wavelength detector will also provide coverage in second order between 485-525 Angstroms. We report here on measurements made on the engineering model of the SPICE detector in a vacuum tank facility at the Rutherford Appleton Laboratory in Harwell, UK. These measurements include the detector flat field, sensitivity, resolution, linearity, and statistical noise. A krypton resonance lamp operating at 1236 Angstroms was used to stimulate the detector. Results at this wavelength are combined with the quantum efficiency measurements of the individual MCPs at this and other wavelengths covering the entire wavelength range to provide a complete calibration curve for the instrument. A calibrated NIST photodiode was used to determine the absolute brightness of the lamp.

Author(s): ***William Thompson (NASA/GSFC)***, Joseph Davila (NASA/GSFC), Gregory Woytko (NASA/GSFC), Thomas Devlin (NASA/GSFC), Patrick Jordan (NASA/GSFC), Alberto Rosanova (NASA/GSFC), William Chang (NASA/GSFC), Nelson Reginald (NASA/GSFC), Thomas Plummer (NASA/GSFC), Patrick Haas (NASA/GSFC), Martin Caldwell (Rutherford Appleton Laboratory), Mark Anderson (Rutherford Appleton Laboratory), Paul Eccleston (Rutherford Appleton Laboratory), Douglas Griffin (Rutherford Appleton Laboratory), Oswald Siegmund (Sensor Sciences, LLC)

123.58 – Tools for 3D Spectropolarimetry - A Birefringent Fiber Optic Image Slicer

Image-slicing technology benefits astronomical spectropolarimetry by transposing a three-dimensional informational set--two spatial and one spectral dimension--into a format more amenable to simultaneous coverage by conventional spectrographs. To probe, for example, the magnetism of the fine-scaled, dynamic chromosphere, methods beyond slit-based spectropolarimetry are essential. Fiber optic integral field units (IFUs) present one promising solution. The importance of a birefringent fiber-optic IFU design stems from the need of spatio-temporal modulation to correct for spurious polarization signals induced either by platform jitter or atmospheric seeing. Standard stock fibers do not typically preserve polarization. Here we characterize the polarization response of a close-packed IFU based on rectangular optical fibers, currently under development for the Diffraction-Limited Near-IR Spectropolarimeter, a facility instrument of the Advanced Technology Solar Telescope. Solar observations utilizing this device will be presented.

Author(s): ***Thomas Schad (University of Hawaii)***, Haosheng Lin (University of Hawaii)

123.59 – Slitless Solar Spectroscopy

Spectrographs have traditionally suffered from the inability to obtain line intensities, widths, and Doppler shifts over large spatial regions of the Sun quickly because of their narrow instantaneous field of view. This has limited the spectroscopic analysis of rapidly varying solar features like, flares, CME eruptions, coronal jets, and reconnection regions. Imagers, on the other hand, have provided high time resolution images of the full Sun with limited spectral resolution. In this paper we present recent advances in deconvolving spectrally dispersed images obtained through broad slits. We use this new theoretical formulation to examine the effectiveness of various potential observing scenarios, spatial and spectral resolutions, signal to noise ratio, and other instrument characteristics. We test this method on two specific observing scenarios. With the original method developed for the single spectral line case, we first analyze the effect of overlapping spectral lines on the resulting spectral parameters. Second, we determine how well the method performs when given dispersed image input with either three orders (0, +1, -1), or with two orders (0, +1). In both cases a more accurate Gauss error function calculation is employed on the dispersed images. This information will lay the foundation for a new generation of spectral imagers optimized for slitless spectral operation, enabling us to obtain spectral information in transient solar events.

Author(s): ***John O'Neill (Catholic University of America)***, Joseph Davila (Goddard Space Flight Center), Figen Oktem (University of Illinois at Urbana-Champaign)

123.60 – The Expanded Owens Valley Solar Array (EOVSA)

The Expanded Owens Valley Solar Array (EOVSA) near Big Pine, CA is undergoing commissioning as a solar-dedicated microwave imaging array operating in the frequency range 2.5-18 GHz. The solar science to be addressed focuses on the 3D structure of the solar corona (magnetic field, temperature and density), and on the particle acceleration, transport and heating in solar flares. The project will support the scientific community by providing open data access and software tools for analysis and modeling of the data, to exploit synergies with on-going solar research in other wavelengths. The array consists of a total of 15 antennas, including the two 27-m antennas with He-cooled receivers for sensitive calibration, and thirteen 2.1-m antennas that each view the entire disk of the Sun. The system includes a completely new control system, broadband signal transmission, and high-speed digital signal processing, using new technology developed for the Frequency Agile Solar Radiotelescope (FASR). We present an overview of the instrument, the current status of commissioning activities, and some initial observations to assess performance. This research is supported by NSF grants AST-1312802, and NASA grants NNX11AB49G and NNX10AF27G to New Jersey Institute of Technology.

Author(s): ***Dale Gary (NJIT)***, Gordon Hurford (UC/Berkeley), Gelu Nita (NJIT), Stephen White (AFRL), James McTiernan (UC/Berkeley), Gregory Fleishman (NJIT)

123.61 – Flight Performance of the HEROES Solar Aspect System

Hard X-ray (HXR) observations of solar flares reveal the signatures of energetic electrons, and HXR images with high dynamic range and high sensitivity can distinguish between where electrons are accelerated and where they stop. Furthermore, high-sensitivity HXR measurements may be able to detect the presence of electron acceleration in the non-flaring corona. The High Energy Replicated Optics to Explore the Sun (HEROES) balloon mission added the capability of solar observations to an existing astrophysics balloon payload, HERO, which used grazing-incidence optics for direct HXR imaging. The HEROES Solar Aspect System (SAS) was developed and built to provide pointing knowledge during solar observations to better than the ~20 arcsec FWHM angular resolution of the HXR instrument. The SAS consists of two separate systems: the Pitch-Yaw aspect System (PYAS) and the Roll Aspect System (RAS). The PYAS compares the position of an optical image of the Sun relative to precise fiducials to determine the pitch and yaw pointing offsets from the desired solar target. The RAS images the Earth's horizon in opposite directions simultaneously to determine the roll of the gondola. HEROES launched in September 2013 from Fort Sumner, New Mexico, and had a successful one-day flight. We present the detailed analysis of the performance of the SAS for that flight.

Author(s): ***Albert Shih (NASA/GSFC)***, Steven Christe (NASA/GSFC), Marcello Rodriguez (NASA/GSFC), Kyle Gregory (NASA/GSFC), Alexander Cramer (NASA/GSFC), Melissa Edgerton (NASA/GSFC), Jessica Gaskin (NASA/MSFC), Brian O'Connor (NASA/MSFC), Alexander Sobey (NASA/MSFC)

123.62 – Observing the Sun in hard X-rays using grazing incidence optics: the FOXSI and HEROES projects

Solar flares accelerate particles up to high energies through various acceleration mechanisms which are not currently understood. Hard X-rays are the most direct diagnostic of flare-accelerated electrons. However past and current hard x-ray observation lack the sensitivity and dynamic range necessary to observe the faint signature of accelerated electrons in the acceleration region, the solar corona. These limitations can be easily overcome through the use of HXR focusing optics coupled with solid state pixelated detectors. We present results from the recent flights of two sub-orbital payloads that have applied grazing incidence HXR optics to solar observations. FOXSI, short for Focusing Optics X-Ray Solar Imager, was launched on a sounding rocket in November 2012 from White Sanda and observed a solar flare. HEROES, short for High Energy Replicated Optics to Explore the Sun, observed the sun for 7 hours from a high altitude balloon on September 21, 2013. We present recent results as well as the capabilities of a possible future satellite mission

Author(s): ***Steven Christe (NASA GSFC)***, Lindsay Glesener (University of California, Berkeley), Sam Krucker (Facchoschule Nordwestschweiz), Albert Shih (NASA GSFC), Jessica Gaskin (NASA MSFC), Colleen Wilson (NASA MSFC)

123.63 – The SUVIT Instrument on the Solar-C Mission

Solar-C is a new space mission being proposed to JAXA, with significant contributions anticipated from NASA, ESA, and EU countries. The main scientific objectives are to: reveal the mechanisms for heating and dynamics of the chromosphere and corona and acceleration of the solar wind; determine the physical origin of the large-scale explosions and eruptions that drive short-term solar, heliospheric, and geospace variability; use the solar atmosphere as a laboratory for understanding fundamental physical processes; make unprecedented observations of the polar magnetic fields. The unique approaches of Solar-C to achieve these goals are to: determine the properties and evolution of the 3-dimensional magnetic field, especially on small spatial scales, and for the first time observed in the crucial low beta plasma region; observe all the temperature regimes of the atmosphere seamlessly at the highest spatial resolution ever achieved; observe at high cadence the prevailing dynamics in all regions of the atmosphere; determine physical properties from high resolution spectroscopic measurements throughout the atmosphere and into the solar wind. The powerful suite of instruments onboard Solar-C will be sensitive to temperatures from the photosphere (~5500 K) to solar flares (~20 MK) with no temperature gap, with spatial resolution at all temperatures of 0.3? or less (0.1? in the lower atmosphere) and at high cadence. The purpose of the Solar UV-Visible-IR Telescope (SUVIT) is to obtain chromospheric velocity, temperature, density and magnetic field diagnostics over as wide a range of heights as possible, through high cadence spectral line profiles and vector spectro-polarimetry. SUVIT is a meter-class telescope currently under study at 1.4m in order to obtain sufficient resolution and S/N. SUVIT has two complementary focal plane packages, the Filtergraph that makes high cadence imaging observations with the highest spatial resolution and the Spectro-polarimeter that makes precise spectro-polarimetric observations. With their powerful sets of spectral lines, FG and SP collect physical measurements from the lower photosphere to upper chromosphere with much better spatial and temporal resolution than Hinode SOT.

Author(s): ***Theodore Tarbell (LMSAL)***, Kiyoshi Ichimoto (Kyoto University)

123.64 – Current and future solar observation using focusing hard X-ray imagers

The efficient processes that accelerate particles in solar flares are not currently understood. Hard X-rays (HXRs) are one of the best diagnostics of flare-accelerated electrons, and therefore of acceleration processes. Past and current solar HXR observers rely on indirect Fourier imaging and thus lack the necessary sensitivity and imaging dynamic range to make detailed studies of faint HXR sources in the solar corona (where particle acceleration is thought to occur). A future generation of solar HXR observers will instead likely rely on direct HXR focusing, which can provide far superior sensitivity and imaging dynamic range. The first wave of focused solar HXR studies is already underway, including sounding rocket and high-altitude balloon payloads, and, in the near future, solar observation by the NuSTAR astrophysics observatory. This poster will (1) summarize the capabilities of current solar HXR instruments, comparing the science that can be done from each platform, and (2) discuss the scientific power of a future, dedicated, spaceborne observatory optimized to observe HXRs from the Sun.

Author(s): ***Lindsay Glesener (University of California, Berkeley)***, Amir Caspi (University of Colorado, Boulder), Steven Christe (Goddard Space Flight Center), Iain Hannah (University of Glasgow), Hugh Hudson (University of California, Berkeley), Gordon Hurford (University of Applied Sciences Northwestern Switzerland), Brian Grefenstette (California Institute of Technology), Sam Krucker (University of Applied Sciences Northwestern Switzerland), Andrew Marsh (University of California, Santa Cruz), Richard Mewaldt (California Institute of Technology), Michael Pivovaroff (Lawrence Livermore National Laboratory), Albert Shih (Goddard Space Flight Center), David Smith (University of California, Santa Cruz), Julia Vogel (Lawrence Livermore National Laboratory), Stephen White (Air Force Research Laboratory)

102 – Extrasolar Planets: Characterization and Theory

Oral Session – America Ballroom North/Central – 02 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Sarah Ballard (Harvard University)

102.01 – Influence of UV activity on the Spectral Fingerprints of Earth-like Planets around M dwarfs

A wide range of potentially rocky transiting planets in the habitable zone (HZ) have been detected by Kepler as well as ground-based searches. The spectral type of the host star will influence our ability to detect atmospheric features with future space and ground based missions like JWST, GMT and E-ELT. Particularly the active and inactive M stars are a stellar class, covering a wide range of UV luminosity, that will influence the detectability of habitable conditions. The UV emission from a planet's host star dominates the photochemistry and thus the resultant observable spectral features. Using the latest UV spectra obtained by Hubble as well as IUE, we model Earth-like planets orbiting a wide range of M-dwarfs from M0 to M9 for both active and inactive stars. These planets are the first ones that should become available to observations with JWST and E-ELT. A wide range of such targets will soon be identified in our Solar Neighborhood by the 2017 TESS mission.

Author(s): ***Sarah Rugheimer (Harvard University - CFA)***, Lisa Kaltenegger (MPIA), Antigona Segura (Universidad Nacional Autónoma de México), Jeffrey Linsky (University of Colorado - Boulder, JILA), Subhanjoy Mohanty (Imperial College London)

102.02 – Effect of Exoplanet Clouds on Visible Wavelength Albedo Spectra and Phase Curves

We use a planetary albedo model to investigate variations in visible wavelength phase curves of the exoplanet Kepler-7b and a theoretical Jupiter-like exoplanet at 2 AU. Thermal and cloud properties for these exoplanets are derived using one-dimensional radiative-convective and cloud simulations. The presence of clouds on these exoplanets significantly alters their planetary albedo spectra. We show that non-uniform cloud coverage on the dayside of tidally locked exoplanets will manifest as changes to the magnitude and shift of the phase curve. We investigate a test case of our model using a Jupiter-like planet orbiting at 2.0 AU from a solar type star to consider the effect of H2O clouds. The model is then extended to the exoplanet Kepler-7b and considers the effect of Mg2SiO4 clouds. We show that, depending on the observational filter, the shift of the phase curve maximum will be ~2-10° for a Jupiter-like planet and up to ~30° (~0.08 in orbital phase) for hot Jupiter exoplanets at visible wavelengths. The model presented in this work can be adapted for a variety of planetary cases at visible wavelengths to include variations in planet-star separation, gravity, metallicity, and source-observer geometry. Finally, we tailor our model for comparison with the recent optical phase-curve observations of Kepler-7b with the Kepler space telescope. We show that models where Kepler-7b has slightly more than half of its dayside covered in Mg2SiO4 clouds provide a good fit to the observed phase-curve magnitude and offset. We also investigate the effect of varying particle sizes and sedimentation efficiencies to explore the ranges that do not fit the currently available data for Kepler-7b and HD189733b. Furthermore; we explore the use of 3D temperature maps/models to more accurately portray the varying albedo across the planet.

Author(s): ***Matthew Webber (MIT)***, Nikole Lewis (MIT), Mark Marley (NASA Ames Research Center), Jonathan Fortney (University of California), Kerri Cahoy (MIT)

102.04 – HARPS-N Contributions to the Mass-Radius Diagram for Rocky Exoplanets

Science operations began with HARPS-N on the TNG in August 2012. About half of the 80 nights per year allocated to the HARPS-N Collaboration have been dedicated to follow-up observations of bright Kepler Objects of Interest that showed promise of being rocky. In this presentation we show how mass determinations from HARPS-N are improving our understanding of the mass-radius diagram for rocky exoplanets, including recent results for Kepler 78 and Kepler 10.

Author(s): ***David Latham (Harvard-Smithsonian, CfA)***, Dimitar Sasselov (Harvard-Smithsonian, CfA)

Contributing teams: HARPS-N Collaboration

102.05 – Three Distinct Exoplanet Regimes Inferred From Host Star Metallicities

The occurrence rate of exoplanets smaller than 4 Earth radii (R_E) in short orbits is ~50%. Despite their sheer abundance, the compositions of planets populating this regime are largely unknown. The available evidence suggests the existence of a compositional range, from small high-density rocky planets to low-density planets consisting of rocky cores surrounded by thick H/He gas envelopes. Understanding the transition from the gaseous planets to Earth-like rocky worlds is important to estimate the number of potentially habitable planets in our Galaxy and provide constraints on planet formation theories. Here, we report the abundances of heavy elements (metallicities) of over 400 stars hosting 600 exoplanet candidates discovered by the Kepler Mission and find that the exoplanets can be categorized into three populations defined by statistically distinct (~ 4.5?) metallicity regions. We interpret these regions as reflecting the formation regimes of terrestrial-like planets ($R_P < 1.7\ R_E$), gas-dwarf planets with rocky cores and H/He envelopes ($1.7 < R_P < 3.9\ R_E$) and ice/gas-giant planets ($R_P > 3.9\ R_E$). These transitions resonate well with those inferred from dynamical mass estimates, implying that host-star metallicity – a proxy for the initial solid inventory of the protoplanetary disk – is a key ingredient regulating the structure of planetary systems.

Author(s): ***Lars Buchhave (Centre for Star and Planet Formation)***, Martin Bizzarro (Centre for Star and Planet Formation), David Latham (Harvard-Smithsonian Center for Astrophysics), Dimitar Sasselov (Harvard-Smithsonian Center for Astrophysics)

102.06 – Detailed Abundances of a Planet-Hosting Wide Binary System: Did Planet Formation Imprint Chemical Signatures in the Atmospheres of HD20782/81?

We present a detailed chemical abundance analysis of a planet-hosting wide binary system (HD20782 + HD20781), where both stars are G-dwarfs, and each of them hosts giant planets on eccentric orbits with pericenters ~< 0.2 AU. We investigate if giant planets on such orbits could scatter inner rocky planets into the atmospheres of their host stars, and thereby imprint a detectable chemical signature in the stellar photospheric abundances. Using high-resolution, high signal-to-noise echelle spectra, we derive the abundances of 15 elements. In addition, the refractory elements ($T_C > 900$ K) in both stars show a positive correlation between the elemental abundances and condensation temperatures (T_C), with similar slopes of $\sim 1\times10^{-4}$ dex K^{-1}. In each star, the measured positive correlations are imperfect, with a scatter of $\sim 5\times10^{-5}$ dex K^{-1} about the mean trend; also, certain elements (Na, Al, Sc) are similarly deviant in both stars. We interpret these results in the context of simulations of giant planet migration that predict the accretion of H-depleted rocky material by the host star. We demonstrate that a simple model for a solar-type star accreting material with Earth-like composition predicts a positive -- but imperfect -- correlation between [X/H] and Tc. According to this model, our measured slopes are consistent with the ingestion of 10-20 Earths by both HD20782 and HD20781.

Author(s): ***Claude Mack (Vanderbilt University)***, Keivan Stassun (Vanderbilt University), Simon Schuler (University of Tampa), John Norris (The Australian National University)

102.07 – Dating Red Dwarfs: Determining the Ages of Red Dwarf Stars and their Hosted Planets

Red Dwarf (dwarf M=dM) stars comprise over 75% of the stars in the Galaxy. The recent statistical analysis of exoplanet systems from the Kepler Mission indicates that about 15% of red dwarf stars host Earth-size planets orbiting in the liquid water Habitable Zones (HZ) of their host stars. This indicates that within 10 pc (~33 Ly) of the Sun (which contains ~240 dM stars), there should be about 35 potentially habitable Earth-size planets. Extrapolating to the entire Galaxy indicates that about 50-100 billion earth-size planets may be orbiting within the HZs of red dwarfs. Determining the ages and radiation/plasma properties of these planet hosting dM stars is crucial in assessing the potential for life on their HZ exoplanets. With these aims in mind we have been carrying out multi-wavelength (X-ray - IR) studies of dM stars as part of our NSF/NASA sponsored “Living with a Red Dwarf” Program. Due to their low masses, nuclear evolution of red dwarfs is very slow and their physical properties (e.g. L/Lo, Teff, R/Ro) do not significantly change over the age of the universe This makes it nearly impossible to determine (nuclear) evolutionary ages as is done with more massive stars. However, their rotation-related magnetic dynamo properties such as- coronal X-ray and chromospheric emissions and star spots coverage dramatically decrease with time as the stars spin down from angular momentum loss via magnetic winds We report on the ongoing calibration of Age-Rotation and (magnetic) Activity relations of dM stars. The ages of the calibrator stars are found from memberships in clusters, & moving groups as well as memberships in wide binaries - ages known from white dwarf & main sequence star components. Kinematical ages are used for old high velocity stars. Using these relations, the ages of a dM stars can be estimated from their measured rotation periods, and/or from coronal & chromospheric emissions. We apply these relations to determine ages of nearby dM stars that host potentially habitable planets that include: GJ 581, GJ 667C, HD 85572, and HD 40307. We acknowledge the support from NSF/RUI grant AST-1009903, and NASA/CHANDRA GO1-12024X, GO2-13020X and HST-GO-13020.01-A

Author(s): ***Edward Guinan (Villanova Univ.)***, Scott Engle (Villanova Univ.), Evan Kullberg (Villanova Univ.), William Watson (Villanova Univ.), Scott Michener (Villanova Univ.)

102.08 – Kepler 56: Present and Future Configuration and Obliquity

Kepler-56 is an interesting multi-planet system with two coplanar inner planets that are highly misaligned with their parent star, and accompanied by an outer 3.3 Jupiter mass planet with an unknown inclination. Determining the true spin orbit angle and the inclination of the outer companion is valuable to study the physical processes that can produce the misalignment. Here, using the observed line of sight measurements, we can constrain the true spin orbit angle and the inclination of the outer companion. These depend on the initial configuration of the system. We consider two inherent scenarios: the first scenario assumes the stellar spin axis to be initially aligned with the inner two planets' angular momentum, and it favors a large range of mutual inclination (~20 -160 degree) between the inner planets and the outer companion. Tighter constraints can be achieved if the true spin orbit angle can be measured (from both asteroseismology and Rossiter-McLaughlin measurements). The second scenario assumes the stellar spin axis to be aligned with the total angular momentum of the system, and it favors the mutual inclination to be around ~40 or ~130 degree. Future observation of the mutual inclination may distinguish the two scenarios and uncover the formation processes of this system. In addition, by modeling the stellar evolution and its tidal effects on the system, we predict that the innermost planet will be engulfed within ~130 Myr.

Author(s): ***Gongjie Li (Harvard Univ.)***, Smadar Naoz (Harvard Univ.), Francesca Valsecchi (Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA), Northwestern University), John Johnson (Harvard Univ.), Frederic Rasio (Department of Physics and Astronomy, Northwestern University)

102.09 – Planets in Wide Binaries from Kepler: Ages, Stability and Evolution of Planetary Systems

Using the Kepler Input Catalog and the fourth U.S. Naval Observatory CCD Astrograph Catalog, we have identified 1509 common proper motion (CPM) binaries in the Kepler field of view, of which a small subset host planet candidates, or Kepler Objects of Interest (KOIs). We have verified the fidelity of the CPM pairs using a Galactic model and follow-up astrometric observations. We present 73 KOIs distributed over 58 CPM pairs and highlight the first wide binary system (separation > 1000 AU) where both stellar components host at least one KOI. Because our binary sample was initially targeted for a gyrochronology analysis, we also present measurements of stellar rotation periods and preliminary estimates of stellar (and planetary) ages. We use these extrapolated planetary ages to investigate longterm planet stability in wide binaries and test potential formation and evolution scenarios of these dynamically complex systems.

Author(s): ***Kolby Weisenburger (Boston University)***, Andrew West (Boston University), Kenneth Janes (Boston University), Saurav Dhital (Embry-Riddle Aeronautical University)

103 – Solar Magnetism I

Meeting-in-a-Meeting – America Ballroom South – 02 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Amy Winebarger (NASA Marshall Space Flight Center)

103.01D – Characterizing and Modeling Magnetic Flux Transport in the Sun's Photosphere and Determining Its Impact on the Sunspot Cycle

Characterization and modeling magnetic flux transport within the surface layers of the Sun are vital to explaining the 11 year sunspot cycle. I have characterized the differential rotation (DR) and meridional flow (MF) and their variations since 1996 using a cross-correlation technique on magnetograms (maps of the magnetic field at the surface of the Sun). The MF is faster at solar cycle minimum and slower at maximum. Furthermore, the MF speeds that preceded the Solar Cycle 23/24 minimum were ~20% faster than the MF speeds that preceded the prior minimum. This faster MF has been suggested to have caused weaker polar field strengths and thus the subsequent extended solar minimum and an unusually weak cycle 24. I have modeled surface magnetic flux transport with a model that advects the magnetic flux emerging in sunspots using the near-surface flows. These flows include the axisymmetric DR and MF and the non-axisymmetric cellular convective flows (supergranules), all of which vary in time as indicated by direct observations. At each time step, magnetic maps of the entire Sun are created. I have tested the predictability of this model using daily sunspot area data as sources of new magnetic flux. I found that the evolution of the polar fields can be reliably predicted many years in advance. The model was then used to determine the impact of MF variations on the sunspot cycle. One simulation included a MF that is constant, a second included a MF that has the observed variations in time, and a third included a MF in which the observed variations were exaggerated. The simulations show that the variations in the MF over cycle 23 produce polar fields that are ~20% stronger, rather than weaker. This suggests that the cause of the weak polar fields at the end of Cycle 23 should be attributed to the emergence of fewer active region sources, rather that the variation in the meridional flow.

Author(s): ***Lisa Upton (University of Alabama Huntsville)***, David Hathaway (NASA/MSFC)

103.02 – Subsurface Structure of Active Regions

Magneto-convection simulations with horizontal, untwisted magnetic field advected into the domain at large (20Mm) depth spontaneously form magnetic loops which emerge as active regions. An active regions emerges as a fragmented, braided magnetic loop. This is what makes the magnetic flux first appear with mixed polarities, that then counter stream into the leading and following spots at the loop legs. After emergence, braided vertical legs are left behind which extend to large depths in the convection zone at the down flow boundaries of the large underlying convective cells. Movies of the emergence process and the subsurface structure underneath the active region will be presented.

Author(s): ***Robert Stein (Michigan State Univ.)***, Aake Nordlund (Copenhagen University)

103.03 – Validation Tests of Data Driven Magnetic Flux Emergence

The emergence of magnetic flux through the solar photosphere into the corona is a key problem to understanding the energization of the solar corona. With the advent of high spatial and temporal resolution solar vector magnetic field measurements, it may now be possible to simulate the dynamical evolution of the corona by using these measurements as the driving boundary condition for magnetohydrodynamical (MHD) simulations of the corona. First, however, methods for using this data to drive simulations must be validated via quantitative tests. We report here on a series of such tests wherein the driving inputs are taken from self-consistent simulations of the emergence of flux ropes from the upper convection zone through the photosphere and chromosphere into the low corona. Photospheric MHD output from these simulations is then used to drive new simulations, and the driven results are compared against the original results for a variety of driving assumptions and algorithms. We will focus here on the relative advantages and disadvantages of data driving a higher order finite-element-based MHD code (HiFi) versus data driving a lower order Lagrangian remap-based MHD code (LARE3D). For each code, we will report on the necessary input conditions (spatial and temporal resolution, specification of MHD variables, and specification of vertical gradients) needed to reproduce a high level of agreement between the original and the driven simulations. Finally, we will report on the level of agreement achieved when using driving input equivalent to that of current solar observations. Based on these tests, we will address the prospects for using high time and spatial resolution vector magnetogram observations to drive MHD simulations of the solar chromosphere and corona. This work was supported by the ONR 6.1 and the NASA LWS programs.

Author(s): ***Mark Linton (Naval Research Laboratory)***, Vyacheslav Lukin (Naval Research Laboratory), James Leake (George Mason University), Peter Schuck (NASA Goddard Space Flight Center)

103.04 – Multiscale Properties of the Local Dynamo on the Sun

Dynamics of the quiet Sun represents a background ('salt-and-pepper') state for powerful manifestations of solar activity. Current numerical simulations have shown that small-scale turbulent dynamics can strongly couple with processes on larger scales, such as formation of pores and sunspots. We perform 3D MHD radiative simulations of top layers of the convection zone and the low atmosphere, taking into account effects of turbulence, magnetic fields, ionization and excitation of all abundant elements. To model the dynamo process we carry a series of the simulations with various initial weak levels of magnetic field perturbations. The results show that an initial, randomly distributed ('seed') magnetic field of 1 micro-gauss, greatly amplifies by subsurface turbulent dynamics. The self generated magnetic field (dynamo) reaches 2 kG magnetic levels in the photosphere. The local dynamo process primary operates 1 Mm below the surface where the magnetic fields are amplified by helical flows. These dynamo-generated magnetic fields are transported by downflows into deeper layers. The process of the magnetic field amplification has a substantially multiscale character, during which self-organized turbulent helical flows work coherently on scales much larger then the turbulent scales. We discuss the apparent contradiction of our results with current paradigm that local dynamo can generate magnetic fields only on the small turbulent scales. We compare our results with other simulations and observations.

Author(s): ***Irina Kitiashvili (Stanford University)***, Alexander Kosovichev (Stanford University), Nagi Mansour (NASA Ames Research Center), Alan Wray (NASA Ames Research Center)

103.05 – The Photospheric Poynting Flux and Coronal Heating

Some models of coronal heating suppose that random (cf., coherent) convective motions at the photosphere shuffle the footpoints of coronal magnetic fields and thereby inject sufficient magnetic energy upward to account for observed coronal and chromospheric energy losses in active regions. Using high-resolution observations of plage magnetic fields made with the Solar Optical Telescope aboard the Hinode satellite, we observationally test this idea by estimating the upward transport of magnetic energy --- the vertical Poynting flux, S_z --- across the photosphere in a plage region. To do so, we combine: (i) estimates of photospheric horizontal velocities, v_h, determined by local correlation tracking applied to a sequence of line-of-sight magnetic field maps from the Narrowband Filter Imager, with (ii) a vector magnetic field measurement from the SpectroPolarimeter. Plage fields are ideal observational targets for estimating energy injection by convection, because they are: (i) strong enough to be measured with relatively small uncertainties; (ii) not so strong that convection is heavily suppressed (as within umbrae); and (iii) unipolar, so S_z in plage is not influenced by mixed-polarity processes (e.g., flux emergence) that cannot explain steady heating in stable, active-region fields. In this and a previously analyzed plage region, we found that the average S_z varied between the regions, but was positive (upward) and sufficient to explain coronal heating, with values near 2 x 10^7 erg/ cm^2/ s. We find the energy input per unit magnetic flux to be on the order of a few times 10^4 erg/ s/ Mx. A comparison of intensity in a Ca II image co-registered with one plage magnetogram shows stronger spatial correlation with unsigned vertical field, |B_z|, than either S_z or horizontal flux density, |B_h|.

Author(s): ***Brian Welsch (UC-Berkeley)***

103.06 – Polarity Reversal of the Solar Photospheric Magnetic Field During Activity Cycle 24

The large-scale solar magnetic field reverses its polarity during the maximum phase of each activity cycle. As observed on the photosphere, active region (AR) magnetic flux migrates poleward in narrow, sheared streams resulted from large-scale flows and diffusion. A small net flux of the trailing sunspot polarity eventually aggregates at high latitudes, manifesting the poloidal field of the next cycle. We characterize this process for the ongoing cycle 24 based on four years' line-of-sight magnetograms from the Helioseismic and Magnetic Imager (HMI). The axial dipole component reversed sign in early 2012, but the poleward flux migration was grossly out of phase in the two hemispheres. As a proxy, the northern polar field (taken as mean above 70 degrees latitude) switched from negative to positive in late 2012, whereas the southern remained positive as of March 2014. Three factors that are in line with the surface flux transport model may have contributed. First, AR emergence started and peaked earlier in the north. Second, several ARs with small or inverse tilt angles (w.r.t. the Joy's law) emerged in the south in late 2010. Third, meridional flow speed inferred from helioseismology varied greatly prior to 2013; slower streams (compared to a three-year mean at the same latitude) appeared earlier in the north. We correlate HMI with the long-running Wilcox Solar Observatory (WSO) dataset, and compare the current cycle with the previous three.

Author(s): ***Xudong Sun (Stanford University)***, Jon Hoeksema (Stanford University), Yang Liu (Stanford University), Junwei Zhao (Stanford University)

104 – Solar Energetic Events I

Meeting-in-a-Meeting – Staffordshire – 02 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Gianna Cauzzi (INAF)

104.01 – Empirical Study of Turbulent Diffusion in Flare Plasma Sheets

Velocity fields in the hot (>10 MK) plasma sheets above post-eruption flare arcades have the hallmarks of turbulent flow. Tracking and measuring these velocity fields enables empirical estimation of transport parameters, e.g. turbulent diffusivity, that are important for determining the spectrum of length scales present in the plasma sheet. These transport parameters thus help to set the rate of magnetic reconnection, and may help us to understand how reconnection can be triggered, accelerated, and prolonged in eruptive flares. In this work we show measurements, for the first time, of transport parameters in flare plasma sheets, enabled by high-resolution observations from SDO and local correlation tracking.

Author(s): *David McKenzie (Montana State Univ.)*, Michael Freed (Montana State Univ.)

104.02 – Acceleration of SEPs in Flaring Loops and CME Driven shocks

We consider two stage acceleration of the Solar Energetic Particles (SEPs). The first occurring via the stochastic acceleration mechanism at the flare site in the corona, which produces the so-called impulsive SEPs, with anomalous abundances, as well as nonthermal particles responsible for the observed radiation. The second is re-acceleration the flare accelerated particles at the CME driven shock associated with larger, longer duration events with relatively normal abundances. Turbulence plays a major role in both stages. We will show how stochastic acceleration can explain some of the salient features of the impulsive SEP observations; such as extreme enrichment of 3He (and heavy ions), and the observed broad distributions and ranges of the 3He and 4He fluences. We will then show that the above hybrid mechanism of first stochastic acceleration of ions in the reconnecting coronal magnetic structures and then their re-acceleration in the CME shock can produce the varied shapes of the 3He and 4He spectra observed in all events ranging from weak impulsive to strong gradual events.

Author(s): *Vahe Petrosian (Stanford University)*, Qingrong Chen (Stanford University)

104.03 – Unusual Sunquake Events Challenge the Standard Model of Solar Flares

"Sunquakes" represent helioseismic waves excited by solar flares. According to the standard flare model, sunquakes are associated with the hydrodynamic response of the low atmosphere to beams of flare-accelerated particles. Observations with the HMI instrument on Solar Dynamics Observatory have shown that sunquakes are a much more common phenomenon than this was found from the previous SOHO/MDI observations. The HMI observations reveal that sunquakes may occur not only during strong X-class flare but also in relatively weak flares of low M-class (as low as M1). It is particularly surprising that, in some cases, the sunquake initiating impacts are observed in the early impulsive or even pre-heating phase, prior to the main hard X-ray impulse and even without a significant hard X-ray signal. We examine properties of such sunquake events, present a detailed analysis of M2.8 flare of February 17, 2013, using HMI, AIA, GOES and RHESSI data, and discuss implications for the standard flare model.

Author(s): *Alexander Kosovichev (Crimean Astrophys. Observatory)*, Ivan Sharykin (Space Research Institute of RAS), Ivan Zimovets (Space Research Institute of RAS)

104.04 – Bulk Acceleration of Electrons in Solar Flares?

In two recent papers it has been argued that RHESSI observations of two coronal “above-the-loop-top” hard X-ray sources, together with EUV observations, show that ALL the electrons in the source volumes must have been accelerated. I will briefly review these papers and show that the interpretation most consistent with the combined flare observations is multi-thermal, with hot, thermal plasma in the “above-the-loop-top” sources and only a fraction, albeit a substantial fraction, of the electrons accelerated. Thus, there is no credible scientific evidence for bulk acceleration of electrons in flares. Differential emission measure (DEM) models deduced from SDO/AIA and RHESSI data, including the inversion of the AIA data to determine DEM, will be discussed as part of this analysis.

Author(s): *Gordon Holman (NASA Goddard Space Flight Center)*

104.05 – Inferred Particle Acceleration by Contracting Magnetic Islands in MHD Simulations of Flare Reconnection

The mechanisms that accelerate ionized particles to the energies required to produce the observed high-energy emission in solar flares are not well understood. Drake et al. (2006) proposed a kinetic mechanism for accelerating electrons in contracting magnetic islands formed by reconnection. In this model, particles that gyrate around magnetic field lines transit from island to island, increasing their energy by Fermi acceleration in those islands that are contracting. Macroscopic regions filled with a large number of these small islands are required to achieve the large observed rates of energetic electron production in flares, but at the moment it is impossible to simulate sufficiently large-scale systems using kinetic models. Our recent high-resolution, compressible MHD simulations of a breakout eruptive flare (Karpen et al. 2012) allow us to resolve in detail the generation and evolution of macroscopic magnetic islands in the flare current sheet, and to study the Drake et al. mechanism in a configuration that more closely represents the flare atmosphere and structure. Based on the Drake et al. studies, we characterize island contractions in our simulations as the islands move away from the main reconnection site toward the flare arcade. To that end, with our null-tracking capabilities, we follow the creation and evolution of X- and O-type (island) nulls that result from spatially and temporally localized reconnection. Preliminary results show that the initial energy of particles could be increased by up to an order of magnitude in a typical contracting island, before it reconnects with the underlying arcade. We conclude that this mechanism is a promising candidate for electron acceleration in flares, but further research is needed, including extending our results to 3D flare conditions.

Author(s): *Silvina Guidoni (NASA Goddard Space Flight Center)*, Judith Karpen (NASA Goddard Space Flight Center), C. DeVore (NASA Goddard Space Flight Center)

104.06 – RHESSI and EIS observations of an above-the-looptop reconnection region

A variety of solar flare observations suggest particle acceleration in the corona, at or above the flare looptop. Hard X-ray (HXR) studies, for example, occasionally reveal accelerated electrons above flare looptops, in some cases suggesting the location of the acceleration region. However, since coronal HXR sources are faint and the structure of the flare as seen in extreme ultraviolet (EUV) images is complicated, it is difficult to say where these sources lie with respect to, for example, the reconnection region. HXR and EUV observations can provide complementary information for investigating this topic. EUV imaging spectroscopy reveals bulk flows and locations of line-broadened (potentially turbulent) sources. Such observations can, for example, identify outflows from the reconnection region. HXR imaging places the flare-accelerated electrons in the context of the overall flare geometry, allowing comparison of the locations of accelerated electrons, the reconnection region, and the flare loop. In this work, data from RHESSI and Hinode/EIS are used to investigate above-the-looptop sources in the 2013 May 15 X-class flare. Above-the-looptop EIS flows and loop-top line-broadening are compared with RHESSI HXR sources in the preimpulsive phase of the flare.

Author(s): *Lindsay Glesener (University of California, Berkeley)*, Hirohisa Hara (National Astronomical Observatory of Japan), Sam Krucker (University of Applied Sciences Northwestern Switzerland)

105 – Topics in Astrostatistics

Special Session – St. George AB – 02 Jun 2014 10:00 AM to 11:30 AM

Modern AstroStatistics has emerged as a new field in recent times, informed by a Bayesian foundation, utilizing powerful computational tools like MCMC, and applied to diverse analysis and inference problems in Astronomy. The use of statistics to validate results and evaluate models is pervasive in modern astronomy and advanced statistical techniques have been extensively applied across cosmology, high-energy astrophysics, solar physics, large surveys, etc. Poisson techniques have proliferated, and the use of MCMC is common today. The diversity of astronomical data has also had positive feedback on Statistics, and has influenced the development of new algorithms and insights. Now, new methods of data collection, and the rapidly increasing amounts of data that are collected (the "Big Data" problem), pose new challenges of analysis and interpretation. The goal of our Special Session is to review current practices, highlight modern techniques, and explore how the transition into the realm of Big Data Astronomy can be facilitated. Analysis and interpretation of the terabyte and petabyte data streams from forthcoming surveys and missions is a major challenge to the practice of Astronomy, and possibly requires a significant restructuring of the types of problems that are addressed. A secondary purpose of this Session is to build broad community awareness about the risks and rewards of principled analysis. We will explore the pitfalls of using advanced and powerful techniques as black boxes, and will highlight the complexities that arise from implementations and broad usage among Astronomers. The session will be complemented by an informal interactive discussion session hosted at the Chandra Booth as part of a program initiated by the SAO/Harvard-based CHASC AstroStatistics Collaboration. CHASC will arrange for Statisticians to be available at specified times to answer questions and discuss AstroStatistical issues with Astronomers.

Chair(s):
Aneta Siemiginowska (Harvard-Smithsonian, CfA)

Organizer(s):
Vinay Kashyap (Harvard Smithsonian, CfA)

105.01 – Towards Good Statistical Practices in Astronomical Studies

Astronomers do not receive strong training in statistical methodology and are therefore sometimes prone to analyze data in ways that are discouraged by modern statisticians. A number of such cases are reviewed involving the Kolmogorov-Smirnov test, histograms and other binned statistics, various issues with regression, model selection with the likelihood ratio test, over-reliance on `3-sigma' criteria, under-use of multivariate clustering algorithms, and other issues.

Author(s): ***Eric Feigelson (Penn State Univ.)***

105.02 – Big Computing in Astronomy: Perspectives and Challenges

Hardware progress in recent years has led to astronomical instruments gathering large volumes of data. In radio astronomy for instance, the current generation of antenna arrays produces data at Tbits per second, and forthcoming instruments will expand these rates much further. As instruments are increasingly becoming software-based, astronomers will get more exposed to computer science. This talk therefore outlines key challenges that arise at the intersection of computer science and astronomy and presents perspectives on how both communities can collaborate to overcome these challenges. Major problems are emerging due to increases in data rates that are much larger than in storage and transmission capacity, as well as humans being cognitively overwhelmed when attempting to opportunistically scan through Big Data. As a consequence, the generation of scientific insight will become more dependent on automation and algorithmic instrument control. Intelligent data reduction will have to be considered across the entire acquisition pipeline. In this context, the presentation will outline the enabling role of machine learning and parallel computing. Bio Victor Pankratius is a computer scientist who joined MIT Haystack Observatory following his passion for astronomy. He is currently leading efforts to advance astronomy through cutting-edge computer science and parallel computing. Victor is also involved in projects such as ALMA Phasing to enhance the ALMA Observatory with Very-Long Baseline Interferometry capabilities, the Event Horizon Telescope, as well as in the Radio Array of Portable Interferometric Detectors (RAPID) to create an analysis environment using parallel computing in the cloud. He has an extensive track record of research in parallel multicore systems and software engineering, with contributions to auto-tuning, debugging, and empirical experiments studying programmers. Victor has worked with major industry partners such as Intel, Sun Labs, and Oracle. He holds a distinguished doctorate and a Habilitation degree in Computer Science from the University of Karlsruhe. Contact him at pankrat@mit.edu, victorpankratius.com, or Twitter @vpankratius.

Author(s): ***Victor Pankratius (MIT)***

105.03 – The Full Monte Carlo: A Live Performance with Stars

Markov chain Monte Carlo (MCMC) is being applied increasingly often in modern Astrostatistics. It is indeed incredibly powerful, but also very dangerous. It is popular because of its apparent generality (from simple to highly complex problems) and simplicity (the availability of out-of-the-box recipes). It is dangerous because it always produces something but there is no surefire way to verify or even diagnosis that the “something” is remotely close to what the MCMC theory predicts or one hopes. Using very simple models (e.g., conditionally Gaussian), this talk starts with a tutorial of the two most popular MCMC algorithms, namely, the Gibbs Sampler and the Metropolis-Hasting Algorithm, and illustrates their good, bad, and ugly implementations via live demonstration. The talk ends with a story of how a recent advance, the Ancillary-Sufficient Interweaving Strategy (ASIS) (Yu and Meng, 2011, http://www.stat.harvard.edu/Faculty_Content/meng/jcgs.2011-article.pdf) reduces the danger. It was discovered almost by accident during a Ph.D. student’s (Yaming Yu) struggle with fitting a Cox process model for detecting changes in source intensity of photon counts observed by the Chandra X-ray telescope from a (candidate) neutron/quark star.

Author(s): ***Xiao-Li Meng (Harvard University)***

106 – Bridging Laboratory & Astrophysics: Atoms

Meeting-in-a-Meeting – St. George CD – 02 Jun 2014 10:00 AM to 11:30 AM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This session will focus on the interplay between astrophysics with theoretical and experimental studies into the underlying atomic processes, which drive our Universe.

Chair(s):
John Harry Black (Chalmers University of Technology)
Organizer(s):
Farid Salama (NASA Ames Research Center)

106.01 – Atomic Data Needs for Understanding X-ray Astrophysical Plasmas

High-resolution X-ray data from current satellites expose the need for high-quality atomic data of all stripes: wavelengths, collisional/radiative rates, and absorption cross sections. Astro-H, to be launched in 2015, will increase the available effective area for high-resolution at some energies by orders of magnitude, bringing the issue into sharp relief. There have been a number of recent successes of both theoretical calculations and laboratory measurements, as well as many remaining atomic data needs which hinder scientific progress (e.g Fe XVII line ratios). These include, amongst other issues, accurate wavelength measurements in the soft X-ray band, well-calibrated diagnostic ratios of select lines, and high-resolution absorption cross sections for abundant ions. Finally, astrophysical charge exchange, a newly identified contribution to soft X-ray emission, will be discussed. This emission arises due to the interaction of highly charged ions with neutral atoms, forming a diffuse background due to solar wind ions interacting in the heliosphere and possibly also arising in more distant environments.

Author(s): ***Randall Smith (Smithsonian Astrophysical Observatory)***

Contributing teams: AtomDB Team

106.02 – Laboratory Astrophysics Using the Electron Beam Ion Trap

X-ray astronomy has seen profound growth in discovery space for over a decade resulting almost entirely from the successful operation of three X-ray observatories: Chandra, XMM-Newton, and Suzaku. The high sensitivity, high resolution instrumentation on these satellites have provided the X-ray astrophysicists with relatively straightforward access to powerful line diagnostics that tightly constrain the physical parameters of celestial sources. For example, accurate measurements of transition energies, line shapes, and intensities provide quantitative measures of a velocity fields, electron densities and temperatures. X-ray measurements probe sources unattainable by any other wavelength bands, such as the regions of accretion disks near black holes, and the hot intracluster medium in clusters of galaxies. Thus, X-ray astronomy in the age of Chandra, XMM-Newton, and Suzaku provides important pieces of the puzzles necessary to understand the formation and evolution of galaxies, stars, the phenomena near black holes, and the evolution of the universe as a whole. Unfortunately, accurate unambiguous interpretation of high quality spectra is often limited by the accuracy and completeness of atomic data rather than the uncertainties related to counting statistics or instrumentation. Starting over twenty years ago, the electron beam ion trap facility at Lawrence Livermore National Laboratory has been used to benchmark spectral models used to interpret celestial data, and to address specific problems facing the astrophysics community. More recently, the portable FLASH-EBIT, built and maintained at the Max Planck Institute for Nuclear Physics, Heidelberg and coupled to third and fourth generation light sources has opened new measurement regimes relavant to the high energy astrophysics community. Selected results will be presented. This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344 and is supported by NASA grants to LLNL and NASA/GSFC.

Author(s): ***Gregory Brown (LLNL)***

106.03 – Assessing atomic data accuracy along isoelectronic sequences

The CHIANTI atomic database provides radiative decay rates and electron excitation rates for modeling collisionally-excited emission lines from 242 ions. We present a new method for assessing atomic data accuracy whereby level populations for specific atomic levels are plotted along isoelectronic sequences. Results are presented for the helium through fluorine isoelectronic sequences. Generally a smooth variation of population with atomic number is found and so anomalies, often due to problems with atomic data, can be identified. One exception is for the iron ions, which can show level populations an order of magnitude larger than neighboring ions. These can be demonstrated to be due to the much larger atomic models that are typically run for iron ions.

Author(s): *Peter Young (George Mason University)*, Uri Feldman (Artep Inc.)

106.04 – Comprehensive X-ray Absorption Models for Atomic Oxygen and Neon

An analytical formula is developed to represent accurately the photoabsorption cross sections of oxygen and neon for all energies of interest for X-ray spectral modeling purposes. In the vicinity of the K-edge, a Rydberg series expression is used to fit R-matrix results, including important orbital relaxation effects, which accurately predict the absorption oscillator strengths below threshold and merge consistently and continuously to the above-threshold cross section. Further minor adjustments are made to the threshold energies in order to align the atomic Rydberg resonances most reliably after consideration of both experimental and observed line positions. At energies far below or above the K-edge region, the formulation is based on both outer-shell and inner-shell direct photoionization, including significant shake-up and shake-off processes that result in photoionization-excitation and double photoionization contributions to the total cross section. The ultimate purpose for developing a definitive model for oxygen absorption is to resolve a discrepancy between the inferred atomic and molecular oxygen abundances in the interstellar medium (ISM) from XSTAR and SPEX spectral models.

Author(s): *Thomas Gorczyca (Western Michigan University)*, Javier Garcia (Harvard Smithsonian Center for Astrophysics), Manuel Bautista (Western Michigan University), Claudio Mendoza (Instituto Venezolano de Investigaciones Cientificas), Efrain Gatuzz (Instituto Venezolano de Investigaciones Cientificas), Timothy Kallman (NASA Goddard Space Flight Center)

107 – Astronomy Research and Development Using Picosatellites

Special Session – Gloucester, 2nd Floor – 02 Jun 2014 10:00 AM to 11:30 AM

As CubeSats move from rare to ubiquitous parts of college programs, picosatellites for instrument prototyping and fledgling science goals feeds back into professional and amateur astronomy. We discuss current and in-design university graduate and undergraduate research as well as private/society satellite experiments with a science or instrumentation goal. Topics include in situ measurements of Sun-Earth interaction, amateur-class space-based imaging, multiple picosatellite constellations, use of picosatellites for undergraduate research, and use of picosatellites for prototyping detector concepts.

Chair(s):
Alexander Antunes (Capitol College)

107.01 – Profiling near-Earth debris using picosatellites

The 'TrapSat' team at Capitol College adopts Aerogel to do in-orbit and potentially trans-lunar capture and observation of incident debris. We present early test results for this detector to measure the mass and distribution of ambient near-Earth and interplanetary debris. Expected debris includes both man-made orbital debris as well as micrometeorite particles. The theory is that depth images showing penetration of debris into the Aerogel capture mechanism (used successfully in comet capture missions) are transmitted to track the accumulation rate and estimated size of particles. We include a brief discussion of how this method can be used for flights beyond near-Earth and compare expected particle densities to the necessary capture area and mission flight time. Initial testing using high altitude flights are presented, along with indication of expected near-Earth distributions and the confidence levels in using TrapSat to measure the near-Earth environment.

Author(s): ***Alexander Antunes (Capitol College)***, Ryan Schrenk (Capitol College), Mikus Bormanis (Capitol College), Angela Walters (Capitol College), Travis White (Capitol College)

107.02 – Conducting Science with a CubeSat: The Colorado Student Space Weather Experiment (CSSWE)

The Colorado Student Space Weather Experiment is a 3-unit (10cm x 10cm x 30cm) CubeSat funded by the National Science Foundation and constructed at the University of Colorado (CU). The CSSWE science instrument, the Relativistic Electron and Proton Telescope integrated little experiment (REPTile), provides directional differential flux measurements of 0.5 to >3.3 MeV electrons and 9 to 40 MeV protons. Though a collaboration of 60+ multidisciplinary graduate and undergraduate students working with professors and professional engineers, CSSWE was designed, built, tested, and delivered in 3 years. On September 13, 2012, CSSWE was inserted to a 477 x 780 km, 65° orbit as a secondary payload on an Atlas V through the NASA Educational Launch of Nanosatellites (ELaNa) program. The first successful contact with CSSWE was made within a few hours of launch. CSSWE then completed a 20 day system commissioning phase which validated the performance of the communications, power, and attitude control systems. This was immediately followed by an accelerated 24 hour REPTile commissioning period in time for a geomagnetic storm. The high quality, low noise science data return from REPTile is complementary to the NASA Van Allen Probes mission, which launched two weeks prior to CSSWE. On January 5, 2013, CSSWE completed 90 days of on-orbit science operations, achieving the baseline goal for full mission success and has been operating since. An overview of the CSSWE system, on-orbit performance and lessons learned will be presented.

Author(s): ***Scott Palo (University of Colorado)***, Xinlin Li (University of Colorado), David Gerhardt (University of Colorado), Lauren Blum (University of Colorado), Quintin Schiller (University of Colorado), Rick Kohnert (University of Colorado)

107.03 – Low Radio Frequency Picosatellite Missions

The dramatic advances in cubesat and other picosatellite capabilities are opening the door for scientifically important observations at low radio frequencies. Because simple antennas are effective at low frequencies, and receiver technology allows low mass and low power instruments, these observations are an ideal match for very small spacecraft. A workshop on cubesat missions for low frequency radio astronomy was held at the Kiss Institute for Space Sciences, Caltech, to explore mission concepts involving one up to hundreds of picosatellites. One result from this workshop was that there are opportunities for viable missions throughout this large range. For example, the sky-integrated spectral signature of highly redshifted neutral hydrogen from the dark ages and cosmic dawn epochs can be measured by a single antenna on a single spacecraft. There are challenging issues of calibration, foreground removal, and RF interference that need to be solved, but the basic concept is appealingly simple. At the other extreme, imaging of angular structure in the high-redshift hydrogen signal will require an interferometer array with a very large number of antennas. In this case the primary requirement is a sufficiently low individual spacecraft mass that hundreds can be launched affordably. The technical challenges for large arrays are long-term relative station keeping and high downlink data rates. Missions using several to a few tens of picosatellites can image and track bright sources such as solar and planetary radio bursts, and will provide essential validation of technologies needed for much larger arrays. This work has been carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Author(s): ***Dayton Jones (JPL)***

107.06 – The Application of the Logo Language for Future Astronomical PocketQubes and CubeSats

The PocketQube T-LogoQube was a successful test of a Logo based system for future astronomical CubeSats. The flight and ground software for T-LogoQube is based on the Logo programing language. This flight software is the first use of the Logo language for the control of any satellite. The T-LogoQube team is compised of ~50 people (professional mentors, faculty, and students). The T-LogoQube uLogo based flight system acheived the following goals: (1) Transmission of fours types of packet data with the RFM22B transceiver. (2) Ability to control T-LogoQube with a "one line uLogo program". (3) The uLogo VM includes a unigue time stamp for all data. (4) Past beacon packets are telemetered for a history of T-LogoQube. (5) Realtime flight analysis of the Magnetometer to measure spin rate on orbit (6) Ability to upload new uLogo code to extend the on orbit operation. (7) Single torque coil to point the T-LogoQube spin axis in any direction (8) Detection and ability to correct SEUs We will present evolution of Logo for future CubeSats for space based astronomy projects.

Author(s): ***J. Jernigan (Little H-Bar Ranch)***

108 – Fred Adams: Effects of Clusters on Planetary Systems and Possible Constraints on the Birth Environment of the Solar System

Plenary Session – America Ballroom North/Central – 02 Jun 2014 11:40 AM to 12:30 PM

Chair(s):
Edward Churchwell (Univ. of Wisconsin)

108.01 – Effects of Clusters on Planetary Systems and Possible Constraints on the Birth Environment of the Solar System

Most stars -- and hence most solar systems -- form within groups and clusters. The first objective of this talk is to explore how these star forming environments affect solar systems forming within them via three channels: dynamical interactions, elevated radiation fields, and increased particle fluxes. The discussion starts with the dynamical evolution of young clusters; we use N-body simulations to study how evolution depends on system size and initial conditions. Multiple realizations of equivalent cases are used to build up a statistical description of these systems, e.g., distributions of closest approaches and radial locations. These results provide a framework from which to assess the effects of clusters on solar system formation. Distributions of radial positions are used in conjunction with UV luminosity distributions to estimate the radiation exposure of circumstellar disks. Photoevaporation models determine the efficacy of radiation in removing disk gas and compromising planet formation. The distributions of closest approaches are used in conjunction with scattering cross sections to determine probabilities for solar system disruption. Finally, we determine the distributions of radioactive nuclei that are provided to circumstellar disks, where they enhance ionization and heating. This work provides a quantitative (but statistical) determination of the effects of clusters on forming solar systems. The second objective of this talk is to use these results to place constraints on the possible birth environments for our own solar system.

Author(s): ***Fred Adams (University of Michigan)***

110 – Long Time Domain Astronomy

Special Session – America Ballroom North/Central – 02 Jun 2014 02:00 PM to 03:30 PM

Long time-domain astronomical data sets are becoming increasingly common, and such data sets have enormous potential value for exploring phenomena lasting longer than a few decades, a human career or lifetime. In stellar astrophysics, there are clearly a number of potential applications of long time-domain data sets. Long-duration phenomena are already being measured for a number of different objects, like eclipsing binaries and pulsating variables. New data sets with all-sky photometry have potential to greatly expand the number of objects and kinds of phenomena potentially observable, leading to both new targets for study and new kinds of variability that could change or refine our understanding of stellar evolution. Modern (electronic) astronomical data sets are being effectively archived and indexed for better access, and older data sets like catalogs, paper records, and plate archives are being converted to electronic format for effective use in modern analyses. This Special Session provides a forum for the general discussion of long time-domain phenomena with various astronomical data sources. Photometric variability is a common theme for the organizers of this special session, but modern long-duration data sets are now capable of yielding new astrophysics in a number of fields. Proper motion studies, measurements of astrophysical light echoes, and planetary astronomy are all examples of potential areas open to exploration in the long time domain.

Chair(s):
Matthew Templeton (AAVSO)

Organizer(s):
Arne Henden (AAVSO)

110.01 – Testing Cataclysmic Variable Evolution Models with Light Curves of >10,000 Magnitudes Over >100 years and Fully-Corrected to Johnson B & V

A combination of magnitudes from the Harvard and Sonneberg plates stacks and the AAVSO data base can create very well-sampled light curves with >10,000 magnitudes and covering all of 1890-2014 for roughly a hundred cataclysmic variables (CVs; novae, novalikes, and dwarf novae). Care must be taken to get all these magnitudes into a modern magnitude system. For the archival plates, these are all close to the B magnitude system so that color terms are small, hence, with the use of modern B magnitudes for the comparison stars, these magnitudes can all be placed onto the Johnson B system. For the archival visual observations, the original comparison sequences can always be found, and the magnitudes for the CV and comparisons must be converted from visual to V, so that the reported magnitudes can be fully corrected to Johnson V. The uncertainties from the plates and the visual magnitudes can always be beaten down by daily or yearly averaging to typical real total error bars of ±0.03 mag, and these are always much smaller than the sampling error arising from flickering and greatly smaller than the range of variations. These very-well-sampled >100 year Johnson B & V light curves can be used to test long term evolution models for CVs. With colleagues, I have made light curves for old novae (GK Per from 1890-2014 with 47,000 mags, V603 Aql from 1898-2014 using 22,722 mags, Q Cyg from 1876-2014 with 6400 mags, T CrB from 1855-2014 using 104,000 mags), Z Cam stars (Z Cam from 1923-2014 with 90,000 mags), and dwarf novae (SS Cyg from 1896-2014 with 403,800 mags). The relative accretion rate is given by both the average flux and by the inverse of the average peak-to-peak time for the dwarf novae. By this means, I have measured the changes in the accretion rate for many CVs and how they change on a yearly basis for a century and longer. These observations are directly compared to various CV evolution models. A complex set of agreements and disagreements is found.

Author(s): ***Bradley Schaefer (Louisiana State Univ.)***

110.02 – Light Echoes from Luminous Transients - Status of the Field and Future Prospects

Scattered-light echoes from luminous transients (supernovae, luminous blue variables/supernova impostors) are unique in their ability to preserve an observable record of the state of a transient in outburst for centuries. Unlike conventional (i.e. intentional) time-series records, the presence of interstellar dust on the light echo ellipsoid from a given outburst allows photometric and spectroscopic study at any epoch where the scattered-light signal reaches a useful signal-to-noise threshold. Additionally, dust located at different positions on an outburst's light-echo ellipsoid will preserve a record of the hemispheric emission of light from the outburst as seen from each dust location, allowing the degree of asymmetry of an outburst to be studied. A more recent application of scattered-light echoes employs the fact that multiple outbursts of high-amplitude, unstable, luminous variables each produce their own light-echo ellipsoids and dust located on such ellipsoids provides an opportunity for multiple outbursts to be studied at the same (modern) epoch. This talk will provide a brief summary of the evolution of light echoes from use as a tool to map out the interstellar medium around luminous events to their richer and more recent use of investigating the outbursts themselves. Important findings from observations of scattered-light echoes regarding SN1987A, Cas A, and eta Car will be highlighted and near-term prospects for new work and new observational opportunities will be presented.

Author(s): ***Douglas Welch (McMaster Univ.)***, Armin Rest (Space Telescope Science Institute)

110.03 – The Importance of Long Time Domain Observations for Understanding Pulsation in Cepheids and M Supergiants

Continuous monitoring of both Cepheids and type C semiregular variables is essential for understanding their pulsation. Cepheids, for example, can undergo regular, periodic, and irregular changes in pulsation period and amplitude that are attributed to stellar evolution, orbital motion about companions, and stochastic processes, respectively. All such information helps to characterize Cepheids in terms of physical attributes. Similar information is also very useful for pulsating M supergiants, which are still poorly understood in terms of their pulsation. Specific examples are provided by BC Cyg and ? Cep, the former a M3 supergiant displaying regular pulsation, the latter a M1 supergiant apparently pulsating in fundamental and overtone modes. Both appear to provide long-period extensions of the Cepheid period-mass and period-age relations.

Author(s): ***David Turner (Saint Mary's Univ.)***

110.04 – Decadal monitoring of variables by the AAVSO community

The American Association of Variable Stars has been in existence for over 100 years. First performing monitoring and follow-up observations for Harvard College astronomers, the organization has expanded into following thousands of variables with a wide variety of instrumentation, as well as participating in the discovery of transient objects and the data-mining of survey catalogs. Several examples of how long, continuous, homogeneous light curves can yield astrophysical results not possible with short lifetime surveys will be given.

Author(s): ***Arne Henden (AAVSO)***

110.05 – Will R Coronae Borealis Ever Return to Maximum Light?

R Coronae Borealis (R CrB) has been in a deep decline for almost 7 years. Before that, it spent 6 uninterrupted years at maximum light. R CrB is the prototype of its eponymous class of stars, which are very rare, and have many unusual characteristics including extreme hydrogen deficiency, and large, sudden declines in brightness of 8 magnitudes or more. These declines are caused by clouds of carbon dust forming near the atmospheres of the stars, which are later dissipated by radiation pressure. The RCB stars are true irregular variables in that the timing of their declines cannot be predicted, but several RCB stars are also known to begin their declines at a particular phase of their pulsations. There is a wide range of dust formation activity among these stars, as well as as a wide variation in the level of activity for an individual star over time. Long Time Domain observations of the RCB stars are necessary to understand the frequency of their declines, and to give clues about how and when the dust forms around these enigmatic stars.

Author(s): ***Geoffrey Clayton (Louisiana State Univ.)***

110.06 – Exploring 100+ Year Variability with DASCH: Statistical Methods and Recent Results.

The Digital Access to a Sky Century at Harvard (DASCH) project is currently digitizing the roughly 500,000 photographic plates maintained by the Harvard College Observatory. The Harvard plate collection covers each point of the sky roughly 500 to 3000 times from 1885 to 1992, with limiting magnitudes ranging from B=14-18 mag and photometric accuracy within ±0.1 mag. Production scanning (roughly 400 plates/day) is proceeding in Galactic coordinates from the North Galactic Pole and is currently at roughly 40 degrees galactic latitude. The vastness of these data makes DASCH unique in its ability to systematically study variability on decade-long time scales across the entire sky. We are developing new statistical mining techniques to predictively identify the many classes of stellar variability and explore their long-term behavior, as well as discover new unusual cases/classes of variability. Most recently, we are working to implement wavelet-based algorithms into our mining routines, better allowing us to analyze localized non-periodic signals. Here we report on the progress of our mining and machine learning routines, as well as share several of the exciting new discoveries that are being made with DASCH. We gratefully acknowledge support from NSF grants AST-0407380, AST-0909073 and AST-1313370.

Author(s): ***George Miller (Harvard-Smithsonian Center for Astrophysics)***, Jonathan Grindlay (Harvard-Smithsonian Center for Astrophysics), Edward Los (Harvard-Smithsonian Center for Astrophysics)

111 – Solar Energetic Events II

Meeting-in-a-Meeting – America Ballroom South – 02 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Dana Longcope (Montana State Univ.)

111.01 – Characteristics of Sustained >100 MeV ?-ray Emissions Observed by Fermi and their Association with Solar Eruptive Events

The Fermi Large Area Telescope (LAT) has detected >20 sustained gamma-ray events >100 MeV lasting up to 20 hours. Three of these events have been discussed by the LAT Collaboration in two papers. Similar high-energy events have been observed earlier and were given the name Long Duration Gamma Ray Flares (LDGRFs; Ryan, 2000). We discuss a comprehensive study of the Fermi events beginning with a list of 98 solar eruptive events (SEEs) from 2008 to 2012 May with broad/fast (>800 km/s) or >100 keV hard X-ray emission or SEPs with >10 MeV proton fluxes above 1 proton flux unit. Our study provides the following characteristics of LAT LDGRFs: of 67 disk SEEs, 41 had broad/fast CMEs and 20 had both broad/fast CMEs and impulsive >100 keV emission; 12 of these 20 were detected by LAT above 100 MeV; no LAT events were detected in 21 events with broad/fast CMEs when hard X-ray emission was <100 keV; no LAT events were detected from the 31 CMEs originating from behind the disk. This suggests that sustained emission appears to require both a broad-fast CME and a flare with impulsive emission >100 keV. From our studies of behind-the-limb SEEs and LAT fluxes vs heliolongitude, we conclude that the protons responsible for the sustained >100 MeV events interact within about 20-30 deg. of the active region, but not necessarily at the footpoints of the flare loops. We also find in a study of all events: >300 MeV proton interactions producing the >100 MeV emission begin from <1 min to tens of min from the peak of the HXR emission; durations of the sustained emission events last from ~30 min to 20 hrs; spectral indices of >300 MeV protons at the Sun range from about -2.5 (2012 May 17 GLE) to steeper than -6 (average about -4.8); the proton spectrum can both soften and harden in time; the numbers of >500 MeV solar protons producing the sustained emission are typically ten-times larger than those in the impulsive flare, but there are exceptions; the numbers of >500 MeV protons producing sustained emission is typically ten-times smaller than the numbers in SEPs and is well correlated, based on a limited number of measurements. This work is funded by the NSF/SHINE and NASA's Fermi/GI programs.

Author(s): ***Gerald Share (University of Maryland)***, Ronald Murphy (Naval Research Laboratory), Allan Tylka (NASA GSFC), Brian Dennis (NASA GSFC), Richard Schwartz (NASA GSFC), Anne Tolbert (NASA GSFC), Stephen White (Air Force Research Laboratory)

111.02 – Modeling Observable Effects Of Canopy Structure On Conduction-driven Evaporation From Impulsive Energy Release

It is well established that the solar corona displays a highly structured appearance. The magnetic field is partially responsible for this structuring (e.g. coronal loops), but the complex density and temperature distribution of plasma along the field also determines appearance. This distribution of plasma may be dictated in part by the coronal heating mechanism, which might be constant (steady-heating) or impulsive (nanoflares). In the impulsive picture, reconnection and loop contraction results in magnetosonic shocks which compress and heat the coronal plasma. Thermal conduction then transports and deposits heat into the chromosphere, resulting in an overpressure that drives plasma up into the loop (a process referred to as chromospheric evaporation). It is expected, however, that the evaporation process will be sensitive to variations of the cross-sectional area of the flux tube, due to the structure of the magnetic canopy above the footpoint. The presence of a magnetic canopy may therefore have a substantial effect on the supply of mass to the corona in response to impulsive heating. In this work, we simulate chromospheric evaporation using a 1-D hydrodynamic code that models a flare loop as a piston shocktube, neglecting gravity and loop curvature. We include a simplified model of the chromosphere and transition region, and use a nozzle-like area profile as a proxy for the canopy variation of the flux tube. We use this code to explore observable effects of the canopy on evaporative flow velocities, loop emission measure, and coronal mass supply during impulsive evaporation.

Author(s): ***Sean Brannon (Montana State Univ.)***, Dana Longcope (Montana State Univ.)

111.03 – On the Nature of the EUV Late Phase of Solar Flares

The EUV late phase of solar flares is a second peak of the warm coronal emissions (e.g., Fe XVI) many minutes to a few hours after the GOES soft X-ray peak, which was first observed by the EUV Variability Experiment (EVE) on board the Solar Dynamics Observatory (SDO). The late phase emission originates from a second set of longer loops (late phase loops) that are higher than the main flaring loops. It is explained as being caused by either additional heating or long-lasting cooling. In this paper, we study the role of long-lasting cooling and additional heating in producing the EUV late phase using the "enthalpy-based thermal evolution of loops'" (EBTEL) experiments. We find that the long cooling process in late phase loops, which definitely exists, can sufficiently explain the emission property of the EUV late phase; meanwhile, we cannot exclude the role of an additional heating of these loops that possibly occurs. Moreover, we provide two preliminary methods based on the UV and EUV emissions from the Atmospheric Imaging Assembly (AIA) on board SDO to determine whether an additional heating plays some role or not in the late phase emission. Through the nonlinear force-free field modeling, we study the magnetic configuration related to the EUV late phase. It is found that the late phase can be generated either in hot spine field lines associated with a magnetic null point or large-scale magnetic loops in multipolar magnetic fields. In this paper, we also explain why the EUV late phase appears most obviously in the warm coronal emissions and why the majority of flares do not exhibit an EUV late phase.

Author(s): ***Ying Li (Nanjing University)***, Mingde Ding (Nanjing University), Yang Guo (Nanjing University), Yu Dai (Nanjing University)

111.04 – Investigating An X-Class Long-Duration Confined Flare

We report the observation of an X-class long-duration flare which is clearly confined. It appears as a compact-loop (~50 Mm high in projection) flare in the traditional EUV passbands (171 and 195A}; ~1 MK), but in the passbands sensitive to flare plasmas (94 and 131A; 6-10 MK), it exhibits a cusp-shaped structure above an arcade of loops (~100 Mm high in projection) like other long-duration events. Inspecting images in a running difference approach, we find that the seemingly diffuse, quasi-static cusp-shaped structure actually consists of multiple nested loops that repeatedly rise upward and disappear approaching the cusp point. Over the gradual phase of the flare, we detect numerous episodes of loop rising, each lasting minutes. A differential emission measure analysis reveals that the temperature is highest at the top of the arcade and becomes cooler at higher altitudes within the cusp-shaped structure. These features are contrary to typical long-duration flares that conform to the standard flare model. With a nonlinear force-free reconstruction of the active region, our analysis of the photospheric squashing factor Q shows that the configuration has locally a tri-polar structure, in the middle of which the negative polarity is divided in half by a high-Q line. The respective halves belong to two adjacent sheared arcades, one of which harbors a magnetic flux rope. The indicated high-Q line is a footprint of a hyperbolic flux tube (HFT) where two quasi-separatrix layers (QSLs) adjoin each other at a T-type junction passing through the joint arcades' apex. Comparing UV 1600A flare ribbons with the photospheric Q-maps at close times, we conclude that the emergence of a new magnetic flux within the arcade void of flux rope triggers the flare, while the preexisting T-type HFT and flux rope dictate the structure and dynamics of the observed flare loops and ribbons. The flux rope fails to escape owing to a strong confining field but contributes to the long-lasting gradual phase with the dissipation of QSL currents.

Author(s): ***Rui Liu (University of Science & Technology of China)***, Viacheslav Titov (Predictive Science Inc.), Tingyu Gou (University of Science & Technology of China), Yuming Wang (University of Science & Technology of China), Kai Liu (University of Science & Technology of China), Haimin Wang (New Jersey Instifiute of Technology)

111.05 – Non-thermal Motions in and Above Flare Loop Tops Measured by the Extreme-ultraviolet Imaging Spectrometer (EIS) on Hinode

The plasma volume above the soft X-ray emitting loop tops is of particular interest for studying the formation of flare loops. We present EIS observations of non-thermal motions (turbulence) determined from spectral line profiles of Fe XXIII and Fe XXIV ions for three well-observed flares near the solar limb. We compare the non-thermal motions at temperatures near 10 MK with the motions along the same lines-of-sight determined from lines of coronal ions such as Fe XII, Fe XIV, and Fe XV formed at 1-2 MK. The take-away is that the non-thermal motions obtained from Fe XXIII and Fe XXIV lines increase with height towards the reconnection region, up to speeds of about 50-60 km/s for the largest heights that we can observe. The implication is that considerable plasma heating occurs outside the reconnection region. In addition, we discuss the implications of results obtained for flares from earlier X-ray Yohkoh observations of line profiles of Fe XXV and Ca XIX on the current results from EIS and AIA. Fe XXV is formed at significantly higher temperatures than any strong flare EUV spectral line observed by EIS or by imaging telescopes such as AIA or TRACE. This work is supported by NASA grants.

Author(s): ***George Doschek (NRL)***, David McKenzie (Montana State University), Harry Warren (NRL)

111.06 – Observations and Implications of Large-Amplitude Longitudinal Oscillations in a Solar Filament

On 20 August 2010 an energetic disturbance triggered large-amplitude longitudinal oscillations in a large fraction of a nearby filament. The triggering mechanism appears to be episodic jets connecting the energetic event with the filament threads. We analyzed this periodic motion to characterize the underlying physics of the oscillation as well as the filament properties. The results support our previous theoretical conclusions that the restoring force of large-amplitude longitudinal oscillations is solar gravity, and the damping mechanism is the ongoing accumulation of mass onto the oscillating threads. Based on our previous work, we used the fitted parameters to determine the magnitude and radius of curvature of the dipped magnetic field along the filament, as well as the mass accretion rate onto the filament threads. These derived properties are nearly uniform along the filament, indicating a remarkable degree of homogeneity throughout the filament channel. Moreover, the estimated mass accretion rate implies that the footpoint heating responsible for the thread formation, according to the thermal nonequilibrium model, agrees with previous coronal heating estimates. We also estimated the magnitude of the energy released in the nearby event by studying the dynamic response of the filament threads, and concluded that the initiating event is likely to be a microflare. We will present the results of this investigation and discuss their implications for filament structure and heating. This work was supported by NASA’s H-SR program.

Author(s): ***Judith Karpen (NASA Goddard Space Flight Center)***, Manuel Luna (Instituto de Astrofisica de Canarias), Kalman Knizhnik (NASA Goddard Space Flight Center), Karin Muglach (NASA Goddard Space Flight Center), Holly Gilbert (NASA Goddard Space Flight Center), Therese Kucera (NASA Goddard Space Flight Center), Vadim Uritsky (NASA Goddard Space Flight Center)

112 – Solar Magnetism II

Meeting-in-a-Meeting – Staffordshire – 02 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Maria Kazachenko (UC Berkeley)

112.01 – New Vector Spectropolarimetry of Sunspots near 4000nm

Magnetic sensitivity of spectral lines increases as the product of the wavelength and the Lande g-factor. While the most magnetically sensitive spectral line known is the Mg I 12318nm line, and observations are often made near 1600nm, little work has been done using solar spectral lines near 4000nm We report on new solar spectropolarimetric observations at these wavelengths, made at the NSO McMath-Pierce facility with the NAC and at the NJIT New Solar Telescope using CYRA. Several photospheric absorption lines have been used to map a sunspot magnetic field, and molecular line Zeeman splitting has also been observed. Several "negative-g" molecular lines are seen, and an atomic line shows unusual profiles.

Author(s): ***Matthew Penn (National Solar Obs.)***, Roy Coulter (New Jersey Institute of Technology), Philip Goode (New Jersey Institute of Technology)

112.02 – A Spectro-polarimetric Analysis of Sunspot Umbrae

The recent quiet solar cycle has invited new questions as to the nature of the solar magnetic field and how it changes over time. To investigate this, we use the National Solar Observatory’s McMath-Pierce Solar Telescope Facility (McMP) and Dunn Solar Telescope (DST) to compare measurements of sunspots from five active regions observed in 2013. Both BABO at the McMP and FIRS at the DST were used to provide spectra of the Fe 1564.8nm line, which is affected by the presence of magnetic fields. The magnetic field is derived from Zeeman splitting in Stokes-I by BABO, and by inversion of the Stokes parameters from FIRS data allowing for comparisons of sunspot properties between the two instruments.. We present the first results from this study including the magnetic fields in sunspot umbrae from five active regions measured simultaneously by BABO and FIRS.

Author(s): ***Fraser Watson (National Solar Observatory)***, Alexandra Tritschler (National Solar Observatory), Matthew Penn (National Solar Observatory), Christian Beck (National Solar Observatory), William Livingston (National Solar Observatory), Valentin Martinez Pillet (National Solar Observatory)

112.03 – Sunspotter: Using Citizen Science to Determine the Complexity of Sunspots

It is well known that sunspot groups with large, complex magnetic field configurations and strong, sheared polarity separation lines produce the largest flares. While methods for determining certain physical properties, such as total magnetic flux and polarity-separation-line length have been successfully developed for characterizing sunspot groups, a reliable automated method for determining sunspot complexity has never been developed. Since complexity can only be measured in a relative sense, we have used crowd-sourcing methods to allow human observers to compare the complexity of pairs of sunspot groups. This allows a large dataset to be ranked in terms of complexity. Sunspotter.org uses the Zooniverse platform and allows the general public to contribute comparisons using a web-browser interface. The results of this project will help to establish the true relationship between sunspot group complexity and flares, which has been discussed in the solar physics community for many decades.

Author(s): ***Paul Higgins (Lockheed Martin)***, David Perez-Suarez (FMI), Michael Parrish (Adler Planetarium), David O'Callaghan (Trinity College Dublin), K Leka (NWRA), Graham Barnes (NWRA), Joseph Roche (Trinity College Dublin), Peter Gallagher (Trinity College Dublin)

Contributing teams: Sunspotter Science Team, Zooniverse Development Team

112.04 – AN ANALYTICAL APPROACH TO SCATTERING REGIMES BETWEEN THIN MAGNETIC FLUX TUBES WITHIN AN ENSEMBLE

Motivated by the inability to directly observe the small scale structure of solar magnetic features. We present an analytical method to model the multiple scattering regime within ensembles of random thin magnetic flux tubes, embedded in a stratified medium. Results demonstrate that the near-field interactions play an important role in the resultant scattered wave field. As such the ensemble no longer behaves as a bunch of individual tubes, rather as a larger collective. It is also shown that the scattering between azimuth orders (m) is as significant as scattering between p-modes. We present a comparison between this analytical model and observations, as well as recent numerical studies.

Author(s): ***Chris Hanson (Monash University)***, Paul Cally (Monash University)

112.05 – The Sun's Magnetic Field During a Grand Minimum of Activity

During a grand minimum of solar activity, no sunspots are observed on the photosphere, but what might the Sun's magnetic field look like? One possibility is that there would be no active regions or larger scale magnetic activity. We have extended our photospheric model for small-scale magnetic flux evolution to cover the full Sun. As an initial study, we consider how the surface magnetic field of the Sun would look if only smaller-scale magnetic features were allowed to emerge. We also consider the resultant coronal and inner heliospheric magnetic fields, and discuss potential consequences of such fields for Earth.

Author(s): ***Karen Meyer (University of St Andrews)***, Duncan Mackay (University of St Andrews)

112.06 – Magnetic Reconnection Above and Below the Transition Region

There is little doubt that the plasma environment in the solar atmosphere varies greatly from the high beta ~1 eV weakly ionized plasmas of the lower chromosphere, to low beta ~100 eV conditions in the quiet Sun corona, to the collisionless ~10 keV plasmas in active flaring regions. At the same time, the theoretical considerations of the the known complexity of evolving solar magnetic field structures, as well as accumulating observational evidence, suggest that the process of magnetic reconnection is ubiquitous throughout the solar atmosphere and likely occurs under each of the above plasma conditions. Yet, a single model of magnetic reconnection that could describe its fundamental properties using a common set of characteristics under such disparate set conditions remains elusive. Here, we explore magnetic reconnection in each of these solar parameter regimes by way of numerical simulations while using a single computational framework. We compare the reconnection dynamics in the three regimes and, in particular, demonstrate three different pathways for the magnetic fields to reconnect at rates that only weakly depend on the micro-physics of magnetic dissipation. In the collisionless flare regime, the self-consistent formation of short, low aspect ratio current sheets allows the plasma to readily flow through the dissipation region leading to fast reconnection. In the quiet Sun corona, it is the process of secondary island formation that effectively broadens the reconnection region much beyond the laminar resistive current sheet prediction, again, reducing its aspect ratio and accelerating the reconnection process. On the other hand, for a range of plasma parameters in the weakly ionized chromosphere, self-consistently generated excessive thinning of the current sheet and order-of-magnitude electron density enhancements in the current sheet can also lead to fast reconnection via rapid recombination. We compare and contrast the three pathways, as well as discuss the prospects for developing a unified parametrized fast solar reconnection model that could capture all three of these regimes. This work was supported in part by the NASA SR&T and LWS TR&T Programs.

Author(s): ***Vyacheslav Lukin (Naval Research Laboratory)***

113 – Extrasolar Planets: Detection

Oral Session – St. George AB – 02 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
David Latham (Harvard-Smithsonian, CfA)

113.01 – How Close are the Nearest Transiting Exoplanet Systems? Updated Planet Occurrence Rates from Kepler & Implications for TESS

Here we consider the most likely distances and apparent magnitudes of the nearest transiting exoplanet systems. In preparation for the next-generation of exoplanet surveys, we would like to know the properties of these systems in order to optimize survey strategies and plan follow-up observations. We begin by populating a catalog of nearby stars with planets using occurrence rates estimated from Kepler. For FGK stars, we rely on previously published estimates of the planet occurrence rate. For smaller stars, we determine the planet occurrence rate by using our own planet detection pipeline to search for additional planets around small Kepler target stars. We empirically measure the planet detection threshold of our pipeline by injecting and recovering transits. After assigning planets to stars, we query the resulting planet catalog to determine the properties of the nearest and brightest transiting exoplanets. We will discuss the implications of this simulated planet population for exoplanet surveys such as TESS, PLATO, MEarth, CARMENES, CHEOPS, ExoplanetSat, ExTrA, HPF, SPECULOOS, and SPIROU. We also consider the observing resources that will be required to follow up these systems with extremely large ground-based telescopes like the GMT, TMT, and E-ELT.

Author(s): ***Courtney Dressing (Harvard-Smithsonian Center for Astrophysics)***, David Charbonneau (Harvard-Smithsonian Center for Astrophysics), Peter Sullivan (Massachusetts Institute of Technology), Joshua Winn (Massachusetts Institute of Technology)

113.02 – The Transiting Exoplanet Survey Satellite Mission

The Transiting Exoplanet Survey Satellite (TESS) will discover thousands of exoplanets in orbit around the brightest stars in the sky. In a two-year survey of the solar neighborhood, TESS will monitor more than 200,000 stars for temporary drops in brightness caused by planetary transits. This first-ever spaceborne all-sky transit survey will identify planets ranging from Earth-sized to gas giants, around a wide range of stellar types and orbital distances. TESS stars will typically be 30-100 times brighter than those surveyed by the Kepler satellite; thus, TESS planets will be far easier to characterize with follow-up observations. For the first time it will be possible to study the masses, sizes, densities, orbits, and atmospheres of a large cohort of small planets, including a sample of rocky worlds in the habitable zones of their host stars. Full frame images with a cadence of 30 minutes or less will provide precise photometric information for several million stars during observation sessions of several weeks. The brighter TESS stars will potentially yield valuable asteroseismic information as a result of monitoring at a rapid cadence of 1 minute or less. An extended survey by TESS of regions surrounding the North and South Ecliptic Poles will provide prime exoplanet targets for characterization with the James Webb Space Telescope (JWST), as well as other large ground-based and space-based telescopes of the future. TESS will serve as the “People’s Telescope,” with data releases every 4 months, inviting immediate community-wide efforts to study the new planets. The TESS legacy will be a catalog of the nearest and brightest main-sequence stars hosting transiting exoplanets, which will endure as the most favorable targets for detailed future investigations. TESS has been selected by NASA for launch in 2017 as an Astrophysics Explorer mission.

Author(s): ***George Ricker (MIT)***, Roland Vanderspek (MIT), David Latham (SAO), Joshua Winn (MIT)

Contributing teams: TESS Science Team

113.03 – Finding the Nearest Extrasolar Planets with the Transiting Exoplanet Survey Satellite

The Transiting Exoplanet Survey Satellite (TESS) is under development for NASA's Explorers Program with a planned launch in 2017. Over a two-year mission, TESS will conduct an all-sky survey to find transiting planets around dwarf stars in the solar neighborhood using four wide-angle optical cameras. TESS will spend between 27 and 350 days covering each of several hundred thousand target stars. In order to predict its yield, we have developed a detailed simulation of the TESS mission. We model the selection of target stars and adopt a planet population from the Kepler results. Next, we calculate the photometric signal-to-noise ratio TESS will achieve, accounting for photon shot noise, instrumental artifacts, and the background from zodiacal light and unresolved stars. We will present the yields of detected planets from the latest simulations, which currently show that TESS should discover over 200 super-Earths and over 400 sub-Neptunes with host stars brighter than I=12. We will also estimate the false-positive rate from blended binary stars. These results will allow the community to prepare for follow-up observations using photometric and radial-velocity techniques.

Author(s): ***Peter Sullivan (MIT-Kavli Institute)***, Joshua Winn (MIT-Kavli Institute), Courtney Dressing (Harvard-Smithsonian Center for Astrophysics), David Charbonneau (Harvard-Smithsonian Center for Astrophysics), Tim Morton (Princeton University), Alan Levine (MIT-Kavli Institute), Roland Vanderspek (MIT-Kavli Institute), George Ricker (MIT-Kavli Institute)

113.04 – Preliminary Planet Population Statistics With Kepler Q1-Q16

We present preliminary extrasolar planet population statistics from analysis of the Kepler Q1-Q16 planet candidate sample. The analysis takes advantage of the recent work on the Q1-Q16 Kepler planet candidate sample, extensive Monte-Carlo transit signal injection and recovery tests of the Kepler Pipeline, and updates to the stellar parameters provided by the Kepler Stellar Working Group. We also explore the sensitivity of the results to alternative inputs by considering a machine learning generated planet sample, systematics in the stellar sample properties, orbital eccentricity, and false positive rates.

Author(s): ***Christopher Burke (SETI Institute / NASA Ames)***, Fergal Mullally (SETI Institute / NASA Ames), Jessie Christiansen (NEXSCI / Caltech), Daniel Huber (NASA Ames), Jeffrey Coughlin (SETI Institute / NASA Ames), Susan Thompson (SETI Institute / NASA Ames), Jon Jenkins (NASA Ames), Natalie Batalha (NASA Ames)

113.05 – The Impact of the Kepler Pipeline Detection Efficiency on the Derived Planet Population Statistics

Analyses of the published Kepler planet candidate catalogues which have attempted to constrain the underlying planet population have thus far been forced to assume a theoretical detection efficiency. We demonstrate the resulting errors that can arise in the calculated planet statistics, which are substantially larger than reported uncertainties on the planet statistics. We also present the latest results from the ongoing study to empirically measure the detection efficiency of the Kepler pipeline via transit injection and recovery, across multiple quarters and including simulated false positives.

Author(s): ***Jessie Christiansen (NASA Exoplanet Science Institute)***

Contributing teams: the Kepler Completeness Working Group

113.06 – Earth-Sized Planets in the Habitable Zones of Cool Stars

The primary goal of the Kepler mission is to determine the frequency of Earth-sized planets in the habitable zone of their parent star. Great strides have been made towards achieving this goal, including the discoveries of Earth-sized planets interior to the habitable zone and several super-Earth-sized planets in the habitable zone. A planet that is both Earth-sized and has an orbit within the habitable zone of a main-sequence star, however, has remained elusive. We present updates several promising multi-planet systems that have Earth-sized, and possibly sub-Earth-sized, candidates in the habitable zone of cool low-mass stars in the Kepler field of view. We will present our methods of combining ground-based observations with transit modeling in our quest to confirm these planets and discuss their potential habitability. More than 70% of the stars in our galaxy are M stars, thus confirming these planets will have profound implications on the number of potentially habitable worlds beyond our Solar System.

Author(s): ***Elisa Quintana (SETI Institute)***, Thomas Barclay (SETI Institute)

113.07 – High Contrast Laboratory Demonstrations with the Vortex Coronagraph

The vortex coronagraph, a phase-based coronagraph that has a small inner working angle and high throughput has the potential to enable observations of exoplanets close to nearby stars. Here we describe recent demonstration experiments in the High Contrast Imaging Testbed, that have yielded monochromatic contrasts better than 10^-9, and contrasts of approximately 10^-8 for light of 10% bandwidth.

Author(s): ***Gene Serabyn (JPL)***

Contributing teams: The vortex TDEM team

113.08 – Hidden in Starlight: A Search for Widely Separated Substellar-Mass Companions

Relatively few widely separated substellar-mass companions of planetary systems are known. These companions can alter the dynamics of planets through Kozai-mechanism-style secular perturbations, and may be a cause of the high mean eccentricity of exoplanets. The orbital periods of such companions are expected to be of the order of tens to thousands of years, making them undetectable by time-domain observations such as transit- and radial velocity searches. We have conducted a Spitzer/Infrared Array Camera (IRAC) 3.6 and 4.5 µm imaging search for widely separated substellar-mass companions with projected separation between 5 to 40 arcsec from their parent star. The 36 stars in my sample range from 4 to 15 pc from the sun, giving a typical sensitivity of 10 MJ for objects with an orbital radius in the range of 50 to 300 au. This search required advanced PSF-subtraction techniques in order to minimize the inner working angle and increase sensitivity. In this talk I present the results of this search and discuss the data analysis methods we developed for it.

Author(s): ***Alan Hulsebus (Iowa State University)***, Massimo Marengo (Iowa State University), Joseph Carson (College of Charleston), Karl Stapelfeldt (NASA Goddard Space Flight Center)

113.09 – Recent Contrast Measurements Made Using the PICTURE Visible Nulling Coronagraph

The PICTURE-B (Planetary Imaging Concept Testbed Using a Rocket Experiment - B) sounding rocket mission will use a visible nulling coronagraph to directly image the exozodiacal dust disk of Epsilon Eridani (K2V, 3.22 pc) in reflected visible light down to an inner radius of 1.5 AU (1.7 ?/D). This mission will demonstrate a number of key technologies for future space-based direct exoplanet imaging missions. These include: wavefront sensing and control using deformable mirrors in space, a lightweight SiC 0.5 meter primary mirror and a milliarcsecond-class fine pointing system. The mission is scheduled for launch in October, 2014. We present laboratory contrast measurements made using the PICTURE-B instrument and model predictions of exozodiacal dust detection limits based on these measurements.

Author(s): ***Christopher Mendillo (UMASS Lowell)***, Ewan Douglas (Boston University), Susanna Finn (UMASS Lowell), Brian Hicks (NASA Goddard Space Flight Center), Jason Martel (UMASS Lowell), Timothy Cook (UMASS Lowell), Supriya Chakrabarti (UMASS Lowell)

114 – Bridging Laboratory & Astrophysics: Molecules

Meeting-in-a-Meeting – St. George CD – 02 Jun 2014 02:00 PM to 03:30 PM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This session will focus on the interplay between astrophysics with theoretical and experimental studies into the underlying molecular processes, which drive our Universe.

Chair(s):
Steven Federman (Univ. of Toledo)
Organizer(s):
Farid Salama (NASA Ames Research Center)

114.01 – Diffuse Molecular Cloud Chemistry: Successes and Challenges

Diffuse molecular clouds are transitional objects thought to form the bridge between the diffuse atomic medium and dense molecular clouds. As a result, their study is critical to advancing our understanding of how molecular clouds form from, and disperse back into, the interstellar medium (ISM). Due to their intrinsically low opacities, diffuse molecular clouds were thought to harbor relatively simple physics and chemistry. However, numerous ground- and space-based observations obtained over a wide wavelength range have uncovered an unexpected molecular complexity that is partially unaccounted for in theories of interstellar clouds and of star and planet formation. The discrepancies between diffuse cloud model predictions and astronomical observations are usually driven by only a few- but major-unknowns: the intrinsic complexity of the observed gas structure in the ISM, a complexity often only partially accounted for in theories, the uncertainties attached to various reaction rates or chemical pathways included in current theories, or the limitations attached to available astronomical instrumentation. I will show how concerted efforts between the astronomical, the theoretical and the laboratory communities have successfully reconciled differences between theoretical predictions and astronomical observations of diffuse molecular clouds and I will discuss how such collaborative efforts need to be pursued in order to address some of the challenges posed by recent astronomical observations.

Author(s): ***Paule Sonnentrucker (Space Telescope Science Institute)***

114.02 – Selected-Ion Infrared Spectroscopy of Small Organic Cations

Small organic cations of interstellar interest are produced in molecular beams by a pulsed discharge/supersonic nozzle source. These ions are mass-selected and studied with infrared laser photodissociation spectroscopy in a time-of-flight mass spectrometer. Infrared spectra are compared to the predictions of theory (DFT and/or MP2) to elucidate the structures of these ions, their isomers and the potential energy surfaces connecting these. The carbocation species studied include C2H3+, C3H5+, C3H3+, protonated benzene, and protonated naphthalene. Protonated naphthalene has spectral lines relevant for the three of the main Unassigned Infrared Bands (UIR's) seen in emission from interstellar gas clouds. Oxygen-containing ions include protonated formaldehyde, formaldehyde cation and methanol cation. Each of these small organic ions exhibits more than one isomer, allowing investigation of the multiple minima on their potential surfaces.

Author(s): ***Michael Duncan (University of Georgia)***

114.03 – Decoding the photochemistry of simple astrophysical molecules

An experimental apparatus with two tunable vacuum ultraviolet (VUV) lasers in a windowless pump-probe configuration with slice imaging detection has been used to study the photochemistry of simple astrophysical molecules such as N_2, NO, CO, and CO_2. The VUV pump laser is set at the desired photodissociation wavelength and the VUV probe laser is set detect the atom by setting it to excite a one-photon transition in the VUV region and then using a visible photon to ionize the excited atoms. The photodissociation of CO_2 in the energy region between 94,000.3 and 98,496.4 cm^{-1} (11.655-12.212eV) is studied and we have been able to show that all of the energetically accessible photochemical channels occur. CO_2+ h? ? $O(^3P''J'')$ + $CO(X^1?^+)$ h? ? 5.45 eV ? $O(^1D)$ + $CO(X^1?^+)$ h? ? 7.42 eV ? $O(^1S)$ + $CO(X^1?^+)$ h? ? 9.64 eV ? $O(^3P_J)$ + $CO(a^3?)$ h? ? 11.46 eV ? $C(^3P_J)$ + O_2 $(X^3?_J^-)$ h? ? 11.44 eV This is the first time that all of these channels in CO_2 have been determined by the direct detection of the atomic fragments. It shows that even simple molecules made up of first row atoms that do not contain H atoms can dissociate into spin forbidden products. We have also been able to use this apparatus to systematically determine the branching ratios between the ^4S, ^2D, and ^2P states of N atoms produced in the photolysis of N_2 in the wavelength range from 100,819.7 to 121,870.1 cm^{-1}(12.500-15.110 eV). These examples show that the photodissociation of the major molecules that occur in the atmospheres of planets, comets, moons and the interstellar medium can be studied in the windowless region of the VUV spectrum.

Acknowledgements: William M. Jackson and Zhou Lu gratefully acknowledge the support of the National Science Foundation (NSF) under Grant No. CHE-1301501. Cheuk Y. Ng acknowledges the support by the Chemical Sciences, Geosciences and Biosciences Division, Office of Basic Energy Sciences, Office of Science, (U.S.) Department of Energy (DOE) under Contract No. DE-FG02-02ER15306.

Author(s): ***William Jackson (University of California)***, Cheuk Ng (University of California), Zhou Lu (University of California), Yih Chang (University of California)

114.04 – Laboratory Studies Of Circumstellar Carbonaceous Grain Formation

The study of the formation processes of dust is essential to understand the budget of extraterrestrial organic molecules. Although dust with all its components plays an important role in the evolution of interstellar (IS) chemistry and in the formation of organic molecules, little is known on the formation processes of carbonaceous dust. We report the progress that was recently achieved in this domain using NASA Ames' COSmIC facility (Contreras & Salama 2013, ApJS, 208, 6). PAHs are important chemical building blocks of IS dust. They are detected in IDPs and in meteoritic samples. Additionally, observational, laboratory, and theoretical studies have shown that PAHs are an important, ubiquitous component of the ISM. The formation of PAHs from smaller molecules has not been extensively studied. Therefore, we have performed laboratory experiments to study the dynamic processes of carbon grain formation, starting from the smallest hydrocarbon molecules into the formation of larger PAH and further into nanograins. Studies of IS dust analogs formed from a variety of PAH and hydrocarbon precursors as well as species that include the atoms O, N, and S, have recently been performed in our laboratory using the COSmIC facility to provide conditions that simulate IS and circumstellar environments. The species formed in the COSmiC chamber through a pulsed discharge nozzle plasma source are detected and characterized with a cavity ringdown spectrometer coupled to a time-of-flight mass spectrometer, thus providing both spectroscopic and ion mass information in-situ. Analysis of solid soot particles was also conducted using scanning electron microscopy at the UCSC/NASA Ames' MACS facility. The SEM analysis of the deposition of soot from methane and acetylene precursors seeded in argon plasmas provide examples on the types of nanoparticles and micrograins that are produced in these gas mixtures under our experimental conditions. From these measurements, we derive information on the size and the structure of IS dust grain particles, the growth and the destruction processes of IS dust and the resulting budget of extraterrestrial organic molecules.
Acknowledgements: This work is supported by NASA SMD (APRA; Carbon in the Galaxy).
Author(s): ***Cesar Contreras (BAER Institute)***, Ella Sciamma-O'Brien (BAER Institute), Farid Salama (NASA Ames Research Center)

115 – Cosmology, CMB, and Dark Matter

Oral Session – Gloucester, 2nd Floor – 02 Jun 2014 02:00 PM to 03:30 PM

Chair(s):

Melanie Simet (Carnegie Mellon University)

115.01D – Light Curves of Type Ia Supernovae and Cosmological Constraints from the ESSENCE Survey

The ESSENCE survey discovered 213 type Ia supernovae at redshifts 0.10 < z < 0.81 between 2002 and 2008. We present their R and I band light curve measurements, obtained using the MOSAIC II imager at the CTIO 4m, along with rapid response spectroscopy for each object from a range of large aperture ground based telescopes. We detail our program to obtain quantitative classifications and precise redshifts from our spectroscopic follow-up of each object. We describe our efforts to improve the precision of the calibration of the CTIO 4m natural photometric system. We use several empirical metrics to measure our internal photometric consistency and our absolute calibration of the survey. We assess the effect of various sources of systematic error on our measured fluxes, and estimate that the total systematic error budget from the photometric calibration is ~1%. We combine 108 ESSENCE SNIa that pass stringent quality cuts with a compilation of 441 SNIa from 3 year results presented by the Supernova Legacy Survey and Baryon Acoustic Oscillation measurements from the Sloan Digital Sky Survey to produce cosmological constraints employing the SNIa. This constitutes the largest sample of well-calibrated, spectroscopically confirmed SNIa to date. Assuming a flat Universe, we obtain a joint constraint of $?_M = 0.266\ ^{+0.026}\ _{-0.016}$ (stat 1-?), and w = $-1.112\ ^{+0.069}\ _{-0.072}$ (stat 1-?). These measurements are consistent with a cosmological constant.

Author(s): ***Gautham Narayan (NOAO)***

Contributing teams: The ESSENCE Project

115.02 – Galaxy shapes and Intrinsic Alignments in the MassiveBlack-II SImulation

The intrinsic alignment of galaxy shapes with the large-scale density field is a contaminant to weak lensing measurements, as well as being an interesting signature of galaxy formation and evolution (albeit one that is difficult to predict theoretically). Here we investigate the shapes and relative orientations of the stars and dark matter of halos and subhalos (central and satellite) extracted from the MassiveBlack-II simulation, a state-of-the-art high resolution hydrodynamical cosmological simulation which includes stellar and AGN feedback in a volume of $(100h^{-1}Mpc)^3$. We consider redshift evolution from *z = 1* to *0.06* and mass evolution within the range of subhalo masses, 10^{10} - $6.0 \times 10^{14.0}h^{-1}M_?$. The shapes of the dark matter distributions are generally more round than the shapes defined by stellar matter. We find that the shapes of stellar and dark matter are more round for less massive subhalos and at lower redshifts. By directly measuring the relative orientation of the stellar matter and dark matter of subgroups, we find that, on average, the misalignment between the two components is larger for less massive subhalos. The mean misalignment angle varies from ? 30°-10° for $M\ ?\ 10^{10} - 10^{14}\ h^{-1}M_?$ and shows a weak dependence on redshift. We also compare the misalignment angles in central and satellite subhalos at fixed subhalo mass, and find that centrals are more misaligned than satellites.

Author(s): ***Ananth Tenneti (Carnegie Mellon University)***, Rachel Mandelbaum (Carnegie Mellon University), Tiziana DiMatteo (Carnegie Mellon University), Yu Feng (Carnegie Mellon University), Nishikanta Khandai (Brookhaven National Laboratory)

115.03 – Observation of Discrete Oscillations in the Plot of Cosmological Scale Factor vs. Lookback Time

We have observed damped longitudinal cosmological-scale oscillations in a unique model-independent plot of scale factor against lookback time. We measured 2 full, constant frequency, oscillations with a period of 0.15 Hubble times. This period corresponds to a fundamental frequency of approximately 7 cycles over the age of the universe, which we term 7 “Hubble-Hertz” (HHz). Transition-z values quoted in the literature generally fall near these oscillation minima and may explain the reported spread and deviation from the predicted ?CDM value of approximately z = 0.77. We also observe second and third harmonics of the fundamental consistent with the spectrum of a sawtooth waveform. We propose a cosmological scalar field damped simple harmonic oscillator model for the observation – which fits well. On this time scale, the scalar field particle mass is extraordinarily small at 10^ -32 ev. Particles on this scale have been suggested in the literature as being associated with massive gravitons, in which case we may be observing longitudinal mode gravitational waves. A multiverse 5-D brane collision scenario is one possible source for the scalar field and waves. This scenario enables an estimate of the compacted 5th dimension radius at approximately 1,000,000 ly – the size of a galaxy dark matter halo. Our scalar field density parameter precisely replaces the ?CDM dark matter density parameter in the Friedmann equations, resulting in identical data fits, and its present value matches the Planck value. We therefore posit that this scalar field manifests itself as the dark matter.

Author(s): ***Harry Ringermacher (Dept. of Physics & Astronomy, U. of Southern Mississippi)***, Lawrence Mead (Dept. of Physics & Astronomy, U. of Southern Mississippi)

115.04 – A Statistical Test of the Relationship between Galactic HI Structure and Small-scale Structure in the Cosmic Microwave Background

The archive of IRIS, PLANCK and WMAP data available at the IRSA website of IPAC allows the apparent associations between galactic neutral hydrogen (HI) features and small-scale structure in WMAP and PLANCK data to be closely examined. In addition, HI new observations made with the Green Bank Telescope are used to perform a statistical test of putative associations. It is concluded that attention should be paid to the possibility that some of the small-scale structure found in WMAP and PLANCK data harbors the signature of a previously unrecognized source of high-frequency continuum emission in the Galaxy.

Author(s): ***Gerrit Verschuur (University of Memphis)***

115.05 – Polarization Measurements of Radio Sources at 43 and 95 GHz in the Q/U Imaging Instrument's Cosmic Microwave Background Survey

We present polarization measurements of extragalactic point sources that were observed during the Cosmic Microwave Background polarization survey of the Q/U Imaging Experiment (QUIET) at Q-band (43 GHz) and W-band (95 GHz). The sources we examined were selected from the public catalog of the Australia Telescope 20 GHz (AT20G) survey. About 480 sources lie within the four patches that QUIET surveyed (totaling ~ 1000 sq. deg.). We detect significant linear polarization for several sources in each frequency band. For the other sources we set limits on the polarized emission. Finally, we compare our polarization measurements to intensity and polarization measurements of the same sources from the literature.

Author(s): ***Kevin Huffenberger (Florida State University)***

Contributing teams: QUIET collaboration

115.06 – Results from the first season of POLARBEAR observations

POLARBEAR is a Cosmic Microwave Background (CMB) polarization experiment operating in the Atacama Desert in Chile since Spring 2012. The instrument covered 30 square degrees on the sky, using 1200 bolometric detectors sensitive in polarization with a resolution of 3.5 arcminutes, leading to one of the deepest CMB polarization maps in existence. The first season of observations with POLARBEAR was dedicated to searching for CMB B-mode polarization generated by the gravitational lensing induced by large scale structure. We will describe the experiment, its performance and the latest results derived from its data set.

Author(s): ***Josquin Errard (Lawrence Berkeley National Lab)***

Contributing teams: The POLARBEAR collaboration

115.07 – Constraints on dark matter annihilation by radio observations of Milky Way

WIMP annihilation in the Milky Way (MW) halo is expected to produce various energetic stable particles. These particles can manifest themselves through various emission processes. Such an emission spans almost the whole spectrum from radio to gamma bands. In a recent few years several groups reported the significant gamma ray excess at GeV energies in the MW center region, which can't be explained by conventional astrophysical sources. To explain this excess, one needs either an additional population of millisecond pulsars or the annihilating dark matter (DM). In the DM scenario, one may estimate the necessary WIMP properties. And several groups report rather close WIMP parameters needed: the annihilation cross section around the thermal relic value <?v>?(1-3)×10^{-26} cm^3/s, low mass $m_?$?(10-50) GeV and a dominant annihilation into b-anti(b) pairs. Naturally, we expect a radio counterpart of this gamma excess to be present, which originates as a synchrotron radiation of leptons produced by WIMP annihilation. And a comprehensive study of such a counterpart has not been conducted yet. Our work is in progress and focused on the low frequency emission. We are planning to present the general constraints on WIMP properties based on whole sky radio observations of MW (involving various radio surveys and Planck data), and also planning to support or weaken the DM interpretation of the gamma excess through studies of its expected synchrotron counterpart. According to our preliminary results, the WIMP parameters mentioned above may cause a serious tension with the corresponding observations, which may, in turn, provide new clues for the DM interpretation of the gamma excess.

Author(s): ***Andrey Egorov (University of Southern California)***, Jennifer Siegal-Gaskins (California Institute of Technology), Elena Pierpaoli (University of Southern California)

115.08 – An X-Ray Line from eXciting Dark Matter

The recently reported 3.5 keV line from galaxy clusters and M31 has rekindled interest in dark matter production of lines at X-ray energies. We propose a model in which WIMPs are collisionally excited and de-excite via photon production, thereby converting WIMP kinetic energy into photons. Such a mechanism has different dependencies on density and velocity than sterile neutrino decay, and has more flexibility for explaining the data. I will summarize the current observational status of the 3.5 keV line and the merits of various scenarios to explain it.

Author(s): ***Douglas Finkbeiner (Harvard Univ.)***, Neal Weiner (New York University)

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116 – Jacqueline van Gorkom: Gas and Galaxy Evolution: from Voids to Clusters

Plenary Session – America Ballroom North/Central – 02 Jun 2014 03:40 PM to 04:30 PM

Chair(s):
Paula Szkody (Univ. of Washington)

116.01 – Gas and Galaxy Evolution: from Voids to Clusters

Our understanding of the growth of large scale structure has advanced enormously over the last decade, thanks to an impressive synergy between theoretical and observational efforts. The formation and evolution of galaxies within these structures is less well understood and especially the details of the gas physics during accretion and outflow are still controversial. Hydrogen images can help distinguish between growth by mergers and accretion of gas, and between inflow and outflow. I will show results of HI imaging surveys of galaxies in the local universe in a wide range of environments, from the deepest underdensities of voids to the cores of galaxy clusters confirming some of the general trends seen in simulations. Small galaxies in voids still seem to accrete gas, and galaxies in clusters are losing it fast. Until recently these HI imaging surveys could not go beyond z~0.1. This has changed dramatically with the upgrade of the Very Large Array. I will present the very first results of CHILES, the COSMOS HI Large Extragalactic Survey, a 1000 hour JVLA survey for which the first observations started this fall. The survey will cover one pointing in the COSMOS field, and image in HI hundreds of galaxies from z=0 to z=0.45.

Author(s): ***Jacqueline Van Gorkom (Columbia Univ.)***

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117 – George Ellery Hale Prize, Tom Duvall: Waves Excited by Noise: Applications to Helioseismology and Beyond

Plenary Session – America Ballroom North/Central – 02 Jun 2014 04:30 PM to 05:20 PM

Chair(s):
Leon Golub (SAO)

117.01 – Waves Excited by Noise: Applications to Helioseismology and Beyond

The vigorous granular convection just beneath the solar photosphere excites acoustic waves. The resultant normal modes of the whole Sun are analogous to the ringing of a bell in a sandstorm. In classical helioseismology, the normal modes are used to study global solar properties, including the sound speed versus radius throughout the Sun and the rotation rate versus depth and latitude in the outer half of the Sun. But solar astronomers wished to better understand the subphotospheric 3-d structure of smaller scale features observed in the photosphere and were hence not satisfied studying only these global properties. One would like to have something akin to seismology, in which the waves from an earthquake traveling from a source through the interior to a distant receiver depend only on the properties along the path. However, the random nature of the solar convective wave sources generally prevents such a simple analogy. It was discovered that the temporal cross correlation of the solar oscillation signal between two locations averaged over many wave periods does mostly contain information about the properties along the path connecting the two locations. This discovery is the basis for time-distance helioseismology, in which travel times are extracted from the temporal cross correlations and mapped for different pairs of locations on the solar surface. A subsequent 3-d tomography aims to map the solar interior. This technique has been used to study the depth variation of a variety of solar photospheric features from small spatial scales (granulation) to larger scales (sunspots and supergranulation) to the largest scales (meridional circulation and rotation). The technique of temporal cross correlation of noise signals from two locations has subsequently been adopted successfully in a number of other fields including seismology, ultrasound, infrasound, ocean acoustics, structural engineering, lunar seismology, and medical diagnostics.

Author(s): ***Thomas Duvall (NASA Goddard Space Flight Center)***

118 – Jonathan Grindlay: Time Domain Astronomy with the Harvard Plates: from Cepheids to DASCH

Plenary Session – America Ballroom North/Central – 02 Jun 2014 06:30 PM to 07:20 PM

Chair(s):
Chryssa Kouveliotou (NASA/MSFC)

118.01 – Time Domain Astronomy with the Harvard Plates: from Cepheids to DASCH

The ~500,000 Harvard glass plate photographic negatives are the world’s largest and most complete (full sky; 107y time span) database for Time Domain Astronomy (TDA) on days-months-decades to century timescales. With plate fields of view ranging from 3^{o} – 30^{o} exposed quasi-randomly full sky from 1885 – 1992, any object is observed ~1000 - 3000 times, with limiting magnitudes ranging from B =12-18. I briefly review some of the colorful history of this massive plate-taking project and a few of the pivotal discoveries (e.g. the “Leavitt Law” for the Cepheid Period-Luminosity relation) made by visual studies of the plates by the true TDA pioneers, the likely <300 different visual users of the plates. I then describe our Digital Access to a Sky Century @ Harvard (DASCH) project to fully digitize and reduce this wealth of data (~1 Pb) and provide it on spinning disk to the full astronomical community and public. Using the full-sky APASS catalog giving BVR magnitudes (for V ~9-17) as well as GSC2.3.2 for both fainter and brighter stars, DASCH does spatially resolved (0.25^{o} -0.6^{o} bins) photometric calibrations to derive B magnitudes with rms~0.1mag over the full plate and over the (typically) ~6-8 different principal plate series (telescopes and plate scales) covering any given object, along with ~0.3-1 arcsec astrometry (depending on plate scale) for each stellar object averaged over ~1year. The high speed/precision scanner, plate processing, and analysis pipeline have now enabled the first data releases (DR1-DR3) of 12 to cover full sky and already enabled a wealth of new discoveries. I describe a few examples, such as: K2III giants with decadal variations; a new class of Symbiotic novae; ~50-100y recurrence times for black hole X-ray binary outbursts; and QPOs from 3C273. The DASCH data are increasingly available (~15% now; 100% in 3.5y) for TDA on largely unexplored timescales. We are grateful to NSF for support with grants AST-0407380, AST-0909073 and AST-1313370.

Author(s): ***Jonathan Grindlay (Harvard-Smithsonian, CfA)***

200 – Sara Seager: Mapping the Nearest Stars for Exotic Habitable Worlds

Plenary Session – America Ballroom North/Central – 03 Jun 2014 08:30 AM to 09:20 AM

Chair(s):
Steven Federman (Univ. of Toledo)

200.01 – Mapping the Nearest Stars for Exotic Habitable Worlds

Exoplanets are planets orbiting stars other than the sun. Thousands of exoplanets are known and thousands of more planet candidates have been found. Until now, the dominant focus on habitable worlds has been on Earth-like planets, because Earth is the only known planet with life. Yet exoplanets are astonishingly diverse—in terms of their masses, densities, orbits, and host star types—and this diversity motivates a radical extension of what conventionally constitutes a habitable planet. The race to find habitable exoplanets has accelerated with the realization that “big Earths” transiting small stars can be both discovered and characterized with current technology. Moreover, technology for space-based direct imaging of Earth analogs has been rapidly maturing. The ambitious goal of inferring signs of life via biosignature gases in an exoplanet atmosphere, once only a futuristic thought, is now within reach.

Author(s): ***Sara Seager (Massachusetts Institute of Technology)***

– LAD Posters Tuesday

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

218 – SPD Posters 2

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

218.01 – Daily Normalized Helicity of Subsurface Flows

Flare-productive active regions are associated with subsurface flows with large values of kinetic helicity density. Kinetic helicity is related to mixing and turbulence of fluids. Reinard et al. 2010 have developed a parameter that captures the variation of kinetic helicity with depth and time, the so-called Normalized Helicity Gradient Variance (NHGV). This parameter increases 2-3 days before a flare occurs and the NHGV values for flaring and non-flaring active regions represent clearly separate populations. We derive subsurface flows from the surface to a depth of 16 Mm using GONG and SDO/HMI Dopplergrams analyzed with the ring-diagram technique and calculate kinetic helicity density as a function of position on the solar disk. We will then calculate the NHGV parameter exploring different normalization schemes and depth ranges. We will present cases studies of active regions observed with GONG and SDO/HMI.

Author(s): ***Rudolf Komm (National Solar Observatory)***, Alysha Reinard (University of Colorado & NOAA/SWPC), Frank Hill (National Solar Observatory)

218.02 – A solar type II radio burst from CME-coronal ray interaction: simultaneous radio and EUV imaging

Simultaneous radio and extreme ultraviolet (EUV)/white-light imaging data are examined for a solar type II radio burst occurring on 2010 March 18 to deduce its source location. Using a bow-shock model, we reconstruct the 3-dimensional EUV wave front (presumably the type-II emitting shock) based on the imaging data of the two STEREO spacecraft. It is then combined with the Nan\c{c}ay radio imaging data to infer the 3-dimensional position of the type II source. It is found that the type II source coincides with the interface between the CME EUV wave front and a nearby coronal ray structure, providing evidence that the type II emission is physically related to the CME-ray interaction. This result, consistent with those of previous studies, is based on simultaneous radio and EUV imaging data for the first time.

Author(s): ***Yao Chen (Institute of Space Sciences)***, Guohui Du (Institute of Space Sciences)

218.03 – Validating Time-Distance Helioseismology With Realistic Quiet Sun Simulations

Linear time-distance helioseismic inversions are carried out for vector flow velocities using travel times measured from two ~100^2 Mm^2 x 20 Mm realistic magnetohydrodynamic quiet-Sun simulations of about 20 hr. The goal is to test current seismic methods on these state-of-the-art simulations. We find that horizontal flow maps correlate well with the simulations in the upper ~3 Mm of the domains for several filtering schemes, including phase-speed, ridge, and combined phase-speed and ridge measurements. In several cases, however, the velocity amplitudes from the inversions severely underestimate those of the simulations, possibly indicating nonlinearity of the forward problem. We also find that results of the inversions for the vertical velocity component depend significantly on the type of data filtering. In particular, phase-speed filters show better results than the other methods. In many cases, the vertical flows are irretrievable due to high levels of noise, suggesting a need for statistical averaging.

Author(s): ***Kyle DeGrave (New Mexico State University)***, Jason Jackiewicz (New Mexico State University), Matthias Rempel (HAO University Corporation for Atmospheric Research)

218.04 – The Divergence of CME and Sunspot Number Rates During Solar Cycle 24

In the previous three solar cycles the frequency of occurrence of CMEs observed in white light has closely tracked the solar cycle in both phase and amplitude, varying by an order of magnitude over the cycle. LASCO has now observed the entire solar Cycle 23 and continues to observe through the current rise and maximum phases of Cycle 24. Cycle 23 had an unusually long decline and extended minimum. During this period we have been able to image and count CMEs in the heliosphere, and can determine rates from both LASCO and STEREO SECCHI (since 2007) coronagraphs and from the Solar Mass Ejection Imager (SMEI – since 2003) and the SECCHI Heliospheric Imagers in the heliosphere. Manual rates estimated by observers are now supplemented by counts from identifications made by automatic programs, such as contained in the SEEDS, CACTus and ARTEMIS catalogs. Since the cycle 23/24 minimum, the CME and sunspot number rates have diverged, with similar cycle 23/24 rise and peak CME rates but much lower SSN rates in this cycle. We will discuss these rate estimates and their implications for the evolution of the global solar magnetic field.

Author(s): ***David Webb (Boston College)***, Orville St. Cyr (NASA/GSFC), Hong Xie (NASA/GSFC), Thomas Kuchar (Boston College)

218.05 – Studying Shallow Meridional Flow by Time-Distance Helioseismology during the Rising Phase of Cycle 24

Using continuous SDO/HMI Doppler observations, we have studied the solar subsurface torsional oscillation and meridional flow during the rising phase of solar cycle 24. The faster bands of the torsional oscillation pattern show clear temporal variations in both width and strength, and the band in the northern hemisphere extends past the equator into the southern hemisphere. The meridional-flow speed drops substantially with the rise of magnetic activity, and at some depths and for some brief periods, the flow even reverses directions in mid-latitudes. The residual meridional flow shows faster and slower bands like the torsional oscillation patterns, but its faster bands approach the equator earlier than the torsional oscillation bands. More interestingly, the meridional flow speed in latitudes above 35 degree slows down (speeds up) when the following-polarity (leading-polarity) magnetic flux is transported poleward, essentially delaying the magnetic polarity reversal and the onset of the next solar cycle.

Author(s): ***Junwei Zhao (Stanford Univ.)***, Alexander Kosovichev (New Jersey Institute of Technology), Richard Bogart (Stanford Univ.)

218.06 – New Insights into the Physical Nature of Coronal Mass Ejections within the Framework of the Three-dimensional Structures

We present new insights into the physical nature of coronal mass ejections (CMEs) within the framework of the three-dimensional (3D) structures. We have developed a forward-fitting method in order to determine the three-dimensional structures of multiple fronts comprising a CME, using data sets taken from STEREO Behind, SOHO and SDO, and STEREO Ahead. We applied the method to time series observations of a CME on 7 March 2012 and the observations from the three different perspectives showed the whole structure of the CME from footprints, so-called EUV waves, to the top, so-called leading edges, through the lateral flanks. From the analyses, we revealed that a CME could consist of two different fronts in the 3D structures: the one is represented well with a shape of ellipsoid, implying that CMEs are bubble-like structure and the other is reproduced well with a shape of graduated cylindrical shell (GCS), indicating that CMEs are flux rope-like structure. The bubble structure is seen as the outermost edge of the CME and pass through coronal streamers (global magnetic separatrices). The footprint of the bubble is the EUV wave front propagating against the solar disk. In addition, the bubble is found to be the front comprising a halo CME in white light observations. On the other hand, the flux rope structure is seen as the three part morphology having fixed legs and cannot pass through coronal streamers. From our results, we concluded that (1) a CME could have both structures, bubble and flux rope-like structure, (2) the bubble is in fact fast magnetosonic wave/shock front while the flux rope structure is the mass carried outward by underlying magnetic structures, (3) EUV wave is the footprint of the wave bubble, and (4) the circular front of the halo CME is the wave bubble.

Author(s): ***Ryun Young Kwon (George Mason University)***, Jie Zhang (George Mason University)

218.07 – Using Synthetic Data From Convection Simulations To Test Helioseismic Holography Inversions For Three-Dimensional Vector Flows

We investigate the efficacy of helioseismic holography for inferring the three-dimensional vector flows in the near-surface layers of the solar interior. Synthetic helioseismic data are taken from compressible convection simulations. Travel times are measured from the synthetic data using helioseismic holography. Kernels for the sensitivity of travel times to subsurface flows are calculated using the Born approximation. Inversions for subsurface flows are then performed using subtractive optimally localized averaging. This provides an opportunity to evaluate the accuracy of the inversion technique. We compare the actual flows present in the convection simulations to the flows retrieved by the inversion. We discuss the influence of the regularization used by the inversion, and the effects of noise and spatial resolution. This work is supported by the NASA SDO Science Center program (NNH09CE41C), the NASA Heliophysics Guest Investigator program (NNH12CF68C), and the NASA LWS TR&T tools and methods program (NNH09CF68C). The National Center for Atmospheric Research is sponsored by the National Science Foundation.

Author(s): ***Ashley Crouch (NorthWest Research Associates)***, Aaron Birch (Max Planck Institute for Solar System Research), Douglas Braun (NorthWest Research Associates), Brenda Javornik (NorthWest Research Associates), Matthias Rempel (National Center for Atmospheric Research)

218.08 – Developing 3D CME Models

We describe the development of CME models in three dimensions, including the energization of active regions and the initiation of eruptions via flux cancellation. We contrast the dynamics from idealized zero-beta models with more sophisticated models based on thermodynamic solutions. We explore the effect of the strength of the magnetic field in the active region (or, more appropriately, the amount of smoothing applied to the observed magnetic field), the profiles for transverse field emergence or applied shear, and the nature of the flux cancellation, on the dynamics of eruptions. In particular, our interest is in understanding which effects lead to fast CMEs.

Author(s): ***Zoran Mikic (Predictive Science, Inc.)***, Tibor Torok (Predictive Science, Inc.), Viacheslav Titov (Predictive Science, Inc.), Jon Linker (Predictive Science, Inc.), Kathy Reeves (Harvard Smithsonian)

218.09 – Observed properties of Giant Cells

The existence of Giant Cells has been suggested by both theory and observation for over 45 years. We have tracked the motions of supergranules in SDO/HMI Doppler velocity data and find larger (Giant Cell) flows that persist for months. The flows in these cells are clockwise around centers of divergence in the north and counter-clockwise in the south. Equatorward flows are correlated with prograde flows - giving the transport of angular momentum toward the equator that is needed to maintain the Sun's rapid equatorial rotation. The cells are most pronounced at mid- and high-latitudes where they exhibit the rotation rates representative of those latitudes. These are clearly large, long-lived, cellular features, with the dynamical characteristics expected from the effects of the Sun's rotation, but the shapes of the cells are not well represented in numerical models. While the Giant Cell flow velocities are small (<10 m/s), their long lifetimes should nonetheless substantially impact the transport of magnetic flux in the Sun's near surface layers.

Author(s): ***David Hathaway (NASA/MSFC)***, Lisa Upton (The University of Alabama, Huntsville), Owen Colegrove (University of Rochester)

218.10 – CME Mass Estimates via EVE Coronal Dimmings for X-class Flares

The EVE instrument on SDO detects post-flare dimmings, mainly in the spectral regions of Fe IX-XII in its MEGS-A range, which is available for most of the 29 X-class flares that have occurred between SDO launch and the end of April 2014. Based upon earlier X-ray observations we interpret these dimmings as the result of CME mass ejection from the low corona. We estimate the masses involved in these dimmings by deriving a best pre-event temperature and emission measure in the dimmed region from EVE, and a source volume from AIA images. The dimming for SOL2011-02-15, the first of these events, "peaked"at -3.4% in Fe IX in terms of the pre-event emission from the whole Sun, with smaller relative depletions in higher ionization states of Fe. The "maximum" occurred more than one hour after GOES peak. The dimming signature is generally cleanly measurable in the EVE/MEGS-A spectral samples at 10 s cadence, with the dominant source of uncertainty stemming from the "sun-as-a-star" integrations; for example flare-related excess emission at a given wavelength tends to compensate for the dimming, and in this sense the mass estimate must be considered a lower limit. We address these uncertainties for the solar case by appealing to the AIA images, but for analogous processes in stellar flares one would not have this luxury.

Author(s): ***Hugh Hudson (University of Glasgow)***, Iain Hannah (University of Glasgow), Karel Schrijver (Lockheed Martin Advanced Technology Center)

218.11 – Photospheric and Chromospheric Dynamics of Sunspots Observed with New Solar Telescope

The 1.6m New Solar Telescope (NST) of Big Bear Solar Observatory allows us to investigate the structure and dynamics of sunspots with unprecedented spatial and temporal resolutions. We present results of simultaneous observations of a sunspot in the photosphere with a broad-band TiO-line filter and in the chromospheric H-alpha line with Visible Imaging Spectrometer, and compare the observational results with MHD models of sunspots. The observations reveal previously unresolved features of the sunspot umbra and penumbra. In particular, the TiO data clearly demonstrate highly twisted dynamics of penumbral filaments and umbral dots and reveal strong shearing plasma flows in sunspot bridges, not explained by the MHD simulations. The high-resolution H-alpha spectroscopic data provide new views of the sunspot chromospheric dynamics, including the fine structure of oscillations and waves, penumbral jets, ubiquitous small-scale eruptions, and accretion flows in a form of dense plasma sheets. The diffraction-limited NST observations show that the sunspot dynamics is more complicated and much richer than it is described by the current sunspot models.

Author(s): ***Alexander Kosovichev (Crimean Astrophys. Observatory)***, Vasyl Yurchyshyn (New Jersey Institute of Technology)

218.12 – Structures of Interplanetary Magnetic Flux Ropes and Comparison with Their Solar Sources

Whether a magnetic flux rope is pre-existing or in-situ formed in the Sun's atmosphere, there is little doubt that magnetic reconnection is essential to release the flux rope during its ejection. During this process, the question remains: whether and how does the magnetic reconnection change the flux rope structure? In this work, we continue with the original study by Qiu et al. (2007) by using a larger sample (19) of events to compare properties of ICME/MC flux ropes measured at 1 AU and properties of associated signatures (flares, CMEs, filaments) on the Sun. In particular, the magnetic field-line twist distribution within interplanetary magnetic flux ropes is systematically derived and examined. The analysis results show that these flux ropes exhibit either a rather flat twist distribution from center to edge or a high twist at the core which decreases toward the edge. We also present detailed case studies for selected events with the corresponding solar source regions either or not dominated by erupting filaments, and discuss how reconnection properties reflected in the flare morphology may be related to the structure of the enfant flux rope formed on the Sun.

Author(s): ***Jiong Qiu (Montana State University)***, Qiang Hu (University of Alabama in Huntsville)

218.13 – Fitting medium and high degrees using GONG, MDI and HMI observations.

I present results from fitting data from the three major helioseismic instruments: GONG, MDI, and HMI, both at medium degree (resolved modes) and at high degrees (ridge fitting). The medium-l fitting was carried out on time-series of varying lengths (1x, 2x, 4x, 8x, 16x, 32x, 64x 72 day longs, and 36 day long ones), the high-l fitting was carried out on co-eval time-series that correspond to the 2001, 2002 and 2010 MDI Dynamics runs. I present these results, compare them and discuss the potential sources of the discrepancies.

Author(s): ***Sylvain Korzennik (Harvard-Smithsonian, CfA)***

218.14 – Height-dependent Refraction of A Global EUV Wave and Its Associated Sympathetic Eruptions

The height dependence of global extreme-ultraviolet (EUV) waves in the solar corona, especially of their wave-like behaviors such as transmission and reflection, is critical to understanding their physical nature. Prior observations of such behaviors, when detected on the solar disk, were compromised because height-dependent information is lost due to the line-of-sight projection from a top-down view. We report a global EUV wave on the limb observed by SDO/AIA from a side-view that evidently shows height-dependent transmission and refraction. As the wave travels through an active region, the orientation of the low-corona wave front changes from a forward inclination toward the solar surface to a backward inclination. This indicates that the EUV wave speed is lower at higher altitudes, which is expected because of the rapid drop with height of the Alfven and fast-mode speeds in active regions, as predicted by MHD models. When traveling into the active region, the EUV wave speed in the low corona increases from ~600 km/s to ~900 km/s. In addition, in the neighborhood of the active region, sympathetic eruptions of local coronal structures take place sequentially upon the wave impact and may appear as wave reflection. Understanding propagation behaviors of global EUV waves brings us one step closer to fully utilizing them for seismological diagnostics of the global corona, such as mapping the spatial distribution of the Alfven speed and magnetic field strength.

Author(s): ***Wei Liu (Lockheed Martin Solar and Astrophysics Laboratory)***, Leon Ofman (Catholic University of America and NASA Goddard Space Flight Center), Cooper Downs (Predictive Science Inc.), Karel Schrijver (Lockheed Martin Solar and Astrophysics Laboratory)

218.15 – A Helioseismic Survey to Investigate Relationships between Subsurface Flows beneath Large Active Regions and Solar Flares

A survey of the subsurface flow properties of about 120 of the largest active regions, determined from the application of helioseismic holography to Dopplergrams obtained with the HMI instrument onboard the Solar Dynamics Observatory, is being carried out. The overriding goal is to characterize differences in the subsurface flows between active regions associated with eruptive flares and the flows observed in relatively quiescent regions. Applications to flare forecasting comprise only one part of this investigation, since the potential response of the subsurface environment to eruptive events during and after their occurrence is also of scientific interest. Other priorities include understanding the limitations of the helioseismic methods, identifying and correcting systematic effects, and validating the reliability of the measurements using artificial data. While inversions to determine the variation with depth of subsurface flows are planned, preliminary results will be discussed which make use of proxies for near-surface depth-integrated properties, including the horizontal component of the flow divergence and the vertical component of the flow vorticity. This work is supported by the Solar Terrestrial Program of the National Science Foundation, through grant AGS-1127327, and by the National Oceanic and Atmospheric Administration SBIR program.

Author(s): ***Douglas Braun (NorthWest Research Associates, Inc.)***, K Leka (NorthWest Research Associates, Inc.), Graham Barnes (NorthWest Research Associates, Inc.)

218.16 – Numerical Simulation of a Slow Streamer-Blowout CME

We present a 3D numerical MHD simulation of the 2008 Jun 2 gradual streamer blowout CME that had virtually no identifiable low coronal signatures. We energize the field by simple footpoint shearing along the source region's polarity inversion line and model the background solar wind structure using an ?2MK isothermal wind and a low-order potential field source surface representation of the CR2070 synoptic magnetogram. Our results show that the CME ``initiation’’ is obtained by slowly disrupting the quasi-steady-state configuration of the helmet streamer, resulting in the standard eruptive flare picture that ejects the sheared fields, but very slowly, on a relatively large scale, and with very little magnetic energy release. We obtain a relatively slow CME eruption of order the background solar wind speed and argue that these slow streamer blowout CMEs (now also known as ``stealth CMEs’’) are simply at the lowest end of the CME energy distribution. We present comparisons of the CME propagation through the corona (?15Rs) in synthetic white-light images derived from the simulation density structure with multi-spacecraft coronagraph data from STEREO/SECCHI and SOHO/LASCO.

Author(s): ***Benjamin Lynch (Univ. of California-Berkeley)***, Sophie Masson (Goddard Space Flight Center), Yan Li (Univ. of California-Berkeley), C. DeVore (Goddard Space Flight Center), Janet Luhmann (Univ. of California-Berkeley), Spiro Antiochos (Goddard Space Flight Center)

218.17 – Helioseismic Ring-diagram Diagnostics of Solar Fares.

Flares are known to excite waves in the solar atmosphere. Maurya et al. (2009), using a local analysis (ring diagrams) of the 2003 Halloween flare, also showed they excite p-modes. We confirm and extend here these results by: -applying the same analysis to other locations on the Sun at the time of the Halloween flare -analyzing another event also showing a signature of p-mode excitation -looking in details at the results of the ring diagrams analysis in terms of noise fitting. The Halloween flare present an apparent localized excitation of p-modes, similar to what is observed for the other event analyzed.

Author(s): ***John Leibacher (Institut d'Astrophysique Spatiale)***, Frédéric Baudin (Institut d'Astrophysique Spatiale)

218.18 – Active region 11748: Recurring X-class flares, large scale dimmings and waves.

AR 11748 was a relatively compact active region that crossed the solar disk between 05/14/2013 and 05/26/2013. Despite its size it produced a number X-class flares, and global scale eruptive events that were captured by the SDO Feature Finding Team's (FFT) Dimming Region Detector. Using the results of this module and other FFT modules, we present an analysis of the this AR region and investigate why it was so globally impactful.

Author(s): ***Alisdair Davey (SAO)***, Anna Malanushenko (Lockheed Martin Advanced Technology Center), Scott McIntosh (High Altitude Observatory)

218.19 – Evolution of the Near-surface Flows Inferred from High-resolution Ring-diagram Analysis of HMI Data

Ring-diagram analysis of acoustic waves observed at the photosphere provides in principle a relatively robust determination of the sub-surface flows at a particular time under a particular region. The depth of penetration of the waves is related to the size of the region, hence the depth extent of the measured flows is inversely proportional to the spatial resolution. Most ring-analysis has focused on regions of extent ~15 deg (200 Mm) or more in order to provide reasonable mode sets for inversions. The HMI analysis pipeline however also provides a set of ring fit parameters on a scale three times smaller. These provide flow estimates for the outer 1% (7 Mm) of the Sun only, with very limited depth resolution, but with spatial resolution adequate to map structures.potentially associated with the belts and regions of magnetic activity. There are a number of systematic effects affecting the determination of flows from local helioseismic analysis of regions over different parts of the observable disc, not all well-understood. In this study we characterize those systematic effects with higher spatial resolution. This enable us to remove them more effectively as we map the temporal and spatial evolution of the flows, leaving open the question of their mean structure which is most affected by the systematics. We present results for the ring-diagram determination of the flow anomalies corresponding to the torsional oscillation pattern in differential rotation and analogous patterns in the meridional cell structure over the early part of the current solar cycle observed by HMI.

Author(s): *Richard Bogart (Stanford University)*, Charles Baldner (Stanford University), Sarbani Basu (Yale University)

218.20 – Structure and Dynamics of One Polar Crown Prominence Eruption

We will present the recent progress on the investigation of the polar crown prominence that erupted on 2012 March 12. This prominence is viewed at the east limb by SDO/AIA and displays a quasi vertical-thread structure. Bright U-shape (horn-like) structure is observed surrounding the upper portion of the prominence before the eruption and becomes more prominent during the eruption. When viewed on the disk, STEREO-B shows that this prominence is composed of a series of vertical threads and displays a loop-like structure during the eruption. We focus on the magnetic support of the prominence by studying the structure and dynamics of the prominence before and during the eruption using observations from SDO, Hinode, and STEREO. We found that the transition from slow rise to fast rise phase is associated with magnetic reconnection below rising prominence threads. We also constructed a series of magnetic field models (including sheared arcade model and twisted flux rope model) of the prominence using the “flux rope insertion method”, we will compare them with observations in order to find the best-fit model. Our recent progress on the thermodynamics of the erupting prominence will also be presented.

Author(s): *Yingna Su (Harvard-Smithsonian Center for Astrophysics)*, Adriaan Van Ballegooijen (Harvard-Smithsonian Center for Astrophysics), Patrick McCauley (Harvard-Smithsonian Center for Astrophysics), Kathy Reeves (Harvard-Smithsonian Center for Astrophysics), Edward DeLuca (Harvard-Smithsonian Center for Astrophysics), Haisheng Ji (Purple Mountain Observatory, CAS)

218.21 – Photospheric and sub-photospheric Flows in Active Regions

The availability of continuous high-cadence and high-spatial resolution Dopplergrams allows us to study sub-surface dynamics that may be further extended to explore precursors of the solar activity. Since p-mode power is absorbed in high magnetic field regions, the helioseismic inferences in these regions are associated with large errors. In order to validate results, we use Dopplergrams from both space-borne (Helioseismic Magnetic Imager-HMI) and ground-based (Global Oscillation Network Group-GONG) observations to infer horizontal flows in photospheric and sub-photospheric layers in and around several active regions with different characteristics. The photospheric flows are calculated using local correlation tracking (LCT) method while ring-diagram analysis technique is used to infer flows in the sub-photospheric regions. A detailed comparison between flows in shear layer and photospheric layer will be made in order to study similarities and discrepancies in these results.

Author(s): *Kiran Jain (National Solar Observatory)*, Rudolf Komm (National Solar Observatory), Sushanta Tripathy (National Solar Observatory), B. Ravindra (Indian Institute of Astrophysics), Frank Hill (National Solar Observatory)

218.22 – Column Densities of an Eruptive Prominence over Time

We present a series of column density measurements for an eruptive prominence. The eruption occurred on March 12th, 2012, and observations were recorded by the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamics Observatory. We estimate the background emission to obtain an optical depth, which can be used to estimate the column density at all positions along the prominence. This is done every 30 minutes for 2 days leading up to the eruption. The series of column density maps can then be used to estimate the total mass of the prominence as it evolves with time. Whether or not there is significant mass loss or loading is an important constraint on the eruption mechanism. Our early work has found no significant change in the prominence mass over the two days leading up to the eruption, but we are currently working to reconcile a discrepancy between independent estimations made using AIA's 193, 211, and 335 Angstrom passbands. The results from this work will be presented.

Author(s): *Patrick McCauley (Smithsonian Astrophysical Observatory)*, Edward DeLuca (Smithsonian Astrophysical Observatory), Yingna Su (Smithsonian Astrophysical Observatory)

218.23 – Sub-surface Meridional Flow Results from MWO, GONG, and MDI during Solar Cycle 23

Time series of full-disk Dopplergrams were acquired at the 60-Foot Solar tower of the Mount Wilson Observatory every year between 1987 and 2009. Analysis of this archive revealed that the focal plane of the Tower did experience a small amount of systematic rotation, which suggested that the alignment of the optics had changed slightly over the years since its construction in 1907. This has caused some of the initial daily flow maps to possess a so-called “washing machine” effect similar to the pattern that was seen in raw GONG flow maps. We have incorporated a systematic program of ring-diagram analysis in which we have tracked the raw solar images using five differing assumed instrumental rotation rates. We have then gone on to compute synoptic maps of the horizontal flow vectors at several different depths over much of Solar Cycle 23 in order to study how such an instrumental rotation might affect both the zonal and meridional flows as functions of latitude, depth, and time. We compare these results with GONG and MDI flow measurements to empirically determine the regime within which the MWO results are reliable and extend our analysis into Solar Cycle 22.

Author(s): ***Stephen Pinkerton (University of Southern California)***, Edward Rhodes (University of Southern California), Richard Bogart (Stanford University)

218.25 – Measuring The Solar Radius With SDO/HMI and SDO/AIA During The Venus Transit Of 2012

During the Venus transit of 2012, the side camera of HMI (Helioseismic and Magnetic Imager, on board SDO) took images in the continuum near 6173 A at a 3.75 second cadence. By timing the crossings by the center of the planet of the solar limb (based on the Venus obscuration of the solar disk), and by comparing the results with an ephemeris, we can accurately estimate the solar radius. Here, this radius is defined as the inflection point of the limb darkening function. We obtain a value at 1 AU of 959.58". We further discuss estimates of the statistical and systematic errors in this measurement (in particular the role of the PSF correction), and we apply the same method to AIA 1600 and AIA 1700 images.

Author(s): ***Sebastien Couvidat (Stanford Univ.)***, Rock Bush (Stanford Univ.)

218.27 – RHESSI/SAS Observations of the Optical Solar Limb Over a Full Solar Cycle

The Solar Aspect System (SAS) of the RHESSI satellite measures the optical solar limb in the red continuum with a cadence typically set at 16 samples/s in each of three linear CCD sensors. RHESSI has observed the Sun continuously since its launch in early 2002, and we have acquired a unique data set ranging over a full 11-year solar cycle and consisting of about 3x10^10 single data points. Analyzing data for an initial period in 2004, these measurements have led to the most accurate oblateness measurement to date, 8.01+-0.14 milli arcsec (Fivian et al., 2008), a value consistent with models predicting an oblateness from surface rotation. An excess oblateness term can be attributed to magnetic elements possibly located in the enhanced network. We have started to also study photometric properties of our data. Previous observations of latitude-dependent brightness variations at the limb had suggested the presence of a polar temperature excess as large as 1.5 K. The RHESSI observations, made with a rotating telescope in space, have great advantages in the rejection of systematic errors in the very precise photometry required for such an observation. Our new measurements of latitude-dependent brightness variations at the limb lead to a quadrupolar term (a pole-to-equator temperature variation) of the order of 0.1 K, an order of magnitude smaller than previously reported. We present the analysis of these unique data, an overview of some results and we report on our progress as we apply our developed analysis method to the whole 12 years of data.

Author(s): ***Martin Fivian (Space Sciences Lab/ UC Berkeley)***, Hugh Hudson (Space Sciences Lab/ UC Berkeley)

218.28 – Combining Models, Theory and Observations to Reconstruct CME and Shock Morphology and Create an Empirical Prediction Model

There are many factors that contribute to the evolution and propagation of a Coronal Mass Ejection as well as associated shock waves in the interplanetary space, including both the initial characteristics of the CME as well as the physical quantities of the solar wind regime the CME will be encountering. No one data set contains enough information to constrain these parameters, but by combining a number of different data sets including in-situ solar wind measurements, remote sensing white light and EUV observations, numerical models and using a theoretical propagation model based on aerodynamic drag, the study of multiple events can lead to an empirical prediction model for the arrival of both the CME ejecta and shock at the Earth. The more events that are studied the more accurate the results will be as the forces governing CME acceleration/deceleration are better understood.

Author(s): ***Phillip Hess (George Mason University)***, Jie Zhang (George Mason University)

218.29 – Statistical Constraints on Joy's Law

Using sunspot data from the observatories at Mt. Wilson and Kodaikanal, active region tilt angles are analyzed for different active region sizes and latitude bins. A number of similarly-shaped statistical distributions were fitted to the data using maximum likelihood estimation. In all cases, we find that the statistical distribution best describing the number of active regions at a given tilt angle is a Laplace distribution with the form $(2?)^{-1}$*exp(-|x-?|/?), with 2° ? ? ? 11°, and 10° ? ? ? 40°.

Author(s): ***Ernest Amouzou (Montana State University)***, Andres Munoz-Jaramillo (Harvard-Smithsonian Center for Astrophysics), Petrus Martens (Harvard-Smithsonian Center for Astrophysics), Edward DeLuca (Harvard-Smithsonian Center for Astrophysics)

218.30 – Rolling Motions During Solar Prominence Eruptions in Asymmetric Magnetic Environments

Panasenco et al. [1] report observations of several CMEs that display a rolling motion about the axis of the erupting prominence. Murphy et al. [2] present simulations of line-tied asymmetric magnetic reconnection that make a falsifiable prediction regarding the handedness of rolling motions of flux ropes during solar eruptions. We will present initial results of our work to investigate this prediction. To determine the strength and any asymmetric properties of the magnetic field in the regions of interest in the photosphere, we use magnetograms from HMI. We use AIA observations to determine if there is any rolling motion and, if so, what handedness the rolling motions have. We then compare the photospheric magnetic information with the handedness information to determine if there is any relationship between the two. Finally, we will discuss prospects for diagnosing rolling motions of erupting prominence using off-limb IRIS observations. [1] O. Panasenco, S. Martin, A. D. Joshi, & N. Srivastava, J. Atmos. Sol.-Terr. Phys., 73, 1129 (2011) [2] N. A. Murphy, M. P. Miralles, C. L. Pope, J. C. Raymond, H. D. Winter, K. K. Reeves, D. B. Seaton, A. A. van Ballegooijen, & J. Lin, ApJ, 751, 56 (2012)

Author(s): ***Sean McKillop (Smithsonian Astrophysical Observatory)***, Mari Paz Miralles (Smithsonian Astrophysical Observatory), Nicholas Murphy (Smithsonian Astrophysical Observatory), Patrick McCauley (Smithsonian Astrophysical Observatory)

218.31 – Temporal Variation of Photospheric Spectral Lines Profiles with the Solar Cycle of Activity

We investigated the variations in the sun-as-a-star profiles of several photospheric spectral lines observed during the decline of solar cycle 23 and the rising phase of cycle 24. Daily measurements were taken with the Integrated Sunlight Spectrometer (ISS) operating at the National Solar Observatory at Kitt Peak (Arizona) since December 2006. ISS, which is one of three instruments comprising the Solar Optical Investigations of the Sun (SOLIS) facility, is designed to obtain high spectral resolution (R = 300,000) observations of the Sun as a star in a broad range of wavelengths (350 nm - 1100 nm). Recent improvements in the spectral calibration of SOLIS/ISS measurements have significantly enhanced the diagnostic capabilities of these data. We will present time series of line parameters and discuss their correlation to the global magnetic flux. Because of their different response to variations in the thermodynamic and magnetic structures of the solar atmosphere, the measured line shape parameters provide an excellent tool to disentangle thermal and magnetic effects occurring during different phases of the solar cycle. The results of this analysis may also help with developing a better understanding of magnetic cycle of activity in other solar-like stars.

Author(s): ***Luca Bertello (National Solar Observatory)***, Alexei Pevtsov (National Solar Observatory), Andrew Marble (National Solar Observatory)

218.32 – Some analysis based on three flare associated CMEs

Magnetic reconnection is the main energy release process during a solar eruption. We try to investigate the relationship between CMEs and magnetic reconnection by analyzing three flare associated CMEs observed by STEREO and SDO. We focus on tracking CMEs from surface and comparing them with associated flare evolutions. We also compare our results with the numerical work.

Author(s): ***Jianxia Cheng (Shanghai Astronomical Observatory, CAS)***, Jiong Qiu (Montana State University), Shane Sullivan (Northern Illinois University)

218.33 – The Constant Size and Shape of the Sun

Over the last four years, the Helioseismic and Magnetic Imager (HMI) instrument on the Solar Dynamics Observatory spacecraft has been measuring the radius and oblateness of the Sun. The primary observations for the solar radius are full Sun images taken twice per day in the continuum wing of the 617.3 nm Fe I absorption line. The solar radius is defined as the mean distance from the center of the Sun to the inflection point of the limb darkening function. After correcting for the varying Sun-spacecraft distance and temperature variation of the optics, the measured solar radius is essentially constant over the rising phase of the solar cycle. Measurements of the solar oblateness are obtained twice per year in April and October when the spacecraft is rotated 360 degrees around the Sun-spacecraft line. HMI observations taken during these roll maneuvers allow the instrument distortion to be separated from the solar shape. There is an apparent spring to fall change which may be due to seasonal variation of the measurements which have not been corrected. The long term trend of the solar oblateness, however, does not show a correlation with the current solar sunspot cycle.

Author(s): ***Rock Bush (Stanford University)***, Marcelo Emilio (Universidade Estadual de Ponta Grossa), Jeffrey Kuhn (University of Hawaii)

218.34 – Comparison of CME three-dimensional parameters derived from single and multi-spacecraft

Several geometrical models (e.g., cone and flux rope models) have been suggested to infer three-dimensional parameters of CMEs using multi-view observations (STEREO/SECCHI) and single-view observations (SOHO/LASCO). To prepare for when only single view observations are available, we have made a test whether the cone model parameters from single-view observations are consistent with those from multi-view ones. For this test, we select 35 CMEs which are identified as CMEs, whose angular widths are larger than 180 degrees, by one spacecraft and as limb CMEs by the other ones. For this we use SOHO/LASCO and STEREO/SECCHI data during the period from 2010 December to 2011 July when two spacecraft were separated by 90±10 degrees. In this study, we compare the 3-D parameters of these CMEs from three different methods: (1) a triangulation method using STEREO/SECCHI and SOHO/LASCO data, (2) a Graduated Cylindrical Shell (GCS) flux rope model using STEREO/SECCHI data, and (3) an ice cream cone model using SOHO/LASCO data. The parameters used for comparison are radial velocities, angular widths and source location (angle ? between the propagation direction and the plan of the sky). We find that the radial velocities and the ?-values from three methods are well correlated with one another (CC > 0.8). However, angular widths from the three methods are somewhat different with the correlation coefficients of CC > 0.4. We also find that the correlation coefficients between the locations from the three methods and the active region locations are larger than 0.9, implying that most of the CMEs are radially ejected.

Author(s): ***Harim LEE (Kyung Hee University)***, Yong-Jae Moon (Kyung Hee University), Hyeonock Na (Kyung Hee University), Soojeong Jang (Kyung Hee University)

218.35 – Which CME cone type is closer to observations?

Recently, CME cone models are widely used for inferring three dimensional structures of CMEs and their propagation through the heliosphere, especially for the input parameters of CME propagation models. However, there has been no observational test which cone type is closer to observations. In this study, we investigate which cone model is proper for halo CME morphology using 33 CMEs which are identified as halo CMEs by one spacecraft and as limb CMEs by the other ones. These CMEs were taken by SOHO/LASCO and STEREO/SECCHI during the period from 2010 December to 2011 June when two spacecraft were separated by 90±10 degrees, which allow us to directly estimate their angular widths from observations. From geometrical parameters of these CMEs such as their front curvature, they are classified into two groups: shallow cone CMEs (5 events), whose curvature radius is equal to the distance of CME front from the center of the Sun, and near full-cone CMEs (28 events), whose front has a semi-circle shape. Noting that the previous cone models are based on flat cone or shallow cone shapes, our results imply that a cone model based on the full cone shape should be developed.

Author(s): ***Hyeonock Na (Kyung Hee University)***, Soojeong Jang (Kyung Hee University), Jea-Ok Lee (Kyung Hee University), Harim LEE (Kyung Hee University), Yong-Jae Moon (Kyung Hee University)

218.36 – Temperature and mass estimation of erupting plasma associated with coronal mass ejections observed by Hinode/XRT and SDO/AIA

We investigate the temperature and mass of erupting plasma observed in X-ray and EUV, which are associated with coronal mass ejections (CMEs) and X-class flares. Hinode/XRT observed the erupting hot plasma in a few passbands, which allows us to determine the temperature of the plasma using a filter ratio method. SDO/AIA observed the erupting plasma in EUV passbands. We estimate the temperatures and emission measures of the erupting plasma in EUV using a differential emission measure method. One of these observations shows an eruptive plasma with a loop-like structure in X-ray and EUV. The temperature of the erupting plasma in X-ray is about 13 MK by the filter ratio method. The estimated mass of this erupting plasma in X-ray is similar to that in EUV. A couple of events are associated with the eruptions of prominences as absorption features in EUV in addition to hot plasma eruption. One event shows that the absorption features change to emission features at the beginning of their eruptions in all EUV wavelengths of SDO/AIA. By estimating the temperature and mass of the erupting plasmas, we discuss the heating of the plasmas associated with coronal mass ejections in the low corona.

Author(s): ***Jin-Yi Lee (Kyung Hee University)***, John Raymond (Harvard-Smithsonian Center for Astrophysics), Kathy Reeves (Harvard-Smithsonian Center for Astrophysics), Yong-Jae Moon (Kyung Hee University), Kap-Sung Kim (Kyung Hee University)

218.37 – The Role of CMEs in the Escape of Solar Energetic Particles

Heliospheric manifestations of intense energy release linked to solar activity include the impact at Earth of energetic particles accelerated during solar eruptions. Observationally, the magnetic configuration of active regions, where solar eruptions occur, agrees well with the standard model of eruption, consisting of a flare and a coronal mass ejection (CME). According to the standard model, particles accelerated at the flare reconnection site should remain trapped in the CME. However, flare-accelerated particles frequently reach the Earth long before the CME does. We present a 3D model that demonstrates how flare-accelerated particles escape into interplanetary magnetic flux tubes during a solar eruption. Our model is based on results of large-scale 3D MHD simulations of a breakout CME erupting into a heliospheric magnetic field that is opened by an isothermal solar wind. The simulations are performed with the Adaptively Refined MHD Solver (ARMS). We describe the multiple reconnection episodes that occur during the evolution of the event, and show how CME magnetic flux reconnects with the open field from a nearby coronal hole. This reconnection allows flare-accelerated particles initially trapped in the CME to escape onto open field lines. Analyzing the dynamics of the reconnected flux during the eruption, we determine the spatial distribution of particle beams originating in the CME flux rope. We find that particle release can occur over a wide longitudinal range, which heretofore has been a puzzling feature of SEP observations. We discuss the implications of our results for CME/flare models and for the origin and transport of SEPs. This work was supported, in part, by the NASA TR&T and SR&T Programs.

Author(s): ***Sophie Masson (NASA/GSFC)***, Spiro Antiochos (NASA/GSFC), C. DeVore (NASA/GSFC)

218.38 – Results from Persistence Mapping of Solar EUV Data

Persistence Mapping is a simple image processing technique that is useful for the visualization and depiction of gradually evolving or intermittent structures. Persistence Mapping allows the user to isolate extreme values in a data set, and is particularly useful for the problem of capturing phenomena that are evolving in both space and time. While integration or "time lapse" imaging uses the full sample (of size N), Persistence Mapping rejects (N-1)/N of the data set and identifies the most relevant 1/N values using the following rule: if a pixel reaches an extreme value, it retains that value until that value is exceeded. The simplest examples isolate minima and maxima, and the technique has been used to extract the dynamics in long-term evolution of comet tails, erupting material, spicules, and EUV dimming regions. The presentation will review the technique and discuss scientific results obtained through Persistence Mapping. For more information, please see http://sipwork.org/persistence-mapping

Author(s): ***Barbara Thompson (NASA's GSFC)***, C. Young (NASA's GSFC)

218.39 – SunPy - Python for Solar Physics, Version 0.4

We presents version 0.4 of SunPy, a community-developed Python package for solar physics. Python, a free, cross-platform, general-purpose, high-level programming language, has seen widespread adoption among the scientific community, resulting in the availability of a large number of software packages, from numerical computation NumPy, SciPy and machine learning (scikit-learn) to visualisation and plotting (matplotlib).SunPy is a data-analysis environment specialising in providing the software necessary to analyse solar and heliospheric datasets in Python. SunPy is open-source software (BSD licence) and has an open and transparent development workflow that anyone can contribute to. SunPy provides access to solar data through integration with the Virtual Solar Observatory (VSO), the Heliophysics Event Knowledgebase (HEK), and the HELiophysics Integrated Observatory (HELIO) webservices. It currently supports image data from major solar missions (e.g., SDO, SOHO, STEREO, and IRIS), time-series data from missions such as GOES, SDO/EVE, and PROBA2/LYRA, and radio spectra from e-Callisto and STEREO/SWAVES. We describe SunPy's functionality, provide examples of solar data analysis in SunPy, and show how Python-based solar data-analysis can leverage the many existing tools already available in Python. We discuss the future goals of the project and encourage interested users to become involved in the planning and development of SunPy.

Author(s): ***Steven Christe (NASA GSFC)***, Stuart Mumford (University of Sheffield), David Perez-Suarez (South African National Space Agency - Space Science), Jack Ireland (ADNET systems), Albert Shih (NASA GSFC), Andrew Inglis (Catholic University), Simon Liedtke (University of Bremen), Russel Hewett (MIT)

Contributing teams: Sunpy collaboration

218.40 – Naming Collections of Solar Physics Data

To better deal with tracking cross-discipline data usage, a number of groups have come up with guidelines and principles for data citation. In 2012, the National Academy's Board on Research Data and Information released the report "For Attribution-Developing Data Attribution and Citation Practices and Standards" [1] and it was followed last year by the CODATA-ICSTI report "Out of Cite, Out of Mind".[2] Participants from a number of groups synthesized a single set of principles for data citation that could be endorsed by all groups involved in research.[3] Implementing these principles can help to improve the scientific ecosystem by giving proper attribution to all contributors to data, improving transparency and reproducability, and making data more easily reusable to both astronomers and other researchers. Unfortunately, to implement these principles, we first need to come up with appropriate groupings of data such that they can be easily cited.[4] From this, we can determine appropriate names/titles to unambiguously identify them. The Virtual Solar Observatory will need to work with PI teams to determine these groupings and document them using the DataCite schema.[5] We will present the Joint Declaration of Data Citation Principles and the DataCite schema, discuss the implication of them for solar physics data, and recommend steps towards implementation. References: [1] National Research Council, 2012. http://www.nap.edu /catalog.php?record_id=13564 [2] CODATA, 2013. http://dx.doi.org/10.2481/dsj.OSOM13-043 [3] FORCE11, 2014. http://www.force11.org/datacitation [4] Wynholds, 2011. http://dx.doi.org/10.2218/ijdc.v6i1.183 [5] DataCite, 2013. http://dx.doi.org/10.5438/0008

Author(s): ***Joseph Hourcle (Wyle IS)***

Contributing teams: Virtual Solar Observatory, FORCE11 Data Citation Synthesis Group

218.41 – Final (or Maybe Not So Final) Archiving of Solar Physics Data: Assuring the Validity of and Access to Data in the Post-NSSDC Epoch

Historically, NASA's National Space Science Data Center was responsible for the long-term preservation, periodic revalidation and recording medium transfer of, and access to, older space solar physics data sets. The NSSDC is fading from view, however, and the Heliophysics Data Management Policy calls for discipline-specific “final archives,” where “final” somehow means less final than a “long-term archive.” The Solar Data Analysis Center may be tasked with the “final” archiving of space solar physics data sets, but we have no expertise in the data preservation activities traditionally carried out by the NSSDC. We also recognize that the largest space solar physics data set, the SDO AIA and HMI data at the Stanford Joint Science and Operations Center (JSOC), will also need preservation and long-term access, as will the potentially much larger data archive of DKIST observations. We have therefore begun a study of data archiving best practices in other disciplines and organizations, including NASA’s Space Physics Data Facility (SPDF), the National Institute of Standard and Technology (NIST), and private industry. We report on the lessons learned so far, and possible cost models. We seek input from the broader solar physics community on the relative value of various levels of preservation effort.

Author(s): Joseph Gurman (NASA GSFC), Jennifer Spencer (NASA GSFC)

218.42 – The Availability of Higher Level SDO/HMI Data Products

The Solar Dynamics Observatory Helioseismic and Magnetic Imager (SDO/HMI) investigation proposed to generate a set of "high level" data products. These are data products that require processing and analysis well beyond the traditional products prepared by Heliophysics mission teams. That is, these are not simply images nor what the HMI team calls "Observables" which are e.g. magnetograms or Dopplergrams. The traditional deliverd data products are often referred to as "Level-1" data products and are the highest level of processing required by contract with NASA. The HMI team planned to also produce higher level products such as flows in the solar interior, solar oscillation mode frequencies and inversions for interior rotation, magnetic vector field inversions with disambiguation, derived indices that may have space-weather applications, et cetera. Most of these products are now in regular production and a series of recent papers and papers in progress describe them in detail. This poster is to bring attention to the availability of these products and describe where and how to get the needed information to use them for new research objectives.

Author(s): ***Philip Scherrer (Stanford Univ.)***

Contributing teams: SDO/HMI Science Team

218.43 – Challenges for the DKIST Data Center

Processing the large volumes of complex, multi-instrument, ground-based data generated at the DKIST will require implementation of algorithms and tools at a level not previously achieved for high-resolution, ground-based solar telescopes. We discuss some the goals of the data reduction pipelines for DKIST, including the different types of calibrations that would (optimally) be applied to the acquired data. We highlight some of the particular challenges for ground-based data, including seeing effects, atmospheric dispersion, and rapid changes in instrumental calibrations. We will describe a possible software framework for the implementation of the pipelines, as well as point out some areas for community input or VSO integration in the development process.

Author(s): ***Kevin Reardon (National Solar Observatory)***, Thomas Rimmele (National Solar Observatory)

218.44 – Helioviewer.org: Enhanced Solar & Heliospheric Data Visualization

Helioviewer.org enables the simultaneous exploration of multiple heterogeneous solar data sets. In the latest iteration of this open-source web application, TRACE and Hinode XRT join SDO, SOHO, STEREO, PROBA2 SWAP, and Yohkoh SXT as supported data sets, with significant additions to the availability of data from STEREO. Version 2 of Helioviewer's Public API for scientists and software developers provides powerful new ways to interact with solar data, complete with extensive documentation and usage examples. A new data coverage visualization demystifies the availability of each data set. The addition of a science data download tool provides a simple way to import FITS files directly into an IDL or Python analysis environment. Finally, a prototype timeline feature explores new ways of browsing image data sets in our viewport as well as interacting with time series data.

Author(s): ***Jeffrey Stys (ADNET Systems Inc.)***, Jack Ireland (ADNET Systems Inc.), V. Hughitt (ADNET Systems Inc.), Daniel Mueller (European Space Agency)

218.45 – WIMAGR: An Interactive SSW IDL Tool for Mapping OVSA Legacy Microwave Interferometry Data

The Owens Valley Solar Array (OVSA), which is currently the subject of a major upgrade leading to the new Expanded Owens Valley Solar Array (EOVSA), has operated between the years 2000-2007 as a 5-7 antenna solar-dedicated radio interferometer, with daily observations at typically 40 frequencies in the microwave frequency range, 1-18 GHz. Given the importance of these unique data for complementary studies with data taken during the same period by Yohkoh, RHESSI, SoHO, TRACE, Hinode and other NASA spacecraft, we have undertaken an effort to maximize their usefulness, ease of use, and longevity by creating a uniform, calibrated OVSA legacy database and community-friendly, SSW-based software, compatible with the RHESSI and EOVSA software packages. With these efforts, we can anticipate that the data will continue serving the community well into the future. In this presentation, we will introduce one of the recent upgrades of the OVSA SSW software package, WIMAGR, whose interface allows the user to generate OVSA radio maps in intensity and polarization at many available frequencies with a spatial resolution about 3” at 18 GHz, which is comparable with the spatial resolution of other imaging instruments. To illustrate the main capabilities of this software tool and its potential for promoting scientific discovery, we will present a real-time computation of a sequence of multi-frequency OVSA microwave maps and compare them with images obtained by other instruments. This work was supported in part by NSF grants AGS-1250374, and NASA grants NNX11AB49G and NNX14AC87G to New Jersey Institute of Technology

Author(s): ***Gelu Nita (NJIT)***, Gregory Fleishman (NJIT), Dale Gary (NJIT)

218.46 – The Virtual Solar Observatory: New Data, Big Data and Better Queries

The Virtual Solar Observatory (VSO) is entering its second decade of serving data to the solar physics community. It continues to provide 'homogenous access to heterogeneous data' at ever increasing volumes, thanks primarily to the Solar Dynamics Observatory. In 2013, the Smithsonian Astrophysical Observatory, one of the primary VSO sites for SDO data distribution served over 90TB in user requests alone. Despite SDOs dominance in terms of data volume, we continue to make available new data sets, and update and improve access to current ones especially via the IDL interface to the VSO. Here we detail new data sets, give updates on new querying capabilities and preview what lies ahead for VSO.

Author(s): ***Alisdair Davey (SAO)***

Contributing teams: The Virtual Solar Observatory Team

218.47 – Rapid Multi-Scale Decomposition of Solar Images

Multi-scale decomposition of astronomical images has been codified into several processing routines in a wide range of image types. This type of decomposition uses band-pass filtering to isolate features of a specific scale from the original data. At each scale, it is then possible to estimate and subtract a noise contribution and amplify a desired signal. We apply this approach to time series of high-resolution solar images. Using a multi-scale analysis of solar images coupled with a high time cadence, we are able to extract an evolving noise estimate as the solar environment changes.

Author(s): ***Michael Kirk (NASA)***, C. Young (NASA)

218.48 – Standardizing Documentation of FITS Headers

Although the FITS file format[1] can be self-documenting, human intervention is often needed to read the headers to write the necessary transformations to make a given instrument team's data compatible with our preferred analysis package. External documentation may be needed to determine what the values are of coded values or unfamiliar acronyms. Different communities have interpreted keywords slightly differently. This has resulted in ambiguous fields such as DATE-OBS, which could be either the start or mid-point of an observation.[2] Conventions for placing units and additional information within the comments of a FITS card exist, but they require re-writing the FITS file. This operation can be quite costly for large archives, and should not be taken lightly when dealing with issues of digital preservation. We present what we believe is needed for a machine-actionable external file describing a given collection of FITS files. We seek comments from data producers, archives, and those writing software to help develop a single, useful, implementable standard. References: [1] Pence, et.al. 2010, http://dx.doi.org/10.1051/0004-6361/201015362 [2] Rots, et.al, (in preparation), http://hea-www.cfa.harvard.edu /~arots/TimeWCS/

Author(s): ***Joseph Hourcle (Wyle IS)***

Contributing teams: Virtual Solar Observatory

218.49 – Using FLCT to Obtain Spectral Information From MOSES Data

The Multi-Order Solar EUV Spectrograph (MOSES) is a high cadence slitless spectrograph that images in He II 304Å. The large field of view (20’x10’) combined with the ability to quickly obtain images containing both spectral and spatial information makes MOSES an ideal platform for probing small scale, short duration flows resulting from magnetic reconnection in the solar transition region. The ease of obtaining co-temporal spectral and spatial data with a slitless spectrograph is counterbalanced by increased difficulty required to disentangling the information captured in the images. The Fourier Local Correlation Tracking (FLCT) routine developed by Fischer and Welch (2007) is developed as a technique for obtaining Doppler shifts and line widths from small scale flows imaged by MOSES. Results are reported utilizing this technique on simulated images and MOSES data.

Author(s): ***Hans Courrier (Montana State University)***, Charles Kankelborg (Montana State University)

219 – Variable Stars, Binaries, and Compact Objects Posters

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

219.01 – Variable Stars from the MG-1 Catalog

This work describes the recent efforts at North Carolina A&T(NCAT) mining the MG catalogs for variable stars. NCAT is a node in both the GNAT network and the SKYNET collaboration which forms the basis of the collaboration including access to instruments. The initial data analysis to obtain the light curves (LC) for MG-1 has been performed and a number of candidate variable stars have been identified including brown dwarf stars, eclipsing binaries and long period variable stars. Many of the identified candidate variable stars are now the subject of coordinated multi-site follow-on observations to elucidate the details of the variability. The coordinated observing includes researchers in Australia, Arizona, Colorado and North Carolina. As a node in both the GNAT network and the SKYNET collaboration NCAT has access to a number of instruments. Much of the observational work is performed using the SKYNET node in Chile. For the North Carolina work reported here, the observational work and initial LC generation is performed using telescopes and applications from the SKYNET program. In this work the instrumentation, the LC analysis and status of the coordinated follow-on observations are presented.

Author(s): ***K. M. Flurchick (North Carolina AandT State University)***, Ben Griego (North Carolina AandT State University), Roger Culver (Colorado State University)

219.02 – The UM-Dearborn Observatory: Variable-object Research from an Urban Site

Since its construction in 2007, the UM-Dearborn Observatory has provided a valuable educational tool both for students at UM-Dearborn and our neighbor-institution the Henry Ford Community College, and for the public at-large. We have recently (Jan 2014) added a systematic long-term research program with our 0.4m main telescope, to photometrically monitor a number of bright variable objects, including X-ray binaries and chemically-peculiar metal-poor stars over long timescales. We ultimately envision assembling a photometric database of (at least) four-color photometry over years-decades (i.e., many hundreds of orbital timescales for close binaries), with the preponderance of datapoints taken by undergraduates. To conduct this program, we have had to overcome a number of site challenges, the solutions of which will be useful to many programs using small telescopes at urban sites. The 0.4m telescope lies on a shared building within UM-Dearborn's main Fairlane campus - i.e., is about 20 meters above sea level, near several sources of water vapor (including an active steam vent less than 15 meters away), experiences significant mechanical vibrations from other building functions, and lies about 6 miles from central Detroit, well within the Detroit-Ann Arbor conurbation. Observing conditions are thus highly variable, with 5 arcsecond seeing typical and significant transparency variations observed even during a clear night. Nevertheless, we are now able to make scientifically useful observations in a semi-automatic way, to which our chosen scientific niche is well-suited. We present here our solutions to these challenges, along with initial results from our ongoing monitoring program.

Author(s): ***Elisabeth Clyne (University of Michigan-Dearborn)***, William Clarkson (University of Michigan-Dearborn), Eric Rasmussen (University of Michigan-Dearborn), Donald Bord (University of Michigan-Dearborn), Kristen Dage (University of Michigan-Dearborn), David Matzke (University of Michigan-Dearborn), Carrie Swift (University of Michigan-Dearborn)

219.03 – Variability in Hot Subdwarfs and Related Objects from the Palomar-Green Catalog

We present a selection of objects chosen from the Palomar-Green (PG) Catalog of Ultraviolet Excess Stellar Objects to search for variability. Variability could be from eclipsing binaries, cataclysmic variables, the irradiation effect and many others. The PG catalog used the Palomar 18 inch telescope to look for stars that were brighter in the ultraviolet than normal stars. One result of the PG catalog was a discovery of hot subdwarfs (sd) that dominated the sky. We chose 988 stars because they were classified in the PG catalog as sd stars or as related objects and present an analysis of 475. We used the Catalina Real-Time Transient Survey and the UBVRI photometric standard stars from Landolt to find that approximately 60 of these objects show evidence of being variable.

Author(s): ***Melissa Blacketer (California State University, Fresno)***, Fred Ringwald (California State University, Fresno)

219.04 – The Semiregular Variable Star Observing Program at Grinnell College

A large body of photometric and spectroscopic data on 38 semiregular variable stars has been acquired at the Grant O. Gale Observatory of Grinnell College since 1984. This includes V and B band photoelectric photometry, CCD spectroscopic monitoring, and a large set of spectra for RS Cygni. The stars in the program were selected because they had a history of “quiescent episodes” in their pulsations that might be explained as mode switches. Time-dependent Fourier analysis has been applied to the photometric data to reveal the dominant frequency components represented in the light curves and to investigate how the strengths of those components vary – sometimes quite abruptly – over time. The spectroscopic monitoring of the entire set of stars is an ongoing project. The 413 RS Cygni spectra have been used to explore the variation of spectral features with phase. The conspicuous dip near the peak of the RS Cygni light curve does not appear to be associated with obvious variations in the strengths of spectral features.

Author(s): ***Robert Cadmus (Grinnell College)***

219.05 – Photometry and Spectroscopy of BD+35 1111 in M38

BD+35 1111 is a ~10.5-magnitude star in the field of M38, an open cluster that has been a target of our ongoing study of H? emission variability in massive stars via narrowband CCD photometry (e.g. Souza, Davis, and Teich 2013, BAAS. 45, PM354.22). BD+35 1111 has no MKK classification in the literature, and is not listed as variable in GCVS, VSX, or NSVS. It is included, with no further characterization, in both the Vatican and Kohoutek catalogs of emission line stars. Using inhomogeneous ensemble photometry (e.g. Bhatti, Richmond, Ford, and Petro 2010, ApJ Supp., 186, 233), we find it to be an irregular variable with a range of ~0.15 mag. To further understand this star we obtained a medium-resolution spectrum using the DIS spectrograph on the ARC 3.5-meter telescope at Apache Point Observatory. We classify BD+35 1111 as B2Ve, the only confirmed Be star in the field of M38. This raises the question of membership, since the age of M38 is likely 250 Ma or greater (Pandey et al. 2007, Publ. Astron. Soc. Japan 59, 547). From published B and V magnitudes we find a nominal distance to BD+35 1111 of 1.6 kpc, but with a range of 1.3 to 2.0 kpc, marginally consistent with distance estimates for M38 ranging from 1.0 to 1.4 kpc. If a member, BD+35 1111 is a candidate blue straggler. If not, it may have escaped from a nearby younger cluster, possibly Kronberger 1 (Kronberger et al. 2006, A&A 447, 921), which has the right heliocentric distance and age. The notion that BD+35 1111 is behind M38 is supported by its reddening of EB-V ~ 0.5, significantly higher than for M38 itself (~ 0.24). We gratefully acknowledge support for student research from NSF grant AST-1005024 to the Keck Northeast Astronomy Consortium, Williams College, and NASA via an American Astronomical Society Small Research Grant.

Author(s): ***Steven Souza (Williams College)***, Karen Kwitter (Williams College), Mona Sami (Williams College), Gillian Beltz-Mohrmann (Wellesley College)

219.06 – The MOST Accurate Photometry for Cepheid Modes

Fundamental mode classical Cepheids have famously repeatable light curves and periods steady enough that we can watch them evolve (change period). Overtone pulsators, on the other hand often have period changes too large to be explained by evolution, at least during the longest (second and third) passages through the instability strip. We obtained a month long series of observations with the MOST satellite of the fundamental mode Cepheid RT Aur and the first overtone pulsator SZ Tau. RT Aur shows the traditional strict repetition of the light curve, with the Fourier amplitude ratio R1/R2 remaining constant (varying by only a percent). The light curve of SZ Tau, on the other hand, fluctuates in amplitude ratio at the level of approximately 50\%. Furthermore prewhitening the RT Aur data with 10 frequencies reduces the Fourier spectrum to noise. For SZ Tau, considerable power is left after this prewhitening in a complicated variety of frequencies. Financial Support was provided by CXC NASA Contract NAS8-03060 (NRE), ESTEC Contract No. 4000106398/12 /NL/KML (LS), European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement No. 269194(IRSES/ASK) (RS, AD).

Author(s): ***Nancy Evans (SAO)***, Robert Szabo (Konkoly Obs.), Laszlo Szabados (Konkoly Obs.), Aliz Derekas (Konkoly Obs.), Laszlo Kiss (Konkoly Obs.), Jaymie Matthews (Univ. British Columbia), Chris Cameron (Univ. British Columbia)

Contributing teams: The MOST Team

219.07 – Principle Component Analysis of Cepheid Variable Stars

We use Principle Component Analysis (PCA) and Fourier decomposition on LMC and SMC cepheids observed by OGLE III to find relationships between a cepheid's period, luminosity, and light curve structure. Unlike the Period-Luminosity and Period-Luminosity-Color relations, these are independent of extinction. We consider their advantages and disadvantages in estimating distances.

Author(s): ***Daniel Wysocki (SUNY Oswego)***, Zachariah Schrecengost (SUNY Oswego), Earl Bellinger (Indiana University), Shashi Kanbur (SUNY Oswego), Sukanta Deb (Department of Physics, University of Delhi), Harinder Singh (Department of Physics, University of Delhi)

219.08 – Photometric Analysis of the Recently Discovered W UMa Star NR Camelopardalis: Period Change and Spot Migration

NR Cam is a short period (P=0.26 days) eclipsing binary of the W UMa type that was relatively recently discovered in the ROTSE1 data of the Northern Sky Variability Survey (NSVS) and was originally listed in the New Catalog of Suspected Variable Stars (NSV) with the identifier NSV 3754. Here we present the first known detailed study of NR Cam, which includes multi-band light curves, color curves, and a photometric orbital solution. NR Cam exhibits a strong O'Connell effect that can be attributed to magnetically induced spot activity on one of the components. Absolute photometry was performed in B and V at the Kutztown University Observatory in 2013 October and November and complementary high precision differential light curves were obtained in BVRI at the same time, as part of the KELT follow-up network, at Brigham Young University's West Mountain Observatory, Swarthmore College's Peter Van de Kamp Observatory, and the University of Louisville's Moore Observatory. After the B-V color curves were used to approximate the stellar surface temperatures and spot locations, the Wilson-Devinney code was employed with a differential corrections routine to determine the most likely stellar properties and orbital parameters. Our solution indicates that the two stars are in contact, sharing a common envelope, and their surface temperatures are approximately 4500 K and 4200 K. The inclination of the orbit was determined to be 68.0 (±0.6) degrees. When compared with the NSVS data, we find that the orbital period of NR Cam has changed over the past decade and that the strength of the O'Connell effect, and the associated spot activity, has also varied significantly.

Author(s): ***Jenae Shoup (Kutztown University)***, Phillip Reed (Kutztown University), Michael Joner (Brigham Young University), Eric Jensen (Swarthmore College), Karen Collins (University of Louisville), Joshua Pepper (Lehigh University)

219.09 – UBVRI Photometric Study of the Totally Eclipsing 6500 K Extreme Mass Ratio W UMa Binary, GSC 3208 1986

We present high precision, UBVRcIc light curves of the suspected eclipsing binary, GSC 3208 1986. The amplitudes of the light curve is very nearly 0.5 mag in all filters. The present curves are immaculate with all spot activity hidden within the low noise of the light curves. The minima are equal to within 0.1 mags. The Wilson Devinney program simultaneous light curve solution shows that this is a totally eclipsing classic A-type, EW binary. GSC 3208 1986 is an extreme mass ratio, 6500 K, W UMa system. The mass ratio is only 0.24, with a component temperature difference of only ~100K. This points to a high degree of thermal and physical contact. Indeed, the Roche lobe fill-out is 39%. The high inclination of 85° results in a long duration secondary total eclipse (an interval of constant light), some 49.5 minutes! The binary is of F6V type, and has no modeled surface discontinuities (no spots were needed in the modeling). The period study of a 13 year time duration indicates that the period is steadily decreasing. This is expected in solar type binaries undergoing magnetic braking. The variable is apparently undergoing solar-type activity with its associated magnetic breaking despite the near absence of spot distortions in the light curves. However, an early curve by Gettel et al. (2006) may give evidence for this. All indications are that this binary is mature and approaching a transitional coalescence into a fast rotating A-type star (Guinan and Bradstreet 1988).

Author(s): ***Ronald Samec (Bob Jones Univ.)***, Danny Faulkner (University of South Carolina), Walter Van Hamme (Florida International University), James Kring (Bob Jones Univ.)

219.10 – Comparison of Observations and Analyses of 2009 and 2012 Light Curves for the Precontact W UMa Binary, V1001 Cassiopeia

A 2012 follow up to the analysis of 2009 observations is presented for the very short period (~0.43d) precontact WUMa Binary, V1001 Cassiopeia. Its short period, similar to the majority of W UMa's, has a distinct EA light curve make it a very rare and interesting system for continuing photometric investigation. Previous photometric VRI standard magnitudes give a K4 spectral type (Samec 2012). Our solutions of light curves separated by some 3 years give approximately the same physical parameters. However the spots have radically changed, both temperature, area and position wise. Whereas only one dark spot was used to model the first curves, two hot spots are now needed. This affects the overall shape of the light curve, especially in the secondary eclipses in B and V. Additional eclipse timings show the orbital period is changing. We conclude that spots are very active on this solar type dwarf and that it may mimic its larger cousins, the RS CVn binaries.

Author(s): ***Robert Hill (Bob Jones University)***, Samuel Koenke (Bob Jones University), Ronald Samec (Bob Jones University), Danny Faulkner (University of South Carolina, Lancaster), Walter Van Hamme (Florida International University)

219.11 – BVRcIc Light Curve Analysis of the Shallow Contact Extreme Mass Ratio W UMa Binary, HR Boo

HR Boo [? (2000) = 14h 48m 33.015s, ? (2000) = +21° 44 ?01.09"] is an NSVS variable first observed in 1999 and listed in the 79th name list (Kazarovets, 2008). It was identified as a W UMa variable and first characterized by the period 0.27289 d. This was later corrected to 0.31587 d. Various observers have reported ~20 timings of minimum light over the past ~4000 orbital epochs. Our 2012 curve is of high precision, with probable errors averaging 5 mmag. The curves have shallow amplitudes, averaging 0.4 magnitudes, yet apparently exhibit total eclipses. J-K observations yield a G6V type for the system. A linear period determination of 0.31596785(7) d was computed with the available timings of minimum light. When the NSVS light curve is considered in the period study, it indicates that the period has been clearly decreasing over the past 15,000 orbits. The quadratic term from this period study is statistically significant at 5 ?. This indicates that the binary is evidently undergoing magnetic breaking due to enhanced magnetic solar activity.The light curve solution reveals that HR Boo is a shallow contact system with a Roche-lobe fill-out of ~4% and a mass ratio of q= 0.25. This is exceedingly rare, since extreme mass ratio binaries usually have high fill-outs. In addition, an unusually dark 13 degree radius cool spot with a T-factor of ~50% was computed near the L1 Point of the primary component. A 32 minute duration of constant light is seen in the secondary eclipse indicating the occurrence of a total eclipse. This was confirmed in the light curve solution. Although the secondary component has a slightly higher temperature than the primary component, some 30 K, the light curves have the appearance of an A-type W UMa system. The system may have come into contact recently.

Author(s): ***Danny Faulkner (Johnson Observatory)***, Ronald Samec (Astronomy Program, Dept. of Physics and Engineering, Bob Jones University), Travis Shebs (Astronomy Program, Dept. of Physics and Engineering, Bob Jones University), Barry Benkendorf (Astronomy Program, Dept. of Physics and Engineering, Bob Jones University)

219.12 – Simulating Contact Binaries

About one in every 150 stars is a contact binary system of WUMa type and it was thought for a long time that such a binary would naturally proceed towards merger, forming a single star. In September 2008 such a merger was observed in the eruption of a “red nova", V1309 Sco. We are developing a hydrodynamics simulation for contact binaries using Self Consistent Field (SCF) techniques, so that their formation, structural, and merger properties could be studied. This model can also be used to probe the stability criteria such as the large-scale equatorial circulations and the minimum mass ratio. We also plan to generate light curves from the simulation data in order to compare with the observed case of V1309 Sco. A comparison between observations and simulations will help us better understand the nova-like phenomena of stellar mergers.

Author(s): ***Kundan Kadam (Louisiana State University)***, Geoffrey Clayton (Louisiana State University), Juhan Frank (Louisiana State University), Joel Tohline (Louisiana State University), Jan Staff (Macquarie University), Patrick Motl (Indiana University), Dominic Marcello (Louisiana State University)

219.13 – The Interplanetary Medium and Astrosphere around ? Cen A and ? Cen B

The stellar winds of ? Centauri A (HD 128620: G2 V) and B (HD 128621: K1 V) combine to carve a bubble, the astrosphere, into the surrounding interstellar medium. The winds and the ISM interact, giving rise to pronounced astrospheric boundaries including a termination shock and an astropause. Inside the termination shock, the two stellar winds interact strongly. These interactions have been characterized numerically with detailed, time-dependent models that also account for the non-equilibrium behavior of interstellar neutral hydrogen that traverses the astrosphere. The results of this modeling are presented, characterizing the interplanetary environment of extrasolar planets in the ? Centauri A+B system, and modeled estimates of diffuse, time-dependent X-ray emission due to stellar wind charge exchange are given.

Author(s): ***Hans Mueller (Dartmouth College)***, Mackenzie Carlson (Dartmouth College)

219.14 – Single Season BVRI Light Curves of KU Cygni and the Current State of its Eccentric and Variable Accretion Disk

KU Cygni is a long period (P=38.4 days) eclipsing Algol-type binary star. The 0.48 Solar mass K5III secondary component is presumably undergoing Roche lobe overflow and donating mass to the 3.85 Solar mass F-type primary. The resulting accretion disk is large, thick, variable, and very likely non-circular. A recent study by the Digital Access to a Sky Century at Harvard (DASCH) project discovered a ~5 year dust accretion event that occurred around 1899 - 1904. KU Cyg has also undergone other significant secular variations that are due to the variability of its accretion disk. Here, we present a complete single-season multicolor photometric study of KU Cyg. During our eight month observing season in 2013, KU Cyg underwent just six complete orbital cycles. This fact significantly reduces the complications of secular variations and therefore these observations show us the photometric effects of the current state of the circumstellar material. Our analysis of the asymmetries in the primary and secondary eclipses lends insight about the current geometry and eccentric nature of the accretion disk.

Author(s): ***Phillip Reed (Kutztown University)***, Katelyn Ciccozzi (Kutztown University)

219.15 – Investigating mass transfer in symbiotic systems with hydrodynamic simulations

We investigate gravitationally focused wind accretion in binary systems consisting of an evolved star with a gaseous envelope and a compact accreting companion. We study the mass accretion and formation of an accretion disk around the secondary caused by the strong wind from the primary late-type component using global 2D and 3D hydrodynamic numerical simulations. In particular, the dependence on the mass accretion rate on the mass loss rate, wind temperature and orbital parameters of the system is considered. For a typical slow and massive wind from an evolved star the mass transfer through a focused wind results in rapid infall onto the secondary. A stream flow is created between the stars with accretion rates of a 2-10% percent of the mass loss from the primary. This mechanism could be an important method for explaining periodic modulations in the accretion rates for a broad range of interacting binary systems and fueling of a large population of X-ray binary systems. We test the plausibility of these accretion flows indicated by the simulations by comparing with observations of the symbiotic CH Cyg variable system.

Author(s): ***Miguel de Val-Borro (Princeton Unversity)***, Margarita Karovska (Harvard-Smithsonian Center for Astrophysics), Dimitar Sasselov (Harvard-Smithsonian Center for Astrophysics)

219.16 – Constraining the Mass-Radius Relationship in White Dwarfs Using Gravitational Redshifts

We present gravitational redshifts (GRs) and masses for over 20 white dwarfs that have distant, non-interacting main-sequence companions. These are the first results from our ongoing NOAO programs at the KPNO 4-m and SOAR 4.1-m telescopes. We have obtained R~10,000 spectra over three or more epochs for each WD+MS binary and measured precise radial velocities and, thus, gravitational redshifts using the template-matching technique. This removes the subjectivity involved in previous GR studies. Our sample is already the largest set of GRs measured in a single study, thus, eliminating the systematic differences between different studies and telescopes. We have obtained independent radius constraints from extant parallax measurements and surface gravity determinations from Balmer series fits to our spectra. By combining our precise GR measurements with those values, we obtained improved estimates of WD masses and radii. While the WD mass-radius relation underlies much of stellar and galactic astrophysics, only one empirical measurement matches the predicted value within 3%. Furthermore, the current published sample covers a small range of WD masses. Our program provides more precise measurements of GRs for a larger range of WD mass, spanning 0.5-1.2 Msun.

Author(s): ***Saurav Dhital (Embry-Riddle Aeronautical University)***, Terry Oswalt (Embry-Riddle Aeronautical University), Jay Holberg (University of Arizona), Trisha Mizusawa (Florida Institute of Technology), Jingkun Zhao (National Astronomical Observatories)

219.17 – A Simple Method to Improve the Quality of RXTE PCA Spectra

We fitted at once all of the several hundred RXTE PCA spectra of the Crab to a simple power-law model; the total number of counts in the composite spectrum is >10^9. We then used the spectrum of fit residuals (data/model) to correct large samples of spectra of GX~339-4, H1743-322, and XTE J1550-564. The correction improved the quality of all the fits, and the improvement was dramatic for spectra with >10^7 counts. The Crab residual spectrum is somewhat different for each of the five PCA detectors, but it was relatively stable during the course of the 16-year mission. We provide public software that automates the process of applying the correction to PCA data and recommend that the correction be applied to all spectra with >10^6 counts.

Author(s): ***Javier Garcia (Harvard-Smithsonian Center for Astrophysics)***, Jeffrey McClintock (Harvard-Smithsonian Center for Astrophysics), James Steiner (Harvard-Smithsonian Center for Astrophysics), Ronald Remillard (Massachusetts Institute of Technology), Victoria Grinberg (Massachusetts Institute of Technology)

219.18 – A Glimpse of Optically Variable Galactic Bulge X-ray Sources: A Comparison of Mosaic-II and DECam Photometry

We present optical photometry and spectroscopy of selected sources from the Galactic Bulge Survey (GBS) using the new DECam imager and the previous Mosaic-II imager on the 4m Blanco telescope at Cerro-Tololo Inter-American Observatory (CTIO). The goal of the GBS is to detect quiescent Low-Mass X-Ray Binaries (LMXB) and identify eclipsing systems for follow-up mass determination to test binary population models and to better determine black hole and neutron star mass distributions. We compare the light curves of spectroscopically intriguing sources with both instruments and show that the DECam observations demonstrate large improvements in sensitivity to short-period binary systems. Because of DECam's field of view of 2.2 degrees, our survey area can be covered in 4 pointings as opposed to 64 with Mosaic-II. This increased our sampling rate from 2-5 times to 28-56 times per target per night, which includes dithering. We find that combining 2x1 secs and 2x90 secs exposures over a two day observing run, we can detect targets between 12th and 23rd magnitude. Overall, we are finding that DECam is a superb instrument for detecting variability of sources in wide-field optical surveys. This work was supported by the National Science Foundation under Grant No. AST-0908789 and by NASA through Chandra Award Number AR3-14002X issued by the Chandra X-ray Observatory Center, which is operated by the Smithsonian Astrophysical Observatory for and on behalf of the National Aeronautics Space Administration under contract NAS8-03060.

Author(s): ***Christopher Johnson (Louisiana State University)***, Robert Hynes (Louisiana State University), Peter Jonker (Harvard-Smithsonian Center for Astrophysics), Manuel Torres (Harvard-Smithsonian Center for Astrophysics), Chris Britt (Texas Tech. University), Danny Steeghs (University of Warwick), Tom Maccarone (Texas Tech. University), Gijs Nelemans (IMAPP, Radbound University), Sandra Greiss (University of Warwick), Austin Baldwin (Louisiana State University)

Contributing teams: The Galactic Bulge Survey Collaboration

219.19 – Searching for a Spin-Superorbital Period-Relation in Bright X-ray Binaries

Thanks to long-term X-ray monitoring, a number of close X-ray binaries are now known to show X-ray periodicities on timescales of at least tens of binary orbital timescales, for which the current favorite model is warping and precession of the accretion disk. In at least one case, the period of this superorbital variation is known to change relatively smoothly on a timescale of years. Initial indications from archival data suggest that the neutron star's pulse period may also vary on a similar timescale from the same object. If confirmed, this would observationally demonstrate a direct link between the properties of the accretion disk precession and the mass transfer rate onto the neutron star accretor. We have undertaken a campaign to systematically search for just such a link, using archival RXTE data going back to 1996. This poster describes our techniques and science results.

Author(s): ***Kristen Dage (University of Michigan-Dearborn)***, William Clarkson (University of Michigan-Dearborn)

219.20 – The Orbital Light Curve of the Low-Mass X-ray Binary V1408 Aquilae

We have obtained high-speed optical photometry of the low mass X-ray binary V1408 Aquilae (= 4U 1957+115), totaling 126 hours of data obtained on 29 nights. The orbital light curve of the system has a large-amplitude and roughly-sinusoidal modulation. We fit the data with synthetic light curves calculated from a model that includes: (1) a black hole primary surrounded by (2) an axisymmetric, optically-thick, physically-thin, viscous, steady-state accretion disk, that is fed from (3) a low-mass, cool secondary star. The secondary star is strongly heated by radiation from the disk. The varying aspect of the secondary's heated face dominates the orbital light curve and is the source of the quasi-sinusoidal modulation. We present the results of an extensive exploration of the model's parameter space.

Author(s): ***Sebastian Gomez (University of Texas-El Paso)***, Paul Mason (University of Texas-El Paso), Edward Robinson (University of Texas)

219.21 – Polarization of the Cygnus X-1 System

With broadband optical polarimetry, we have observed the Cygnus X-1 system using the POLISH2 polarimeter at the Lick Observatory 1-m telescope. We have observed this system for a total of 19 nights during July, August, and September of 2012, and June of 2013, with the goal of constraining orbital inclination and determining the true mass of the black hole in the system. While Kemp et al. made a significant effort to determine this mass in the 1980’s, it was unsuccessful due to limitations in instrument sensitivity and the complexities of the rapidly evolving system. We aim to improve upon this effort with our data, which achieves 0.01% sensitivity simultaneously in the B band for both linear and circular polarization. Further observations in UBV bands are planned for the spring and summer of 2014 in order to study the black hole and supergiant system continually, as it evolves throughout its 5.6-day orbital period. We present results of our initial, high SNR observations that show dramatic changes in polarization of signal taken one month apart. We also find that the circular polarization (Stokes V) appears more phase-locked than the linear polarization (Stokes Q and U), indicating a strong possibility that we are observing the jet of the black hole. This work is supported by UCO/Lick Observatory.

Author(s): ***Larissa Nofi (University of California, Santa Cruz)***, Sloane Wiktorowicz (University of California, Santa Cruz)

219.22 – Soft X-ray Excesses and X-ray Line Variability in Cygnus X-3

Cygnus X-3 is an X-ray binary (XRB) system containing a stellar-mass compact object, most likely a black hole, and a Wolf-Rayet companion star, which produces collimated, relativistic jets, placing it in the sub-class of XRBs known as microquasars. During a Swift/XRT monitoring program of Cygnus X-3, a soft X-ray excess (below 1 keV) was observed at certain states and phases of activity. This soft excess appears to be similar to the variable soft emission observed in Seyfert galaxies. The presence of these features in Cygnus X-3 would argue for a greater support of the black-hole nature of the compact object and serve to better highlight the similarities of microquasars and AGN. We present the results of our investigations of these soft excesses, as well as the variations of the X-ray Fe line region (6.4-7.0 keV) as a function of the state activity and orbital phase.

Author(s): ***Angelo Varlotta (SAO)***, Michael McCollough (SAO)

219.23 – Faraday Structure of the Jets of the Microquasar SS433. I. Rotation Measure Distribution

We report a detailed study of the Faraday rotation in the jets of SS433 using five epochs of data from the Jansky VLA. Observations spanning 4.5-8.5 GHz were used to create linear polarization images in multiple spectral windows using CASA, and the data passed to AIPS for analysis. We used both the traditional rotation measure derivation task RM and the Faraday rotation measure synthesis task FARS to derive the distribution of the Faraday rotation measure ("RM") across the source. We find it to be non-uniform, indicating that at least part of the RM is local to the source. We track the evolution of the RM structure over a period of about 50 days and find significant changes, further supporting the local origin of some of the rotation. In a companion paper we attempt to correlate the RM structure with the well-known 3-D morphology of the jets.

Author(s): ***Michael Kosowsky (Brandeis University)***, David Roberts (Brandeis University), John Wardle (Brandeis University)

219.24 – Faraday Structure of the Jets of the Microquasar SS433. II. Modeling the Source in 3-D

In a companion paper we report Jansky VLA observations of the Faraday rotation measure structure of the jets in SS433. Here we analyze those data in light of the well-known 3-D structure of the source using Faraday rotation measure synthesis ("FRMS"). The power of FRMS is that in principle it permits us to determine the 3-D structure of the synchrotron emissivity and of the product of the longitudinal component of the magnetic field and the thermal particle distribution. We combine the Faraday depth structure of SS433 revealed in our FRMS analysis with information from the linear polarization of the observed synchrotron emission and the known 3-D source morphology. From this we attempt to build a model of the magnetic field in three dimensions that is consistent with all of the data.

Author(s): ***David Roberts (Brandeis Univ.)***, Michael Kosowsky (Brandeis Univ.), John Wardle (Brandeis Univ.)

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220 – Molecular Clouds and Dust Posters

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

220.01 – Enigmatic Extinction: An Investigation of the 2175Å Extinction Bump in M101

Evidence from studies of starburst galaxies indicates that active formation of high mass stars modifies the UV dust extinction curve as seen by a lack of the characteristic 2175Å bump. For over 45 years, the source of the 2175Å extinction feature has yet to be positively identified. Small aromatic/PAH grains are suggested as a leading contender in dust grain models. The face-on spiral galaxy M101 is an ideal laboratory for the study of dust, with many well-studied HII regions and a steep metallicity and ionization gradient. The Interstellar Medium Absorption Gradient Experiment Rocket (IMAGER) probes the correlation between dust extinction, and the metallicity and radiation environment in M101 at ultraviolet wavelengths. IMAGER simultaneously images M101 in three 400Å-wide bandpasses, measuring the apparent strength of the 2175Å bump and the UV continuum. Combining data from IMAGER with high S/N far- and near- UV observations from the MAMA detectors on the Hubble STIS instrument, we examine the apparent strength of the 2175Å bump in HII regions of M101. With additional infrared data from Spitzer, the DIRTY radiative transfer model, and stellar evolution models, we probe the correlation between the 2175Å feature and the aromatic/PAH features across HII regions of varying metallicity and radiation field hardness. The results of this experiment will directly impact our understanding of the nature of dust and our ability to accurately account for the effects of dust on observations at all redshifts.

Author(s): ***Meredith Danowski (Massachusetts Institute of Technology)***, Timothy Cook (University of Massachusetts- Lowell), Karl Gordon (Space Telescope Science Institute), Supriya Chakrabarti (University of Massachusetts- Lowell), Brandon Lawton (Space Telescope Science Institute), Karl Misselt (University of Arizona)

220.02 – COS/HST Local Interstellar Medium Analysis and Kinematic Survey using White Dwarfs (CLIMAKS)

Objects with well-constrained continua are extremely well-suited to studies of the interstellar medium; white dwarfs are of particular use in this regard. We present here further analysis of archival HST-Cosmic Origins Spectrograph spectra of 36 white dwarfs within 100 pc. These spectra are part of a much larger sample, obtained as part of a large scale survey by Gaensicke et al. to determine the extent of pollution from circumstellar debris disk reaccretion. The sensitivity of the COS instrument and the quality of the WD models combine to make this data set very suitable for studying the properties of the local ISM. We have analyzed and fit the spectra to determine the characteristics of the intervening ISM absorber(s), specifically in CII/CII*, NI, OI, and SiII/SiII*/SiIII. From the results of such analyses, we can extract values for the kinematics, abundances, electron density, ionization structure, and physical size of the absorbing cloud(s). Given the sample size, it is also possible to use these measurements to refine preexisting kinematic models of the various LISM absorbing clouds.

Author(s): ***Benjamin Tweed (Wesleyan University)***, Seth Redfield (Wesleyan University), Boris Gaensicke (University of Warwick), Detlev Koester (University of Kiel), Jay Farihi (University College London)

220.03 – A Direct Measurement of the CO/H2 Abundance Ratio in the Magellanic Clouds

Theoretical and observational evidence suggests that molecular gas (H2) is not always correlated with CO emission, because CO is photo-dissociated more easily than H2. The mass of CO-poor H2 present in the envelopes of giant molecular clouds (GMCs) is expected to be higher in low metallicity GMCs, which are more exposed to dissociating radiation due to their lower dust abundance. Since we cannot detect H2 directly, the mass of these CO-poor envelopes is effectively "hidden" from radio telescopes. As a result, theoretical predictions of the CO/H2 abundance, are difficult to test and validate, and the amount of molecular gas present in low metallicity galaxies is not well constrained. The most sensitive and unambiguous way to determine CO and H2 column densities is to derive them from UV absorption spectroscopy. We have acquired high S/N spectra of the 4th positive absorption band of CO with HST/COS toward 9 translucent (AV~1) Magellanic Cloud sight-lines probing the edges of GMCs, for which previous FUSE spectra and H2 column density determinations are available from the FUSE catalogs and archive. After removing spectral features associated with the stellar sources, we find CO column densities as low as ~1013 cm-2 toward those translucent sight-lines. We have computed the CO and H2 abundances as a function of total gas column and extinction, and have found this relation to be compatible with predictions from numerical models of CO and H2 formation and dissociation. The cooling rate associated with CO rotational emission appears to be negligible compared to cooling by ionized carbon (C II) in this density regime.

Author(s): ***Julia Roman-Duval (Space Telescope Science Institute)***, Mark Krumholz (University of California at Santa Cruz), Alberto Bolatto (University of Maryland), Karl Gordon (Space Telescope Science Institute), Christopher McKee (University of California at Berkeley), Jason Tumlinson (Space Telescope Science Institute)

220.04 – $C^{15}N$ in Diffuse Molecular Clouds

We report the first detection of $C^{15}N$ in absorption in diffuse molecular gas from a detailed examination of archival VLT/UVES data covering the CN lines near 3875 Å. Absorption from the $C^{15}N$ isotopologue is detected in three out of the four directions studied and appears as a very weak feature between the main ^{12}CN and ^{13}CN absorption lines. Column densities for each CN isotopologue are determined through profile fitting, after accounting for weak additional line-of-sight components, which are observed in CH and CH^+. The weighted mean value of $C^{14}N/C^{15}N$ for the three sight lines with detections of $C^{15}N$ is 277±16, in very good agreement with the terrestrial $^{14}N/^{15}N$ ratio of 272. Our results help to clarify the situation regarding the nitrogen isotope ratio in the solar neighborhood, with important implications for interstellar chemistry and Galactic chemical evolution.

Author(s): ***Steven Federman (Univ. of Toledo)***, Adam Ritchey (Univ. of Washington), David Lambert (McDonald Observatory)

220.05 – A 3D Dust Map from PanSTARRS 1

We present a 3D map of dust reddening in the Milky Way, using photometry from more than half a billion well observed stars in the PanSTARRS 1 (PS1) 3pi survey. We group stars into pixels, and then infer the line-of-sight reddening vs. distance relation from the individual stellar reddenings and distances. We derive the full probability density of reddening as a function of distance in each ~7'x7' pixel on the sky, incorporating prior knowledge about the distribution of stars throughout the Galaxy and 5-band PS1 photometry. We show that in the large-distance limit, our 3D map has good agreement with the emission-based 2D dust map of Schlegel, Finkbeiner & Davis (1998), despite the very different datasets and methods the two maps rely on. A greater understanding of the 3D distribution of dust in the Galaxy will allow a wealth of detailed science in the Galactic plane, where dust hinders stellar parameter estimation and obscures structure. The method we use can be extended to take advantage of other datasets, such as 2MASS, WISE, SDSS and, eventually, LSST.

Author(s): ***Gregory Green (Harvard Univ.)***, Eddie Schlafly (MPIA), Douglas Finkbeiner (Harvard Univ.)

220.06 – The Galactic Plane Infrared Polarization Survey (GPIPS): Final Calibration and Full Data Release

All observations for the Galactic Plane Infrared Polarization Survey (GPIPS) have been completed on the 1.8m Perkins telescope with the Mimir near-infrared instrument. Final calibration has been established and applied, and polarization and photometric data products (catalogs and images) have been released for general use. GPIPS surveyed 76 sq deg of the northern Galactic plane, from L = 18 to 56 deg and B = -1 to +1 deg, in the H-band (1.6 ?m). The survey was conducted over 360 telescope nights between 2006 and 2013 as 3,237 dithered sky placements of the 10x10 arcmin FOV of Mimir. Pixel sampling of 0.58 arcsec was well-matched to the average seeing of 1.5 arcsec; all GPIPS data met a 2 arcsec seeing criterion. The calibration process utilized stars in globular cluster fields, mostly off the Galactic plane along low extinction sightlines, and in specific fields hosting multiple polarization standard stars. The polarization calibration floor is under 0.1% for single observations. GPIPS sampled stellar polarizations from 7th to 12th mag in H-band, resulting in nearly 1 million stars with measured polarizations, which probed directions with up to 20-30 mag of visual extinction. GPIPS data are ideal for mapping plane-of-sky magnetic field orientations in interstellar gas and dust clouds, identifying regions of star formation, and discovering stars with circumstellar scattering dust structures. Tools for accessing and exploring the GPIPS data products have been developed and will be highlighted. GPIPS has been supported through NSF grants AST 06-07500 and 09-07790.

Author(s): ***Dan Clemens (Boston University)***, Lauren Cashman (Boston University), Sadia Hoq (Boston University), Jordan Montgomery (Boston University), Michael Pavel (Boston University)

220.07 – Testing for Helical Magnetic Fields in the Orion Molecular Cloud Integral-Shaped Filament

The Orion Molecular Cloud (OMC) is one of the closest and most well-studied regions of ongoing star formation. Within the OMC, the Integral-Shaped Filament (ISF) is a long, filamentary structure of gas and dust that stretches over 7 pc and is itself comprised of many smaller filaments. Radial density profiles of the ISF indicate that these filamentary structures may be supported by helical magnetic fields (Johnstone & Bally 1999). To test for the presence of helical fields, we have collected deep near-infrared (NIR) H-band (1.6 ?m) and K-band (2.2 ?m) linear polarimetry of background starlight for a grid of six 10x10 arcmin fields of view fully spanning the ISF. NIR polarizations from scattered light and young stellar objects, which do not trace the magnetic field, are identified by examining the ratio of percent polarization in H-band to K-band. The data were collected using the Mimir NIR instrument on the 1.8m Perkins Telescope located outside of Flagstaff, AZ. This work is partially supported by NSF grant AST 09-07790.

Author(s): ***Lauren Cashman (Boston Univ.)***, Dan Clemens (Boston Univ.)

220.08 – High-Mass Star Formation in IRDCs: The Role of Magnetic Fields

The role of the Galactic magnetic field in creating high-mass stars within Infrared Dark Clouds (IRDCs) is not well understood. Three prevailing theories describing the nature of the magnetic field are strong-field models, weak-field models, and helical fields. Each has different implications of how the field affects cloud and star formation. We use a sample of 30 IRDCs in the first Galactic quadrant to study the relationships between magnetic fields and cloud properties. To trace the magnetic field in the vicinity of the clouds, we use near-infrared (NIR) H (1.6 ?m) and K-band (2.2 ?m) polarimetric observations of background starlight from the Mimir instrument on the 1.8m Perkins telescope. The Herschel Hi-GAL Survey of dust continuum emission was used to estimate the IRDC column densities, and the Spitzer GLIMPSE & MIPSGAL Surveys were used to find their level of star formation activity. We determine whether the direction of the magnetic field inferred from the NIR polarizations differentiate between the different magnetic field models, and whether any correlations exist between magnetic field properties (direction and dispersion) and IRDC properties, such as density and level of star formation activity. This work is partially supported by NSF grant AST 09-07790.

Author(s): ***Sadia Hoq (Boston Univ.)***, Dan Clemens (Boston Univ.)

220.09 – Spitzer observations of infrared cirrus around embedded B stars

I discuss IRAC and MIPS observations of the infrared cirrus around two embedded B stars, HR 5336 and HR 890. IRAS observations have previously shown a deficit in mid-IR emission relative to longer infrared wavelengths for the ISM around these objects. The deficit suggests that small dust grains (VSGs and PAHs) are depleted in the vicinity of the UV radiation field from these stars. Color maps from 3-160 microns are presented and the relative abundances of each grain population are modeled using DUSTEM.

Author(s): ***Sean Carey (Caltech)***

220.10 – Bow-Shock Nebulae in the WISE All-Sky Survey: Around the Celestial Equator

This is a preliminary survey for bow-shock nebulae within one degree of the celestial equator using the WISE All-Sky Data Release. Bow-shock nebulae are clumps of gas and dust that have been condensed by the winds of stars moving through the interstellar medium. This survey has discovered twenty-four bow-shock nebula candidates and their candidate wind-blowing stars. bow-shocks were preferentially found at low galactic latitudes and near the Galactic Center and Anti-Center, as expected. Intriguingly and contrary to previous assumptions, they were not found primarily around OB-runaway stars. A third of the bow-shock nebulae we discovered were around T Tauri stars or young stellar objects (YSOs). Even more unexpectedly, another third of the bow-shock nebulae we found are around A- and F-type stars, which seem too cool to excite the nebulae. This research was funded by a NASA California space grant.

Author(s): ***Kendall Hall (California State Univ., Fresno)***, Fred Ringwald (California State Univ., Fresno)

220.11 – The hydration dependence of $CaCO_3$ absorption lines in the Far IR

The far infrared (FIR) absorption lines of CaCO3<\sub> have been measured at a range of relative humidities (RH) between 33 and 92% RH using a Bruker 66v/S spectrometer. Hydration measurements on CaCO3<\sub> have been made in the mid-infrared (MIR) by [Al-Hosney, H.A. and Grassian, V.H., 2005, Phys. Chem. Chem. Phys., 7, 1266], and astrophysically-motivated temperature-dependent FIR measurements of CaCO3<\sub> in vacuum have also been reported [Posch, T., et al., 2007, Ap. J., 668, 993]. The custom sample cell constructed for these hydrated-FIR spectra is required because the 66v/S bench is under vacuum (3 mbar) during typical measurements. Briefly, the sample cell consists of two Thalium Bromoiodide (KRS-5) windows, four O-rings, a plastic ring for separating the windows and providing a volume for the saturated atmosphere. CaCO3<\sub> was deposited on KRS-5 windows using doubly-distilled water as an intermediary. The KRS-5 window with sample and assembled sample cell were placed in a desiccator with the appropriated saturated salt solution [Washburn, E.W. (Ed.), International Critical Tables of Numerical Data, Physics Chemistry and Technology, Vol. 1, (McGraw-Hill, New York, 1926), p. 67-68] and allowed to hydrate for 23 hours. For spectroscopy the desiccator was quickly opened and the second KRS-5 window placed in the cell to seal the chamber. A spectrum was then taken of the sample at the appropriate RH. The spectra taken characterize the adsorption of water vapor and CaCO3<\sub> that might occur in circumstellar environments [Melnick, G.J., et al. 2001, Nature, 412, 160]. The MIR and FIR reflectance spectra of calcite (CaCO3<\sub>) have been thoroughly studied by [Hellwege, K.H., et al., 1970, Z. Physik, 232, 61]. Five Lorentzian curves were fit to our data in the range from 378-222 cm-1<\sup> and each was able to be assigned to a known mode of CaCO3<\sub>. The data does not support the conclusion of a hydration effect on these modes of CaCO3<\sub>, but it does suggest a possible broadening of three modes peaked at 281 cm-1<\sup>. The goal of this work is to bridge the body of work on CaCO3<\sub> in physical chemistry and previous laboratory astrophysical observations to aid interpretation of FIR spectra obtained by observatories such as the Spitzer Space Telescope.

Author(s): ***Johnny Powell (Reed College)***, Logan Emery (Reed College)

220.12 – A Herschel-SPIRE Survey of the MonR2 Giant Molecular Cloud

We present a new survey of the MonR2 giant molecular cloud with SPIRE on the Herschel Space Observatory. We cross-calibrated SPIRE data with Planck-HFI and accounted for its absolute offset and zero point correction. We fixed emissivity with the help of flux-error and flux ratio plots. As the best representation of cold dusty molecular clouds, we did greybody fits of the SEDs. We studied the nature of distribution of column densities above and below certain critical limit, followed by the mass and temperature distributions for different regions. We isolated the filaments and studied radial column density profile in this cloud.

Author(s): ***Riwaj Pokhrel (University of Massachusetts)***, Robert Gutermuth (University of Massachusetts), Babar Ali (IPAC, Caltech), S. Thomas Megeath (U of Toledo), Judith Pipher (U of Rochester), Philip Myers (Harvard University), William Fischer (U of Toledo), Thomas Henning (Max Planck Institute for Astronomy), Scott Wolk (Harvard University), Lori Allen (NOAO), John Tobin (NRAO)

220.13 – A New Method of FIR Modeling of Filamentary IRDCs

We present a novel method to extract high spatial resolution dust column density and temperature maps associated with filamentary infrared dark clouds (IRDCs). We combine the usual cloud far-infrared emission from SPIRE bands with the higher resolution absorption images at the PACS bands. Our approach allows us to obtain more precise temperatures and column density maps at the best angular resolution available in the data, set by the PACS70 micron beam size, but it requires careful modeling of the Galactic background and foreground emission. The method is especially useful to study the remarkable sample of IRDCs unveiled by *Herschel*, which are cold and dense enough to appear in absorption against the Galactic far-infrared background at 70 ?m. For these IRDCs, we compare our method with physical parameters independently derived from continuum and molecular line data, and find consistent results.

Author(s): ***Andres Guzman (Harvard Smithsonian Center for Astrophysics)***, Howard Smith (Harvard Smithsonian Center for Astrophysics), Juan Rafael Martinez-Galarza (Harvard Smithsonian Center for Astrophysics)

220.14 – Two-component Thermal Dust Emission Model: Application to the Planck HFI Maps

We present full-sky, 6.1 arcminute resolution maps of dust optical depth and temperature derived by fitting the Finkbeiner et al. (1999) two-component dust emission model to the Planck HFI and IRAS 100 micron maps. This parametrization of the far infrared thermal dust SED as the sum of two modified blackbodies serves as an important alternative to the commonly adopted single modified blackbody dust emission model. We expect our Planck-based maps of dust temperature and optical depth to form the basis for a next-generation, high-resolution extinction map which will additionally incorporate small-scale detail from WISE imaging.

Author(s): ***Aaron Meisner (Harvard University)***, Douglas Finkbeiner (Harvard University)

220.15 – Towards a Unified Model of Polarized Emission and Extinction from Interstellar Dust

We present models of interstellar grains that reproduce observational constraints on dust extinction, polarized extinction, infrared emission, and elemental abundances. Employing spheroidal graphite-PAH and "astrosilicate" grains of varying axial ratio, we constrain the size distribution and degree of alignment as a function of grain size. We discuss in particular the polarized emission from each model in the context of results from Planck as well as the effects of including contributions from ferromagnetic iron nanoparticles. We outline our next steps in developing a model of dust in the diffuse ISM by leveraging observational constraints on scattering and adapting our models to environments other than the diffuse ISM.

Author(s): ***Brandon Hensley (Princeton University)***, Bruce Draine (Princeton University)

220.16 – Grain Destruction in Evolving Supernova Remnants

Supernova remnant (SNR) shocks are believed to be the primary regions of destruction for interstellar dust grains. This destruction occurs primarily because of the grain acceleration that occurs when the shock causes the gas and magnetic field to be compressed. Most calculations of grain destruction in shocks have used steady, plane parallel shocks, but in the interstellar medium most shocks result from SNRs and have significant time dependent and non-planar effects. We present new results for grain destruction that use numerical hydrodynamical calculations of supernova remnant evolution and include all important grain processes. We show that the lower density behind SNR shocks leads to substantially less grain destruction, alleviating the discrepancy between the grain destruction and creation timescales for silicate grains.

Author(s): ***Jonathan Slavin (Harvard-Smithsonian, CfA)***

220.17 – Collision of High Velocity Clouds with the Galactic Disk under the Effect of Dark Matter

The fate of high velocity clouds (HVCs) will affect the evolution of the Milky Way. If currently observed HVCs survived the interaction with the halo gas and reached the Galactic disk eventually, HVCs could provide fuel for the star formation in the disk. For this reason, the collision of HVCs with the Galactic disk has been extensively studied via numerical simulations. Recently, an idea that some HVCs are accompanied by dark matter has been suggested based upon the scenario that HVCs originated from the stripped gas of satellite galaxies which tend to have dark matter. Along the similar line of reasoning, it is worth investigating the effect of dark matter on the collision of HVCs with the Galactic disk. By using the FLASH hydrodynamics code, we simulate this scenario and search for proper parameters of dark matter and baryonic matter that can explain the currently available observations such as the Smith Cloud.

Author(s): ***Kyujin Kwak (Ulsan National Institute of Science and Technology (UNIST))***, Hyun Taek Lee (Ulsan National Institute of Science and Technology (UNIST)), Seungwon Yang (Ulsan National Institute of Science and Technology (UNIST)), Kwang Hyun Sung (Ulsan National Institute of Science and Technology (UNIST)), Jongsoo Kim (Korea Astronomy and Space Science Institute (KASI))

221 – AGN, QSO, Blazars Posters

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

221.01 – The Clustering of Quasars at Redshift 2.5 from the Final SDSS-III/BOSS Sample

Measuring the mass of the dark matter halos that host quasars is a critical question in the field of galaxy evolution. Estimates of how the mean mass of the dark matter halos in which quasars are triggered evolves with time can potentially constrain scenarios in which the quasar phase is triggered in different dark-matter environments as the Universe progresses. Quasar clustering measurements on linear scales across a range of redshifts is a powerful tool with which to estimate the masses of the dark matter halos that are inhabited by the galaxies that host quasars. Although there are many measurements of quasar clustering at redshift $z < 2.2$, and a few at $z > 3$, there are very few precise measurements around z~2.5, where the quasar phase appears to peak before declining at $z < 2$. The SDSS-III/BOSS survey targets redshifts of $2.2 < z < 3.5$, and should therefore offer the most precise estimates of quasar clustering near the epoch of peak quasar activity. We use data from SDSS-III/BOSS to measure the clustering of quasars over the redshift range $2.2 < z < 2.8$ via the real and redshift space two point correlation functions. The data consists of a homogeneously selected sample of 62960 BOSS CORE quasars drawn from SDSS DR11. Our homogeneous sample covers ~4460 (deg)^2 corresponding to a comoving volume of ~12 (Gpc/h)^3. We obtain the correlation length of quasars near z~2.5 and derive the bias of the dark matter halos that host quasars. We study the mass of the dark matter environments of quasars using the formalism of the Halo Occupation Distribution (HOD). We will discuss our results at z~2.5, and also results obtained by dividing the BOSS quasar sample into three redshift ranges to study how the correlation length, bias, and dark matter halo mass of quasars evolve over this key redshift range.

Author(s): ***Sarah Eftekharzadeh (Department of Physics and Astronomy, University of Wyoming)***, Adam Myers (Department of Physics and Astronomy, University of Wyoming), Martin White (Department of Phhysics and Astronomy,University of California Berkeley,601 Campbell,94720), Jo Bovy (Institute for Advanced Study, Einstein Drive, Princeton, NJ 08540), Xiaohui Fan (Steward Observatory, The University of Arizona), Jean-Marc Le Goff (CEA, Centre de Saclay, Irfu/SPP, 91191), Pierre Laurent (CEA, Centre de Saclay, Irfu/SPP, 91191), Cameron McBride (Harvard-Smithsonian center for Astronomy,60 Garden Street,MA 02138), Jordi Miralda-Escude (Institut de Ciencies del Cosmos, Universitat de Barcelona), Nathalie Palanque-Delabrouille (CEA, Centre de Saclay, Irfu/SPP, 91191), Patrick Petitjean (Universit Paris 6 et CNRS, Institut dAstrophysique de Paris, 98bis blvd. Arago, 75014), Nicholas P. Ross (Lawrence Berkeley National Laboratory, One Cyclotron Road, Berkeley, CA 94720), Donald Schneider (Dept. Astron. & Astrophys. and Institute for Gravitation & the Cosmos, Pennsylvania State University, University Park, PA 16802), Yue Shen (Harvard-Smithsonian center for Astronomy,60 Garden Street,MA 02138), Michael Strauss (Department of Astrophysical Sciences, Princeton University), Alina Streblyanska (Instituto de Astrofisica de Canarias (IAC), E-38200 La Laguna), David Weinberg (Department of Astronomy and CCAPP, Ohio State University), W. Wood-Vasey (Pittsburgh Particle Physics, Astrophysics, and Cosmology Center (PITT PACC), Physics and Astronomy Department, University of Pittsburgh,PA 15260), Matteo Viel (INAF Osservatorio Astronomico via Tiepolo 11 I-34143), Christophe Yeche (CEA, Centre de Saclay, Irfu/SPP, 91191), Don York (Department of Astronomy and Astrophysics, University of Chicago, 5640 South Ellis Avenue,IL 60637), Idit Zehavi (Department of Astronomy, Case Western Reserve University)

221.02 – AGN Feedback in the Hot Halo of NGC 4649

Using the deepest available Chandra observations of NGC 4649 we find strong evidences of cavities, ripples and ring like structures in the hot interstellar medium (ISM) that appear to be morphologically related with the central radio emission. These structures are reminiscent of the structures observed in NGC 1275 Chandra images. In common with that source, we found no significant temperature variations in correspondence with higher pressure regions (0.5 kpc < r < 3 kpc), suggesting that the observed structures may be isothermal waves whose energy is dissipated by viscosity. On the same spatial scale, a discrepancy between the mass profiles obtained from stellar dynamic and Chandra data represents the telltale evidence of a significant non-thermal pressure component in this hot gas, which is related to the radio jet and lobes. On larger scale we find agreement between the mass profile obtained form Chandra data and planetary nebulae and globular cluster dynamics. The nucleus of NGC 4649 appears to be extremely radiatively inefficient, with highly sub-Bondi accretion flow. Consistently with this finding, the jet power evaluated from the observed X-ray cavities implies that a small fraction of the accretion power calculated for the Bondi mass accretion rate emerges as kinetic energy. Comparing the jet power to radio and nuclear X-ray luminosity the observed cavities show similar behavior to those of other giant elliptical galaxies.

Author(s): ***Alessandro Paggi (Harvard-Smithsonian Center for Astrophysics)***, Giuseppina Fabbiano (Harvard-Smithsonian Center for Astrophysics), Dong-Woo Kim (Harvard-Smithsonian Center for Astrophysics), Francesca Civano (Harvard-Smithsonian Center for Astrophysics), Jay Strader (Department of Physics and Astronomy, Michigan State University)

221.03 – Disk Wind Mass Loss Estimates in QSOs

We derive here a relatively simple expression for the total wind mass loss rates in QSOs within the accretion disk wind scenario. We show that the simple expression derived here for QSO disk wind mass loss rate is in very good agreement with the more “exact” values obtained through significantly more complex and detailed numerically intensive 2.5D time-dependent simulations. Additionally we show that for typical QSO parameters, the disk itself will be emitting mostly in the UV/Optical spectrum, in turn implying that the X-ray emission from QSOs likely is produced through some physical mechanism acting at radii smaller than the inner disk radius (for a standard accretion disk, half of the initially gravitational potential energy of the accreting disk mass is emitted directly by the disk, while the other half “falls” closer towards the black hole than the inner disk radius). We also show that for typical QSO parameters, the disk itself is dominated by continuum radiation pressure (rather than thermal pressure), resulting in a “flat disk” (except for the innermost disk regions).

Author(s): ***Nicolas Pereyra (University of Texas - Pan American)***

221.04 – Radio-Loud and Radio-Quiet BAL Quasars Differ Only in Their Radio Properties

Recent studies of the rest-frame ultraviolet (observed-frame optical) spectral properties of radio-loud broad absorption line (BAL) and radio-loud non-BAL quasars have shown that they are quite similar. Here we extend this analysis to compare spectral properties in radio-loud (73) and radio-quiet (472) BAL quasars selected from the Sloan Digital Sky Survey (SDSS). The samples have similar redshift ranges (from 1.5 to 3.5) and broad-band luminosities. We compare several continuum, emission-line, and absorption-line properties. While most spectral properties in the two samples have no significant differences, we find that the properties of the CIV emission line may differ slightly. However, CIV is difficult to measure in BAL quasars due to the strong absorption, and we find evidence that the apparent CIV differences may be related to small but systematic differences in the velocity structure of the BAL wind in radio-loud compared to radio-quiet objects. We conclude that radio-loud and radio-quiet BAL QSOs have few physical differences, except for their radio properties. This indicates that results using samples of radio-loud BAL quasars extend to their radio-quiet counterparts, and the two do not form significantly different subclasses.

Author(s): ***Thomas Rochais (University of Wyoming)***, Michael DiPompeo (University of Wyoming), Adam Myers (University of Wyoming), Michael Brotherton (University of Wyoming)

221.05 – Breaking Degeneracies between Quasar Halo Occupation Distribution Models: Extending Direct Measurements of the Mean Occupation Distribution to Redshift 0.6

Recent work on quasar clustering suggests a degeneracy in the halo occupation distribution (HOD) constrained from two-point correlation functions. To break this degeneracy, we made the first direct measurement of the mean occupation function (MOF) of quasars at redshift z ~ 0.2 from cross-matching SDSS DR7 quasars with clusters of galaxies drawn from the MaxBCG catalog. A limitation of our measurement is that at z ~ 0.2 the number of quasars declines rapidly compared to at higher redshift. To circumvent this limitation, we repeat our measurement using clusters drawn from the RedMapper catalog. The number of matched quasars increases significantly in this new analysis, as RedMapper clusters probe as high as z ~ 0.6. Preliminary results show that the MOF increases monotonically with halo mass. We also measure the variance, the second moment of the HOD, which closely resembles a Poisson distribution. The radial distribution of quasars within dark matter halos is well described by a power law with a slope of ~ -1. The conditional luminosity function (CLF) of quasars and conditional black hole mass function (CMF) show no dependence with host halo mass, similar to inferences drawn from measurements of the two-point correlation function.This work is supported by the National Science Foundation through grant number 1211112 and by NASA through ADAP award NNX12AE38G.

Author(s): ***My Nguyen (University of Wyoming)***, Suchetana Chatterjee (Presidency University), Adam Myers (University of Wyoming), Zheng Zheng (University of Utah), Eduardo Rozo (Stanford University), Eli Rykoff (Stanford University)

221.06 – Structure Function Analysis of AGN Variability using Kepler

We study the variability properties of AGN light-curves observed by the Kepler satellite. AGN optical fluxes are known to exhibit stochastic variations on time-scales of hours, days, months and years. Previous efforts to characterize the stochastic nature of this variability have been hampered by the lack of high-precision space-based measurements of AGN fluxes with regular cadence. Kepler provides light-curves with a S/N ratio of 10^{-5} for 87 AGN observed over a period of ~ 3 years with a cadence of once every 30 minutes allowing for a detailed examination of the variability process. We probe AGN variability using the Structure Functions of the light-curves of the Kepler AGN. Monte-Carlo simulations of the structure function are used to fit the observed light-curve to models for the Power Spectral Density. We test various models for the form of the PSD including the damped random walk and the powered exponential models. We show that on the shorter time-scales probed by Kepler data, the damped random walk model fails to adequately characterize AGN variability. We find that the PSD may be better modelled by combination of a steep power law of the form $1/f^3$ on shorter time-scales, and a more shallow power law of the form $1/f^2$ on the longer time-scales traditionally probed by ground-based variability studies.

Author(s): ***Vishal Kasliwal (Drexel University)***, Michael Vogeley (Drexel University), Gordon Richards (Drexel University)

221.07 – Observational Tests to Detect Photometric Reverberation in H-alpha

We present photometric observations of several AGN that were secured with the 0.9-m telescope located at the West Mountain Observatory that is operated by Brigham Young University. The new observations use standard BVR filters along with several custom filters that are part of a red shifted H-alpha set. Light curves are presented for several of the targets along with a summary of the analysis made to detect lag times between the continuum and broad emission line flux as evidence for photometric reverberation. Plans are presented for future research that will continue along these lines. We thank the Department of Physics and Astronomy along with the College of Physical and Mathematical Sciences at Brigham Young University for continued support of the research work being done at the West Mountain Observatory.

Author(s): ***Michael Joner (Brigham Young Univ.)***, Carla Carroll (Brigham Young Univ.)

221.08 – Three Gamma-ray Active Periods in the Quasar PKS1510-089 and their Connection with the Parsec Scale Jet Behavior

Since the start of Fermi Large Area Telescope operations in 2008 August, the quasar PKS1510-089 has undergone three periods of high gamma-ray activity - in 2009, 2011, and 2013 - with different amplitudes and complex structure of gamma-ray outbursts. We analyze the parsec scale jet structure of the quasar with a resolution of 0.1 milliarcseconds using 68 epochs of Very Long Baseline Array (VLBA) observations at 43 GHz from 2007 June to 2014 January. We find that the innermost jet of PKS1510-089 during a quiescent state consists of a compact core and a stationary feature $\sim$0.5 mas from the core. During the 2009 and 2011 gamma-ray outbursts, two superluminal knots appeared in the jet for each event, while during the 2013 outburst only one knot was detected. The knots moved down the jet at different apparent speeds, ranging from 23c to 13c. Extrapolated epochs of the passage of the knots through the core coincide within 1σ uncertainty with peaks of the gamma-ray light curve. We explain the complex structure of the outbursts as the result of propagation of blobs of relativistic plasma from the broad line region to the mm-wave core of the jet through a non-uniform field of external photons, with the physical parameters of the blobs similar to those of the superluminal knots seen on the VLBA images. This research is funded in part by NASA Fermi Guest Investigator grants NNX11AQ03G and NNX13AO99G.

Author(s): ***Svetlana Jorstad (St. Petersburg University)***, Alan Marscher (Boston Univ.), Nicholas MacDonald (Boston Univ.), Vishal Bala (Boston Univ.)

221.09 – The Role of Multiple Shocks in the Production of GeV Gamma-ray Flaring in the Blazar 1156+295

As part of work to identify jet conditions during GeV flaring detected by the Fermi-LAT, we have carried out radiative transfer modeling of a pair of centimeter-band, total and polarized flux outbursts in the FSRQ 1156+295 from the UMRAO data archive. The modeling incorporates propagating shocks and uses the observed spectral evolution between 14.5 and 4.8 GHz as constraints. The two outbursts are nearly identical in amplitude, spectrum and duration. However, the centimeter-band outburst peaking in 2010.75 is temporally associated with a series of GeV flares extending over nearly 300 days with peak photon flux exceeding 10^{-6} photons/cm^2/s, while the centimeter-band outburst which commenced in early August 2008 is temporally associated with a well-defined gamma-ray quiescent state. Our analysis reveals that the shocks in the parsec-scale jet during the two events have a similar sense (forward), orientation (transverse) and compression, but in the case of the orphan radio-band flare only 2 shocks were required to reproduce the light curves, while in the event with a paired gamma-ray flare, 4 shocks were required. VLBA imaging of the inner jet at 43 GHz identifies a single jet component during the orphan flare and complex structure in the later event. This suggests that differences in shock structure, and associated shock interactions, play a role in the production of gamma-ray flares. This work was supported in part by Fermi GI grants NNX11AO13G, and NNX13AP18G (U. Michigan) and NNX11AQ03G (Boston U.). T. H. was supported in part by a grant from the Jenny and Antti Wihuri foundation and by the Academy of Finland project number 267324.

Author(s): ***Margo Aller (Univ. of Michigan)***, Philip Hughes (Univ. of Michigan), Hugh Aller (Univ. of Michigan), Talvikki Hovatta (California Institute of Technology), Svetlana Jorstad (Boston University), Alan Marscher (Boston University), Venkatessh Ramakrishnan (Aalto University Metsähovi Radio Observatory)

221.10 – The Low End of the Electron Spectrum in Relativistic Jets

There are two problems related to the low end of the relativistic electron spectrum in extragalactic jets that can be addressed with low radio frequency observations with arcsec resolution. The first is a test of the beamed inverse Compton model (IC/CMB) for the X-ray emission from quasar jets. Synchrotron emitting electrons with Lorentz factors of gamma in the range of 50-400 are those responsible for IC/CMB X-ray emission so it is generally necessary to make a blind extrapolation to very low radio frequencies from the arcsec resolution data predominantly obtained at cm wavelengths. The second issue relates to predictions of shock acceleration models that suggest there could be a low energy break in the electron distribution around gamma ~ 2000, i.e. at an energy where the electron momentum is comparable to that of a proton. Intensities and spectral shapes near 100 MHz will significantly reduce the required extrapolation and provide evidence for or against the conflicting expectations: a single power law extending down to gamma ~ 100 versus a break near gamma=2000. In order to interpret the observations that will be forthcoming from LOFAR and eventually with SKA, it is necessary to understand the uncertainties affecting the determination of the magnetic field strength in the emitting region, the key factor in associating a frequency with gamma. In this contribution we examine the factors involved in computing the equipartition field and argue that invoking parameters that minimize B(eq) will provide an upper limit to gamma corresponding to an observed frequency. We briefly describe a LOFAR observation scheduled for May 2014 which will represent a first step in constraining the low end of the electron spectrum. This work was partially supported by NASA grant GO3-14106X.

Author(s): ***D. Harris (SAO)***, Teddy Cheung (NRL), L. Godfrey (ASTRON)

221.11 – High Density Optical Observations of PKS 0558-504

PKS 0558-504 is a radio-loud Narrow Line Seyfert 1 with an SED that resembles that of a blazar. We present three nights of high density optical observations. These observations will be put into an historical perspective using literature to produce a long-term light curve.

Author(s): ***Amy Campbell (Georgia Gwinnett College)***

221.12 – Measuring Supermassive Black Hole Spins in NGC 1365 and MCG--6-30-15 Using XMM-Newton and NuSTAR

We report on detailed spectral modeling of the Seyfert 1 AGN NGC 1365 and MCG--6-30-15 using simultaneous, broadband X-ray spectra from XMM-Newton and NuSTAR. Both of these galaxies show evidence for relativistic reflection from the inner accretion disk in addition to complex, variable absorption. The high signal-to-noise across the 0.2-79 keV energy band enabled by these observations allows us to definitively disentangle the spectral signatures of the continuum, warm and cold absorption, and reflection from the torus and the inner disk in both sources. These deep pointings also enable the use of time-resolved spectral fitting in order to assess the role of each component in driving the spectral and temporal variability of the AGN. This type of analysis allows us to isolate the relativistic reflection signatures in each object, facilitating the most accurate, precise constrains ever obtained on the spins of their supermassive black holes.

Author(s): ***Laura Brenneman (Harvard-Smithsonian Center for Astrophysics)***, Andrea Marinucci (Universita Roma Tre), Dom Walton (California Institute of Technology), Guido Risaliti (INAF/Arcetri), Giorgio Matt (Universita Roma Tre), Fiona Harrison (California Institute of Technology), Daniel Stern (California Institute of Technology)

Contributing teams: The NuSTAR team

221.13 – The AGN Corona and Supermassive Black Hole of NGC 4151 as Revealed by *NuSTAR* and *Suzaku*

Through timing and spectral analyses of simultaneous, 150 ks *Nuclear Spectroscopic Telescope Array* (*NuSTAR*) and *Suzaku* X-ray observations of the Seyfert 1.5 galaxy NGC 4151, we disentangle the continuum, reflection, and absorption properties of the innermost regions of the active galactic nucleus (AGN). Utilizing *NuSTAR's* broadband (3-79 keV) X-ray sensitivity and *Suzaku's* CCD energy resolution from 0.7-10 keV, we robustly determine properties of the AGN corona and supermassive black hole (SMBH). We constrain the coronal temperature and optical depth to be $kT_e = 44_{-29}^{+9}$ keV and $?=1.4_{-0.3}^{+2.0}$, respectively, assuming a coronal slab geometry. Additionally, we determine the dimensionless spin, a?0.99, of the SMBH in NGC 4151 for the first time through a spectral analysis. Finally, we show evidence that the coronal flux varies on time-scales as short as four hours. We discuss constraints our results put on the coronal geometry. To robustly test for the presence of relativistic reflection from the inner accretion disks of Seyfert 1 AGNs, we develop a library of time-dependent spectra and light curves from simulated eclipses of an accretion disk by clumpy, absorbing material covering a large range of disk, black hole, and absorber parameters. When applied to a high signal-to-noise observation of a Compton-thick eclipse of the accretion disk, these simulations will enable observational tests for the presence of inner accretion disk reflection in Seyfert 1 AGN emission using current X-ray observatories and standard X-ray data analysis software.

Author(s): ***Mason Keck (Boston University)***, Laura Brenneman (Harvard-Smithsonian Center for Astrophysics), Martin Elvis (Harvard-Smithsonian Center for Astrophysics), Felix Fuerst (California Institute of Technology), Grzegorz Madejski (Stanford Linear Accelerator Center), Giorgio Matt (Università Roma Tre), Fiona Harrison (California Institute of Technology), Daniel Stern (California Institute of Technology), Jonathan McDowell (Harvard-Smithsonian Center for Astrophysics), Guido Risaliti (INAF – Osservatorio Astrofisico di Arcetri)

Contributing teams: The *NuSTAR* Team

221.14 – The Interplay of the NIR to UV Spectral Energy Distributions of Gamma-Ray Bright Blazars

The small fraction of AGN in which a relativistic jet is aligned with the observer's line of sight are classified as blazars. Radiation from the accretion disk and perhaps the jet is absorbed and reprocessed through various structures inside the AGN, and subsequently re-emitted across a broad range of frequencies. In some blazars, relatively unprocessed radiation from the accretion disk is visible in the optical-UV portion of the spectrum. In spectral energy distributions (SEDs) this produces the so-called Big Blue Bump (BBB). Measuring the strength of the BBB emission is complicated by the fact that the synchrotron emission from the relativistic jet is also prominent in the same portion of the SED. We separate the unpolarized BBB emission of a sample of blazars from the polarized synchrotron emission present in the optical-UV emission through the use spectropolarimetric observations spanning ?= 4000-7000 ? in the observer's frame. With the assumption that the BBB emission is unpolarized, the spectral index of the synchrotron emission, $?_s$, is determined from the polarized flux spectrum. The strength of the BBB then follows by fitting a two component model of the form $F_? = A\ ?^{??s} + B\ ?^{??BBB}$, where $?_{BBB}$ is the spectral index of the BBB and is set to 5/3. We combine these observations with a time series of photometric observations spanning the NIR (*J, H,* and K_s) and the optical (*u? , g? , r? , i? ,* and *z?*) spectrum. This yields a time baseline of several years for a sample of gamma-ray bright blazars to determine the variability of the BBB and to trace its impact on both the NIR emission from the torus, as well as any effect on gamma-ray production. Any such variability indicates that the structure of the accretion disc evolves appreciably on time scales of few years. Coupling of BBB emission with dust emission will help determine the size scale of the inner-most radius of the torus. This is needed to determine the radiation environment of the torus and and thereby constrain inverse Compton models for gamma-ray production. This research is supported in part by NASA Fermi Guest Investigator grants NNX11AQ03G and NNX11AO40G and by NSF GK12 GLACIER DGE-0947950.

Author(s): ***Michael Malmrose (Boston Univ.)***, Alan Marscher (Boston Univ.), Svetlana Jorstad (St.Petersburg State University)

221.16 – Optical Spectroscopy of the Restarting Radio Galaxy 3C 219

We are investigating the mechanism for the triggering radio jet formation in active galactic nuclei (AGNs). The radio source 3C 219 appears to have both an ancient remnant lobe system and a small recently-initiated jet. One interpretation of this unusual structure is that the AGN was active in the distant past, went dormant, and is now forming jets again. Thus 3C 219 provides an opportunity to study the mechanism of jet formation in a very young object. One hypothesis for triggering jet formation in an AGN is gravitational interaction with another galaxy. This interaction should leave traces of optical activity such as enhanced star formation in the host galaxy of the AGN. Optical spectroscopy is used to study the radiation from ionized gas which tells about the physical conditions in the host galaxy of 3C 219. We have produced spectra of 3C 219 and the comparison galaxy B1213+422, and are examining the differences between these two fields. Preliminary results show little evidence of recent star formation in 3C 219.

Author(s): ***Kathryn Weil (Brandeis University)***, David Roberts (Brandeis University)

221.17 – Modeling the Reverberation Response of the Dusty Torus Emission from AGN

The obscuring circum-nuclear torus of dusty molecular gas is one of the major components of AGN (active galactic nuclei), yet its size, composition, and structure are not well understood. These properties can be studied by analyzing the time response of the dust emission from the torus with respect to variations in the AGN continuum luminosity; a technique known as reverberation mapping. An international campaign to monitor 12 Type 1 AGN using the Spitzer Space Telescope and several ground-based telescopes has recently been completed. These data provide a unique set of well-sampled mid-infrared (IR; 3.6, 4.5 microns) and optical (B, V bands) light curves over a two-year baseline, which will be used to determine approximate sizes of the tori for these galaxies. To help extract structural information contained in the data we are also developing a computer model that simulates the reverberation response of a clumpy torus for direct comparison with the observed IR light curves. Here I present preliminary results from these simulations and compare them to the light curves of NGC 6418, one of the 12 galaxies observed during the Spitzer campaign.

Author(s): ***Triana Almeyda (Rochester Institute of Technology)***, Andrew Robinson (Rochester Institute of Technology), Michael Richmond (Rochester Institute of Technology), Billy Vazquez (Rochester Institute of Technology)

221.18 – Time-dependent Photoionization of Gaseous Nebulae: Time-dependent Version of XSTAR

In a previous paper we developed a code to study the problem of time-dependent photoionization of pure hydrogen gaseous nebulae subjected to sudden changes in the intensity of ionizing radiation. We have showed that changes in the ionizing radiation yield ionization/thermal fronts that propagate through the cloud creating large pressure imbalances with important dynamical effects in the cloud. Now we present a full time-dependent version of the XSTAR code to solve the energy balance, ionization balance, and radiation transfer equations in a self-consistent fashion in nebulae subjected to rapidly changing ionizing radiation. We compare the results of the previous paper of the simplified hydrogen model to that of the current full atomic model. Further, we investigate time-dependent ionization effects in Quasar Broad Absorption Line (BAL) clouds.

Author(s): ***Ehab Elhoussieny (Western Michigan University)***, Manuel Bautista (Western Michigan University), Timothy Kallman (NASA Goddard Space Flight Center), Javier Garcia (Harvard-Smithsonian Center for Astrophysics)

221.19 – Time-variable Linear Polarization as a Probe of the Compact Jets of Blazars

A single measurement of linear polarization of a nonthermal source provides direct information about the mean direction and level of ordering of the magnetic field. Monitoring of the polarization in blazars, combined with millimeter-wave VLBI imaging in both total and polarized intensity, has the potential to determine the geometry of the magnetic field. This is a key probe of the physical processes in the relativistic jet, such as ordered field components, turbulence, magnetic reconnections, magnetic collimation and acceleration of the jet flow, particle acceleration, and radiative processes that produce extremely luminous, highly variable nonthermal emission. The authors will show some examples of well-sampled monitoring observations of multi-waveband flux and radio-optical polarization of blazars. In some cases, the observed polarization patterns appear systematic, while in others randomness dominates. Explanations involve helical magnetic fields, turbulence, and perhaps particle acceleration that depends on the angle between the magnetic field and shock fronts that might be present. This research is supported in part by NASA through Fermi Guest Investigator grants NNX11AQ03G, NNX12AO79G, and NNX13AP06G to Boston U., NNX12AO93G to Steward Obs., and RFBR grants 12-02-00452 and 12-02-31193 to St. Petersburg State U.

Author(s): ***Alan Marscher (Boston University)***, Svetlana Jorstad (St. Petersburg State U.), Valeri Larionov (St. Petersburg State U.), Ivan Agudo (JIVE), Paul Smith (Steward Obs.)

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222 – Evolution of Galaxies Posters

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

222.01 – HIghMass – High HI Mass, HI-rich Galaxies at z~0 (Sample Definition, Optical and H? Imaging, and Star Formation Properties)

We present first results of the study of a set of exceptional HI sources identified in the 40% ALFALFA extragalactic HI survey catalog ?.40 as being both extremely HI massive ($M_{HI} > 10^{10}$ $M_?$) and having high gas fractions for their stellar masses: the HIghMass galaxy sample. We analyze UV- and optical- broadband and H? images to understand the nature of their relatively underluminous disks in optical and to test whether their high gas fractions can be tracked to higher dark matter halo spin parameters or late gas accretion. Estimates of their star formation rates (SFRs) based on SED-fitting agree within uncertainties with the H? luminosity inferred current massive SFRs. The HII region luminosity functions, parameterized as dN/dlogL ? $L^?$, have standard slopes at the luminous end (? ~ ?1). The global SFRs demonstrate that the HIghMass galaxies exhibit active ongoing star formation (SF) with moderate SF efficiency, but relative to normal spirals, a lower integrated SFR in the past. Because the SF activity in these systems is spread throughout their extended disks, they have overall lower SFR surface densities and lower surface brightness in the optical bands. Relative to normal disk galaxies, the majority of HIghMass galaxies have higher H? equivalent widths and are bluer in their outer disks, implying an inside-out disk growth scenario. Downbending double exponential disks are more frequent than upbending disks among the gas-rich galaxies, suggesting that SF thresholds exist in the downbending disks, probably as a result of concentrated gas distribution. Future observations of the HIghMass galaxies will study the HI-to-H_2 transition and the empirical Kennicutt-Schmidt (KS) relation in more detail to explore how such massive HI disks can exist without having converted the bulk of gas into stars yet.

Author(s): *Shan Huang (Cornell University)*, Martha Haynes (Cornell University), Riccardo Giovanelli (Cornell University), Gregory Hallenbeck (Cornell University), Michael Jones (Cornell University), Elizabeth Adams (Cornell University), Jarle Brinchmann (Sterrewacht Leiden), Jayaram Chengalur (National Centre for Radio Astrophysics), Leslie Hunt (INAF-Osservatorio Astrofisico di Arcetri), Karen Masters (Institute of Cosmology and Gravitation, Portsmouth), Satoki Matsushita (ASIAA), Amelie Saintonge (University College London), Kristine Spekkens (Royal Military College of Canada)

222.02 – Merger Signatures in the Galaxy Cluster Abell 98

We present results from *Chandra* and *XMM-Newton* observations of the galaxy cluster Abell 98 (A98), which shows three major components: a relatively bright subcluster to the north (A98N), a disturbed subcluster to the south (A98S), and a fainter subcluster to the far south (A98SS). We find evidence of a surface brightness and temperature asymmetry in A98N that is consistent with the presence of a leading bow shock to the south, created by an early stage merger between A98N and A98S. We also find that A98S has an asymmetric temperature structure in the core, likely due to a separate ongoing merger. Evidence for this is also seen in the optical data. A98S hosts a wide-angle tail (WAT) radio source powered by a central active galactic nucleus (AGN). We find evidence for a cavity in the intracluster medium (ICM) that has been evacuated by one of the radio lobes, suggesting that AGN feedback is operating in this system. The three main subclusters lie along a line in projection, suggesting the presence of a large scale filament. We observe an excess of emission along the filament between A98N and A98S, but a surface brightness profile shows that this excess emission is consistent with the overlap of the extended gas haloes of A98N and A98S. We find that the temperature of this region is consistent with the temperature of the gas at similar radii outside this bridge region. Lastly, we examine the cluster dynamics. We find that A98N and A98S are likely bound to one another, with a 67% probability, while A98S and A98SS are not bound at a high level of significance.

Author(s): *Rachel Paterno-Mahler (Center for Astrophysics)*, Scott Randall (Center for Astrophysics), Esra Bulbul (Center for Astrophysics), Felipe Santos (Center for Astrophysics), Christine Jones (Center for Astrophysics), Stephen Murray (Johns Hopkins University), Elizabeth Blanton (Boston Univ.), Ryan Johnson (Gettysburg College)

222.03 – 3C28 in Abell 115- A Radio Source With a Twist: Tracing Gas Vortices in a Merging Subcluster Core

Abell 115 is one of the “bimodal” clusters, first identified from Einstein Observatory X-ray images. The X-ray image is dominated by emission from two subclusters, separated by about 900 kpc, that are in the process of merging. The northern subcluster (A115-N) contains a bright central galaxy that hosts the radio source 3C28. 3C28 has a remarkable morphology. Although there is no evidence of a presently active nucleus, there are two prominent jets connected to a pair of radio lobes, each of which exhibits a radio tail. A115-N shows a classic cold front, the remarkable phenomenon first studied from Chandra cluster observations. We describe the overall structure of the cluster from detailed Chandra obserations. In addition, we exploit the Chandra data and the cold front phenomenon to study the gas motions in and around A115-N that hosts 3C28. The subcluster motion of A115-N through the cluster induces counter-rotating vortices in the subcluster gas that give rise to the unique radio morphology of 3C28 with its two radio tails pointing in the direction of motion of A115-N. Thus, the radio emitting plasma acts as a dye in a fluid tracing the vortices in the X-ray emitting gas, resembling text book pictures of fluid motions.

Author(s): ***William Forman (SAO)***, Eugene Churazov (IKI), Sebastian Heinz (University of Wisconsin), Simona Giacintucci (University of Maryland), Christine Jones (SAO), Akos Bogdan (SAO), Laurence David (SAO), Ralph Kraft (SAO), Matteo Murgia (OAC-INAF), Maxim Markevitch (GSFC), Scott Randall (SAO), Reinout Van Weeren (SAO), Alexey Vikhlinin (IKI)

222.04 – K-band Polarimetry of NGC 891

We present the first K-band (2.2 um) polarimetry observations of the edge-on galaxy NGC 891. Near-infrared (NIR) polarimetry reveals the plane-of-sky projected magnetic (B) field orientations in dusty, star-forming interstellar media. Previous optical wavelength polarimetry of NGC 891 found predominantly disk-perpendicular polarizations (Scarrott & Draper 1996) while H-band polarimetry revealed mostly disk-parallel polarizations with an interesting 15 degree offset from the major axis position angle (Jones 1997; Montgomery & Clemens 2014). In H-band, Montgomery & Clemens also detected the first NIR polarization null-point, located about 5 kpc northeast of NGC891's center. It may be related to the polarization null-points predicted by Wood (1997) and modeled by Wood & Jones (1997). At the longer K-band wavelength, these new observations better reveal B-field orientation changes in the disk. The Wood (1997) radiative transfer polarization model predicted null-point location changes with wavelengeth. We will use the new K-band polarimetry, along with our H-band polarimetry, to test this prediction. If the null-point location does not depend on wavelength, then the null-point may instead be due to spiral arm aligned B-fields (e.g., Fletcher et al. 2011). This research was supported through NSF grant AST 09-07790.

Author(s): ***Jordan Montgomery (Boston University)***, Dan Clemens (Boston University)

222.05 – Unraveling ICM Physics and AGN Feedback with Deep Chandra X-ray Observations of the Galaxy Group NGC 5813

We present results from deep (650 ks) Chandra X-ray observations of the galaxy group NGC 5813. This system shows three pairs of colinear cavities, with each pair associated with an elliptical AGN outburst shock. Due to the relatively regular morphology of this system, and the unique unambiguous detection of three distinct AGN outburst shocks, it is particularly well-suited for the study of kinetic mode AGN feedback and the AGN outburst history. Topics presented include results on the role of shock heating in AGN feedback, feedback as a solution to the cooling flow problem, the variability of the AGN outburst power over long timescales, and constraints on the microphysics of the ICM.

Author(s): ***Scott Randall (Harvard-Smithsonian Center for Astrophysics)***, Paul Nulsen (Harvard-Smithsonian Center for Astrophysics), Tracy Clarke (Naval Research Lab), William Forman (Harvard-Smithsonian Center for Astrophysics), Christine Jones (Harvard-Smithsonian Center for Astrophysics), Ralph Kraft (Harvard-Smithsonian Center for Astrophysics), Elizabeth Blanton (Boston University)

222.06 – A study of the temporal behavior of the X-ray Sources in the Galaxy NGC 1232 over a three year period

The Galaxy NGC 1232 has been observed using the Chandra X-ray Observatory over a three year period with samples ranging from 50 ks to up to three years. Most of the X-ray sources are found to be variable, with some only appearing in one of the five observations taken over the three years. The problem of source confusion with background quasars will be discussed. This work was supported by Contract SV2-82024 from the Smithsonian Astrophysics Observatory to the Huntingdon Institute for X-ray Astronomy, LLC.

Author(s): ***Gordon Garmire (Huntingdon Institute for X-ray Astronomy, LLC)***, Audrey Garmire (Huntingdon Institute for X-ray Astronomy, LLC)

222.07 – Photometric Profiles of Nearby Early-Type Galaxies Using SDSS

The outer regions of galaxies provide information about their assembly histories. We are carrying out a detailed analysis of the Sloan Digital Sky Survey (SDSS) photometric profiles of a large sample of nearby early-type galaxies, in order to look for transitions between their inner and outer properties. Here we present initial results from this survey.

Author(s): ***Beth Johnson (San Jose State University)***, Aaron Romanowsky (University of California Observatories)

222.08 – A New Search for Ultra-Compact Dwarfs

Ultra-compact dwarfs (UCDs) are a recently discovered class of object that consists of high stellar densities in a radius of around 10 to 40 pc. We are searching for UCDs around local galaxies using the SDSS database, with spectroscopic follow. We present initial results of our survey including a discovery of a unique and interesting object.

Author(s): ***Richard Vo (San Jose State University)***, Aaron Romanowsky (University of California Observatories), Jay Strader (Michigan State University), Charlie Conroy (University of California - Santa Cruz), Mark Norris (Max Planck Institute for Astronomy), Jean Brodie (University of California Observatories)

222.09 – Gas-phase metallicity of void dwarf galaxies

We study how the cosmic environment affects galaxy evolution in the Universe by comparing the metallicities of galaxies in voids with similar-sized galaxies in more dense regions. Ratios of the fluxes of emission lines, particularly those of the forbidden [OIII] and [SII] transitions, provide estimates of a region's electron temperature and number density. From these two quantities and the emission line intensities, we estimate the abundance of oxygen with the Direct Te method. We estimate the metallicity of 19 void dwarf galaxies and 35 wall dwarf galaxies using data from SDSS via the MPA-JHU value-added Garching catalog. We find very little difference between the two sets of galaxies, indicating little influence from the large-scale environment on stellar evolution. Of particular interest are a number of extremely metal-poor dwarf galaxies.

Author(s): ***Kelly Douglass (Drexel University)***, Michael Vogeley (Drexel University)

222.10 – The HI Content of Galaxies in Groups as Measured by ALFALFA

We present the HI content of galaxies in a sample of eleven well-studied groups in the Arecibo Legacy Fast-ALFA (ALFALFA) survey. Specifically, we compare the HI deficiency, HI mass function, and HI mass fraction for galaxies in the center 1.5 Mpc of the groups to those for galaxies in a “field” sample defined as a 2-5 Mpc projected annulus surrounding each group.

Author(s): ***Mary Crone-Odekon (Skidmore College)***, Rebecca Koopmann (Union College), Martha Haynes (Cornell University), Rose Finn (Siena College)

Contributing teams: ALFALFA Team

222.11 – Using Chandra X-ray Observations to Characterize the Planck ESZ Clusters of Galaxies

Through the SZ effect, the Planck mission has provided a complete nearly mass-limited sample of clusters of galaxies. Through extensive Chandra X-ray observations of the large sample of Planck ESZ clusters at z<0.35, we can characterize each cluster in terms of its X-ray luminosity, gas mass, gas temperature, entropy, central cooling time, presence of active AGN, and morphology. We determine the fraction of Planck clusters with different cluster morphological types, ranging from cool core clusters to disturbed major mergers. Examples of each cluster type will be presented, including cool core clusters, "Coma-like" flat core systems, and "bullet-like" major mergers. We will compare the fraction of morphological types in the Planck (z<0.35) sample with higher redshift samples.

Author(s): ***Christine Jones (Harvard-Smithsonian, CfA)***, William Forman (Harvard-Smithsonian, CfA), Felipe Santos (Harvard-Smithsonian, CfA)

Contributing teams: Chandra-Planck XVP Consortium

222.12 – Early Type Galaxies in the Chandra COSMOS survey

We study a sample of 69 X-ray detected Early Type Galaxies (ETGs), selected from the Chandra COSMOS survey, to explore the relation between the X-ray luminosity of hot gaseous halos L_(X, gas) and the integrated stellar luminosity (L_K) of the galaxies, in a range of redshift extending out to z=1.5. In the local universe a tight steep relationship has been stablished between these two quantities suggesting the presence of largely virialized halos in X-ray luminous systems. We use well established relations from the study of local universe ETGs, together with the expected evolution of the X-ray emission, to subtract the contribution of low mass X-ray binary populations (LMXBs) from the X-ray luminosity of our sample. Our selection minimizes the presence of active galactic nuclei (AGN), yielding a sample representative of normal passive COSMOS ETGs; therefore the resulting luminosity should be representative of gaseous halos, although we cannot exclude other sources such as obscured AGN, or enhanced X-ray emission connected with embedded star formation in the higher z galaxies. We find that most of the galaxies with estimated L_X<10^42 erg/s and z<0.55 follow the local relation. For these galaxies, the gravitational mass can be estimated with a certain degree of confidence from the local virial relation. However, the more luminous (10^42<L_X<10^43.5 erg/s) and distant galaxies present significantly larger scatter; these galaxies also tend to have younger stellar ages. The divergence from the local relation in these galaxies implies significantly enhanced X-ray emission, up to a factor of 100 larger than predicted from the local relation. We discuss the implications of this result for the presence of hidden AGN, and the evolution of hot halos, in the presence of nuclear and star formation feedback.

Author(s): ***Francesca Civano (SAO)***, Giuseppina Fabbiano (SAO), Silvia Pellegrini (Bologna University), Dong-Woo Kim (SAO), Alessandro Paggi (SAO), Martin Elvis (SAO)

222.13 – ALMA detected overdensity of sub-mm sources around WISE-selected extremely red galaxies

We study a sample of 49 regions around the extremely red WISE-selected galaxies which earlier studies suggest are hyper luminous z~2 AGN sources. They were observed with the Atacama Large Millimeter/Submillimeter Array in Band 7 (345 GHz) down to an rms of ~0.2mJy and 0.5mJy for observations at 0.5" and 1.2", respectively. We detect a total of 31 sources with signal to noise higher than 3.5 in 20 of the 49 fields. We produce the source counts of the sources located in the primary beam radius (18.1"). The counts clearly show an excess compared with previous counts and models suggesting these sources reside in highly clustered environments.

Author(s): ***Andrea Silva (Tufts University)***, Anna Sajina (Tufts University)

222.14 – Analyzing a High-Redshift Galaxy Cluster

How far back in cosmic history clusters of galaxies formed is a major question in extragalactic astronomy. Galaxy clusters make up the largest scale structures of the universe. The farthest galaxy cluster currently known is at redshift 1.62 (Papovich, C. et al, 2010), corresponding to nearly 10 billion years ago. We do not yet know if this is the earliest point in time for galaxy clusters or if they go back still further to the start of the universe 13.7 billion years ago. A candidate galaxy cluster at redshift 2.3 was previously identified through the work of Professor James Lowenthal of Smith College. Analysis of the emission spectrum of a quasar at redshift 2.6, QSO PHL 957, revealed a Damped Lyman-alpha Absorber (DLA)- a huge intervening cloud of neutral hydrogen- at redshift 2.3 (Lowenthal et al, 2000). Further observations with the Hubble Space Telescope (HST) and other telescopes revealed 19 emission galaxies associated with the DLA including the Coup Fourré Galaxy, a Lyman-alpha emitting galaxy and 18 other galaxies within 2 Mpc (Lowenthal et al, 2010). This strong overdensity is one of the best current candidates for a massive, high-redshift, gravitationally bound cluster of galaxies. If these galaxies are at the same redshift, we should detect strong Lyman-alpha peaks at 400 nanometers for each of the 13 galaxies studied. Images of the entire cluster, along with spectra for 13 of its 20 objects, had been obtained using the Gemini North Telescope in 2010. Imaging and spectroscopy was performed on this galaxy cluster- resulting in detected Lyman-alpha peaks at 400 nanometers in only 3 galaxies, indicating that these three, at least, are all at redshift 2.3. Also achieved was a clearer, publishable set of spectra along with a high-quality image of the cluster. We are presently in the process of completing photometry on the galaxies, which involves measuring the intensity of emitted light in various wavelengths. It is possible that we will be able to confirm the redshift for several galaxies by comparing the measured intensity of light at different wavelengths coming from these distant galaxies to models of what the spectrum should look like if we were at the source.

Author(s): ***Isabel Lipartito (Smith College)***, James Lowenthal (Smith College)

222.15 – First Spectroscopic Confirmation of a Monster Galaxy at z=3.3 and Detailed Stellar Population and Structural Properties

We present the first spectroscopic confirmation of an ultra-massive galaxy at z,phot = 3.3 using data from Keck-NIRSPEC, VLT-Xshooter, and GTC-Osiris. We detect strong [OIII] and Ly? emission, and weak [OII], CIV, and HeII, confirming the redshift at z,spec = 3.3512. Modeling the emission-line corrected spectral energy distribution (from the Galex UV to IRAC 8 ?m, as well as the binned spectra) results in a best-fit stellar mass of M,stellar = 3×10'11M,sun (Kroupa), SFR of a few solar masses per year, negligible dust extinction, an age of ? 300 Myr, and a very short burst of star formation, setting the formation redshift of this galaxy at z?4. From the analysis of the line ratios and widths, and the observed flux at 24 ?m we confirm the presence of a luminous AGN, with bolometric luminosity of ? 8 × 10'45erg/s. The non detection in the X-ray data implies a Compton-thick nature for the type-2 AGN. Potential contamination of the observed SED from the AGN continuum is constrained, placing a lower limit on the stellar mass of 2 × 10'11M,sun. HST/WFC3 H160 and ACS I814 images were modeled with GALFIT, resulting in a very compact galaxy (effective radius r,e ? 1 kpc) and a de Vaucouleurs’s profile with n?4. This object represents the prototype galaxy of an ultra-massive galaxy that formed at z?4 in a very intense burst, is about to transition to quiescent, and it hosts a very powerful super massive black hole potentially responsible for the quenching of the star formation activity.

Author(s): ***Zehra Cemile Marsan (Tufts University)***, Danilo Marchesini (Tufts University)

222.16 – SED Modeling of z~0.3-4 IR-Luminous Galaxies Using Hydrodynamic Simulations

We examine a sample of 343 24?m-selected (U)LIRGS with z~0.3-4 using a library of hydrodynamic galaxy merger simulations. Each galaxy in our sample has Spitzer IRS spectra (the largest non-local sample to date) along with broadband photometry, including Hershel far-IR data. The spectra display a large range of relative stellar and AGN contributions to the infrared spectrum amongst our sources. The simulations, built from GADGET-2 hydrodynamic merger simulations processed through the SUNRISE radiative transfer code, span a range of dust properties, merger stages, AGN strength, and viewing perspectives. By comparing these simulations to our observed data we are able to investigate how the underlying physical conditions of galaxies affect the observed SEDs, with particular emphasis on the role AGN. Moreover the simulations allow us to investigate the level of systematic uncertainty, which with traditional methods would be difficult or impossible.

Author(s): ***Eric Roebuck (Tufts University)***, Anna Sajina (Tufts University), Alexandra Pope (University of Massachusetts Amherst), Allison Kirkpatrick (University of Massachusetts Amherst), Lin Yan (California Institute of Technology), Christopher Hayward (Max-Planck-Institut für Astrophysik), Gregory Snyder (Johns Hopkins University), Lars Hernquist (Harvard–Smithsonian Center for Astrophysics)

222.17 – A Markov Chain Monte Carlo Software Package to Constrain the Evolution of Luminosity Functions, Test SED Models, and Simulate Future Surveys

We present a novel simulation and fitting program which employs MCMC to constrain the spectral energy distribution makeup and luminosity function evolution required to produce a given mutli-wavelength survey. This tool employs a multidimensional color-color diagnostic to determine goodness of fit, and simulates observational sources of error such as flux-limits and instrumental noise. Our goals in designing this tool were to a) use it to study Infrared surveys and test SED template models, and b) create it in such a way as to make it usable in any electromagnetic regime for any class of sources to which any luminosity functional form can be prescribed. I will discuss our specific use of the program to characterize a survey from the Herschel SPIRE HerMES catalog, including implications for our luminosity function and SED models. I will also briefly discuss the ways we envision using it for simulation and application to other surveys, and I will demonstrate the degree to which its reusability can serve to enrich a wide range of analyses.

Author(s): ***Noah Kurinsky (Tufts University)***, Anna Sajina (Tufts University)

223 – Young Stellar Objects, Star Formation, and Star Clusters Posters

Poster Session – Essex Ballroom and America Foyer – 03 Jun 2014 09:00 AM to 06:30 PM

223.02 – How is kinematic structure connected to the core scale from filament scale?; Mopra mapping observations with multi-lines of dense cores in Lupus I

Recently, high sensitivity mappings of nearby molecular clouds in far-infrared and submillimeter wavelengths with Hershel and AzTEC/ASTE show ubiquitous existence of the filamentary structures with 0.1-pc uniform width. It is important to investigate dense core formation from large scale structure via fragmentation. We have conducted MOPRA multi-line mapping observations covered on 0.02 - 0.2 pc scales of 8 dense cores in a filamentary cloud of nearby Lupus I at 140 pc. A class 0/I protostellar core IRAS 15398-3359 is included as a sample, which has an adjacent prestellar core with the separation of 0.13pc in the west. The maps of N2H+, HNC, HC3N show well associated with each core. The velocity field of C18O shows 1.4 km/s/pc from north to south over the region containing two dense cores, which is consistent with past observation of NANTEN. In contrast to C18O results, the velocity field of HC3N shows different structures, which suggest counter rotation of two dense cores; 1.2 km/s/pc from north-west to south-east around a protostellar core and 0.8 km/s/pc from east to west around a presteller core. The filament will be fragmentized and collapsed to dense cores when the line density is over 2Cs/G (where Cs is sound speed and G is gravitational constant). If that velocity gradient was caused by such situation, it should be red-blue-red-blue across two dense cores but the observed kinematics is not consistent with this scenario, which requires that the filament structure would be extremely curved with a skew angle. Although we cannot reject the collapsing interruption, those results suggest the spin-up rotating picture separated from large-scale structure.

Author(s): ***Kazuhiro Kiyokane (National Astronomical Observatory of Japan)***, Masao Saito (National Astronomical Observatory of Japan), Kengo Tachihara (Nagoya University), Kazuya Saigo (National Astronomical Observatory of Japan), Tim van Kempen (Leiden Observatory), Paulo Cortes (Joint ALMA Observatory), Tracey Hill (Joint ALMA Observatory), Lewis Knee (Joint ALMA Observatory), Yasutaka Kurono (National Astronomical Observatory of Japan), Satoko Takahashi (National Astronomical Observatory of Japan), Higuchi Aya (National Astronomical Observatory of Japan), Lars-Ake Nyman (Joint ALMA Observatory)

Contributing teams: SOLA team

223.03 – Multiplicity study of Herbig Ae/Be stars

We present the results of a high resolution imaging survey to study the multiplicity of Herbig Ae/Be stars. 143 stars were observed with Adaptive Optics imaging, during two separate periods: 1993-1996 and 2005-2007. A total of 248 companions were detected, around 87 primary stars. 69 system were found to be likely true multiple systems, based on a statistical analysis. A complementary study for those stars for which multi-epoch data exists, confirms the results for almost all of the stars of this subset providing their proper motion is large enough and the multi-epoch data spanned a long enough time period.

Author(s): ***Nicole Van Der Bliek (CTIO/NOAO)***, Sandrine Thomas (NASA Ames Research Center), Bernadette Rodgers (Gemini), Jerome Bouvier (Observatoire de Grenoble), Claudia Araya (NASA Ames Research Center), Greg Doppmann (Keck Observatory), Maria Cordero (Indiana University)

223.04 – Spitzer Observations of the Eclipsing T Tauri System KH15D

We present 3.6 micron and 4.5 micron photometry of the binary T Tauri system KH15D obtained with the Spitzer Space Telescope. The data cover the full range of phases of this eclipsing system. Its components have spectral types K7 (Star A) and K1 (Star B) and an orbital period of approximately 48 days. Models suggest that a precessing circumbinary ring is responsible for the eclipses. The ring is inclined with respect to the binary orbit and the stars “rise” and “set” with respect to its sharp edge during each cycle. The system’s colors show distinct reddening when it is in its faint phase and the degree of reddening exceeds what is expected from just the stars. One explanation for the excess is a young, luminous giant planet orbiting beyond the outer edge of the ring. We consider this hypothesis as well as the possibility that the excess radiation comes from disk emission or from reddening. If reddening is implicated the size of the grains must be of the order of 5 microns or larger. We are grateful to J. Stauffer and the CSI 2264 team for their assistance with this project.

Author(s): ***Nicole Arulanantham (Wesleyan University)***, William Herbst (Wesleyan University), Ann Marie Cody (Spitzer Science Center California Institute of Technology)

Contributing teams: CSI 2264 Team

223.05 – Characterizing YSO Evolutionary States from their Mid-Infrared Colors

Near and mid-infrared (NIR/MIR) colors have long been used to identify young stellar objects (YSOs) for further study. For example, the NIR/MIR spectral energy distributions (SEDs) are used to classify the YSOs into classes or stages that signify the relative amounts of mass in the YSO envelopes and disks, from massive thick envelopes down to essentially no remaining envelope but still the presence of a disk. The extension of the SEDs to far-infrared (FIR) wavelengths has enabled much better estimates of the luminosity, the mass in the YSO envelopes, the accretion rates, and some estimate of the ages of the YSOs through the use of Monte Carlo radiation transfer models. However, further details about the envelopes and disks of the YSOs required spectra, either IR or radio. In fact, basic information about the composition of the envelopes is also available from the YSO colors as measured by Spitzer's Infrared Array Camera (IRAC). In this poster we demonstrate how the presence of either ices in the envelopes or PAHs in the outflow regions substantially changes the observed colors away from the locus of the majority of observed red objects. The reason is that ice absorption features decrease the fluxes in the IRAC 3.6, 5.8, and 8.0 micron bands much more than in the 4.5 micron band, leaving the 4.5 micron band comparatively bright. This is shown in the [3.6]-[4.5] vs [4.5]-[5.8] color-color plot, where the icy-envelope YSOs and the PAH-emitting YSOs fall on very different loci from other dusty objects. Visually, candidate icy-envelope YSOs can be detected by plotting IRAC images with red, green, and blue colors used for the IRAC 5.8, 4.5, and 3.6 micron bands: the YSOs with icy envelopes stand out has having a distinct yellow color in contrast to blue stars and red YSOs whose MIR spectra are dominated by PAH emission and sometimes the forbidden lines of a massive YSO close to the main sequence. We interpret the presence of icy envelopes as indicating the central protostar has not evolved to a high enough temperature to evaporate the ice or excite the PAHs. Confirmation of YSO candidates should be obtained from the FIR SED. Applications include estimating the evolutionary status of the YSOs found in FIR surveys.

Author(s): *Janet Simpson (SETI Institute)*, Angela Cotera (SETI Institute), Barbara Whitney (Space Science Institute)

223.06 – Radio Recombination Line and Continuum Emission from Flickering UC HII Regions in Sgr B2 Main

We have observed the Galactic Center star forming regions Sgr B2 Main and North at 1.3 cm and 7 mm with the VLA over a 23 year time baseline. The 1.3 cm observations, at a resolution of ~0.25", indicate that 4 of the 41 ultracompact sources in Sgr B2 Main and North have experienced significant changes in flux density between 1989 and 2012, with three sources brightening (F10.303, F1 and F3) and one source fading (K3). We present a summary of these results, as well as new 7 mm continuum images of Sgr B2 Main and North. Finally, we present the first high spectral resolution radio recombination line (RRL) observations of the sources with detected flux density changes.

Author(s): *Christopher De Pree (Agnes Scott College)*, Roberto Galvan-Madrid (ESO), Miller Goss (NRAO), Eric Keto (Harvard-Smithsonian CfA), Ralf Klessen (Institut f\"{u}r Theoretische Astrophysik), Mordecai-Mark Mac Low (American Museum of Natural History), Thomas Peters (Institut f\"{u}r Theoretische Physik), Ashley Monsrud (Agnes Scott College), David Wilner (Harvard-Smithsonian CfA)

223.07 – Clustering Properties of Young Stellar Objects in the Massive Star Forming Region W49

Massive stars play a vital role in the star formation process, yet their own formation and their effects on subsequent generations of star formation is not well understood. To improve our understanding, we have begun a detailed study of massive and active star forming complexes in giant molecular clouds outside the Galactic Center. One of the main goals of this study is to identify and classify the Young Stellar Objects (YSOs) in each region by using Spitzer Space Telescope IRAC & MIPS data. Following this,YSO clusters will be identified based on spatial distributions of the detected sources. Studying clusters with different evolutionary stages will help us to understand the formation and evolution processes from beginning to end. This study will also provide significant information on how massive stars interact with their environment and how they affect the low-mass star formation in the cloud. Within this context, we present the initial results of our investigation on the star-forming complex W49 that is one of the youngest, most luminous and most massive star formation region in the Galaxy. We used a combination of Spitzer Space Telescope IRAC & MIPS data, Two Micron All Sky Survey (2MASS) and UKIRT Deep Infrared Sky Survey (UKIDSS) data to identify and classify the Young Stellar Objects (YSOs) and generated a final catalog with a photometry of sources containing more than 2 million sources within an area of size *?l*x*?b* = 2°.6 x 3°.4, centered at (*l*,*b*) = (42°.7,0°.04) over a wavelength range from 1.2 to 24 ?m. With a preliminary source classification we identified thousands of YSO candidates. In addition, to understand the evolution of star formation in W49 we analyzed the distributions of YSOs to identify the clusters based on spatial distributions of the detected sources.

Author(s): *Gozde Saral (Istanbul University)*, Joseph Hora (Harvard-Smithsonian Center For Astrophysics), Xavier Koenig (Yale University), Talat Saygac (Istanbul University)

223.08 – The Study of tidal stripping substructures around four metal-poor globular clusters in the Galactic bulge

We have investigated the stellar spatial density distribution around four metal-poor globular clusters (NGC 6266, NGC 6626, NGC 6642, and NGC 6723) in the Galactic bulge region, by using 45’×45’ wide-field J, H, and K images obtained with WFCAM detector on the United Kingdom Infrared Telescope. In order to minimize the field star contamination and identify the cluster’s member candidate stars, we used a statistical filtering algorithm and then weighted the stars on the color-magnitude diagram. In two-dimensional stellar density maps, we found that the spatial density distribution of stars around four globular clusters is asymmetric and show tidal stripping features. The orientation of tidal substructure seems to associate with the effect of dynamical interaction with the Galaxy and the cluster’s space motion. Indeed, the radial surface density profile accurately describes this striping structure as a break in the slope of profile. We expect that our observational results could give us further constraints to understand the evolution of clusters as well as merging scenario of the formation of the Galaxy.

Author(s): *Sang-Hyun Chun (Yonsei University Observatory)*, Minhee Kang (Department of Astronomy, Yonsei University), Young-Jong Sohn (Department of Astronomy, Yonsei University)

223.09 – Globular Cluster Membership Probabilities from All-Sky Proper Motion Catalogs

Recent all-sky catalogs such as UCAC4 (Zacharias et al. 2013, AJ, 145:44) and PPMXL (Roeser et al. 2010, AJ, 139, 2440) contain proper motions with errors of 1-10 mas/yr. This precision is sufficient to determine membership probabilities for stars in the fields of globular clusters if the cluster motion is reasonably different from the field star motion. We use membership probabilities for stars in the field of the globular cluster NGC 6397 derived from very high precision relative proper motions (~ 0.2 mas/yr errors) from long-focus plates to test membership probabilities derived from UCAC4 and PPMXL motions. We also explore the use of UCAC4 and PPMXL to search for cluster members beyond the small field of the long-focus plates. This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by NASA and the NSF. This research has made use of the VizieR catalogue access tool, CDS, Strasbourg, France. This research has been partially supported by the NSF.

Author(s): ***Richard Rees (Westfield State University)***, Kyle Cudworth (Yerkes Observatory, The University of Chicago)

223.10 – Ruprecht 147: Dating middle-aged stars

Ruprecht 147 is the oldest nearby star cluster, with an age of 3 Gyr and distance of 300 pc, which allows R147 to serve as a sorely needed intermediate-aged benchmark. Stellar ages are difficult to infer for main sequence stars, but age can reveal itself through the spin down of stars via magnetic braking, which also causes magnetic activity to wane with time. We have present results of our studies of the magnetic activity and rotation of FGK stars. We also hope to have newly identified M dwarf members by the time of this meeting, and will discuss their activity, manifested in chromospheric H-alpha emission.

Author(s): ***Jason Curtis (Penn State)***, Jason Wright (Penn State)

223.11 – Stellar Variability in the M2 and M3 Globular Clusters

We present results from an on-going project to understand the enrichment of the interstellar medium by evolved metal-poor stars, particularly while they are on the red and asymptotic giant branches. Our project is targeting globular clusters and nearby galaxies, as these have relatively well known global properties such as metallicity, age, and distance. Here, we present near-infrared observations of the globular clusters M2 and M3 in the Milky Way. These clusters served as calibration targets for the Galactic polarization project GPIPS with Mimir on the 1.8m Perkins telescope. As such, they were observed several times in H and K bands from 2008 to 2012, which enables us to identify the long period variables in the clusters, particularly when combined with older data from the 2MASS project. Comparing the variability properties of the stars with their locations on the color-magnitude diagrams allows us to estimate the time the stars spend in these stages of their post-main sequence evolution. We will also compare M2 and M3 to our previous results for M5 and M15, which have higher and lower metallicities, respectively.

Author(s): ***Kathleen Kraemer (Boston University)***, G. Sloan (Cornell University), Dan Clemens (Boston University), E. Lagadec (Observatoire de la Cote d'Azur), D. Barry (Cornell University), C. Goes (Cornell University)

223.12 – The Motif of Globular Clusters and Low Mass X-ray Binaries in Ellipticals: a Tale of Three Galaxies

I will discuss significant inhomogeneities in the projected two-dimensional spatial distributions of Globular Clusters and Low Mass X-Ray Binaries observed in three elliptical galaxies with extensive spatial coverage in the optical and X-ray: NGC4261, NGC4649 and NGC4278. The spatial structures in the distributions of GCs and LMXBs have been detected with a new method based on the K-Nearest Neighbor density estimator of Dressler (1980), complemented by MonteCarlo simulations to establish the statistical significance of the results. I will present the spatial structures as a function of the color and luminosity of the GCs, and will compare their shape and significance with the spatial distribution of field LMXBs. I will then examine the nature of these structures in the context of the evolution history of the host galaxies.

Author(s): ***Raffaele D'Abrusco (SAO)***, Giuseppina Fabbiano (SAO), Stefano Mineo (SAO), Jay Strader (Michigan State University), Tassos Fragos (SAO), Dong-Woo Kim (SAO), Bin Luo (Pennsylvania State University), Andreas Zezas (SAO)

223.13 – Exploring the Formation of Galaxies through Metallicities of Globular Clusters

Globular clusters (GCs) are among the oldest stellar objects in the universe. They have long served the role of providing constraints on many aspects of galaxy evolution theory. Bimodal color distribution of GC systems in many luminous early-type galaxies is an observationally established phenomenon and has been interpreted as evidence of two GC subgroups with different metallicities. In this study, we use spectroscopic data on the GC systems of two giant galaxies, M31 (the Andromeda) and M87 (NGC 4486), to investigate the GC bimodality and the underlying metallicity distributions. Recent high signal-to-ratio spectroscopic data on M31 GCs revealed a clear bimodality in absorption-line index distributions of old GCs. Given that spectroscopy provides a more robust probe into stellar population than photometry, the reported spectral line index bimodality may indicate the presence of two distinct GC populations. However, here we show that the spectroscopic dichotomy of M31 GCs is due to the nonlinear nature of metallicity-to-index conversion and therefore one does not need two separate GC subsystems. We consider this as an analogy to the recent interpretation in which metallicity-color nonlinearity is the prime cause for observed GC color bimodality. We present spectra of ~130 old globular clusters (GCs) associated with the Virgo giant elliptical galaxy M87, obtained with the Multi-Object Spectrography (MOS) mode of Faint Object Camera and Spectrograph (FOCAS) on the Subaru telescope. The fundamental properties of globular clusters such as age, metallicity and elemental abundance ratio are investigated by comparing with a set of Simple Stellar Population (SSP) models. M87 GCs with reliable metallicity measurements exhibit significant inflection along the color-metallicity relations, through which observed color bimodality is reproduced using a broad, unimodal metallicity distribution. Our findings lend further support to this new interpretation of the GC color bimodality, which could change much of the current thought on the formation of GC systems and their host galaxies.

Author(s): ***Sooyoung Kim (Yonsei University)***, Suk-Jin Yoon (Yonsei University), Chul Chung (Yonsei University), Nelson Caldwell (Center for Astrophysics), Ricardo Schiavon (Liverpool John Moores University), Yong Beom Kang (Chungnam National University), Soo-Chang Rey (Chungnam National University), Young-Wook Lee (Yonsei University), Naoyuki Tamura (Kavli Institute for the Physics and Mathematics of the Universe), S. Tony Sohn (Space Telescope Science Institute), Nobuo Arimoto (National Astronomical Observatory of Japan), Tadayuki Kodama (National Astronomical Observatory of Japan), Yoshihiko Yamada (National Astronomical Observatory of Japan)

223.14 – Hierarchical Star Formation in LEGUS Galaxies

Star formation generally follows a hierarchical distribution in galaxies from kpc scales in giant star complexes down to sub-pc scales in embedded clusters. This hierarchy corresponds to a power law distribution function for the number of star forming regions as a function of size or luminosity. Using the Legacy ExtraGalactic Ultraviolet Survey (LEGUS), we examine six galaxies, NGC 1566, NGC 1705, NGC 2500, NGC 5253, NGC 5477, and IC 4247, which span types from grand design and flocculent spirals to irregulars and starburst irregulars. Power law size and luminosity distributions were measured from Gaussian-blurred images in the NUV and UV using SExtractor. Slopes ranged from -1 to -1.8, with the steepest slopes corresponding to the starburst galaxies. The slopes did not vary from the NUV to the UV. The fraction of light contained within the largest scales ranged from 85 to 95 percent, independent of galaxy type. We acknowledge support from grant HST-GO-13364.

Author(s): ***Debra Elmegreen (Vassar College)***, Bruce Elmegreen (IBM T.J. Watson Res. Ctr.)

Contributing teams: LEGUS

201 – On the Shoulders of Giants: Planets Beyond the Reach of Kepler I: What We Know Today and What We Would Like to Learn

Meeting-in-a-Meeting – America Ballroom North/Central – 03 Jun 2014 10:00 AM to 11:30 AM

What kind of planets lie at orbit radii of 1-2 AU - beyond the reach of Kepler? In the last two decades we have explored a large sample of RV-detected and transit-detected planets, discovered distant planets with microlensing and several hot young planets at large radii using direct imaging, as well as the debris disks that provide clues to formation and evolution. In these 4 sessions, we explore the near future, and how we can expect to learn much more about the demographics and properties of cold outer planets. WFIRST-AFTA will open up this area, with a microlensing survey to probe the population of long-orbit planets, and coronagraphy to take images and spectra of large planets in orbits at a few AU. Session I covers an introduction to this Meeting-in-Meeting, and presents the current state of theoretical understanding of planets in long orbits - beyond the reach of Kepler.

Chair(s):
Stephen Unwin (JPL)

201.01 – Planets Beyond the Reach of Kepler - Introduction

What kind of planets lie at orbit radii of 1-2 AU - beyond the reach of Kepler? In the last two decades we have explored a sample of RV-detected planets, discovered distant planets with microlensing, and several hot young planets at large radii have been detected by direct imaging, as well as the debris disks that provide clues to formation and evolution. In these 4 sessions, we explore the near future, and how we can expect to learn much more about the demographics and properties of cold outer planets. AFTA-WFIRST will open up this area, with a microlensing survey to probe the population of long-orbit planets, and coronagraphy to take images and spectra of large planets in orbits at a few AU.

Author(s): ***Stephen Unwin (JPL)***

201.02 – Studying Extrasolar Planets with WFIRST

The WFIRST mission will be a powerful tool for studying extrasolar planets. Through observations of gravitational microlensing, the mission will probe the demographics of extrasolar planetary systems. Its coronagraph will enable imaging and spectroscopic study of nearby planets. It will also be able to complement GAIA's astrometric measurements of masses and orbits of nearby planets.

Author(s): ***David Spergel (Princeton Univ. Obs.)***

201.03 – Theory of giant planet atmospheres and spectra

Giant exoplanet atmospheres have now been studied by transit spectroscopy, spectroscopy and photometry at secondary eclipse, photometric light curves as a function of orbital phase, very high-resolution spectroscopic velocity measurements, and high-contrast imaging. Moreover, there is a correspondence between brown dwarf and giant planet atmospheres and spectra that has been profitably exploited for many years to better understand exoplanets. In this presentation, I endeavor to review the information extracted by these techniques about close-in giant exoplanet compositions and temperatures. Then, I will summarize the expected character of the spectra, light curves, and polarizations of the objects soon to be studied using high-contrast imaging by GPI, SPHERE, WFIRST-AFTA, and Subaru/HiCIAO as a function of mass, age, Keplerian elements, and birth properties (such as entropy). The goal will be to frame the theoretical discussion concerning what physical information can be gleaned in the next years about giant planet atmospheres by direct (or almost direct) imaging and characterization campaigns, and their role as stepping stones to the even more numerous sub-Neptunes, super-Earths, and Earths.

Author(s): ***Adam Burrows (Princeton University)***

201.04 – Observed & Predicted Debris Disks Structures Beyond the Reach of Kepler

Over the last several years our theoretical understanding of debris disks has evolved significantly. A number of new computational advances, in the realms of disk modeling and data analysis, have deepened our knowledge of structures in debris disks. More than ever, we are acutely aware of the many sources of structures--be they gravitational perturbations by planets, other external perturbations, or more subtle non-perturbative sources. At the same time, new observatories, instruments, and observation strategies have provided a rich data set for debris disk theorists to test and constrain their models. I will discuss our current understanding of structures in debris disks. I will show the wide array of structures that planets can dynamically sculpt and comment on how imaging of these structures with future missions may constrain the underlying planetary system. I will also present a cautionary tale of interpreting debris disk structures as planetary perturbations, show how our appreciation of alternative sources of structures has grown, and present new methods for disentangling true density structures from projection and scattering effects.

Author(s): ***Christopher Stark (NASA Goddard Space Flight Center)***

201.05 – Theoretical Albedo Spectra of Exoplanet Direct Imaging Targets

Space-based coronagraphic telescopes currently under study would enable direct imaging of scattered light from giant exoplanets in orbits beyond 1 AU from their host stars. Considering the known radial-velocity planets alone, directly imaged planets will encompass a broad range of atmospheric properties, including a number of possible cloud species. Here we present theoretical albedo spectra (0.35 to 1 micron) for the most favorable targets for spaced-based coronagraph observations (good angular resolution and contrast) from the current population of known radial-velocity planets. We consider a range of internal temperatures and atmospheric metallicities as constrained by the system ages and planetary minimum masses. Additionally, we construct a grid of theoretical Jupiter and Neptune-like exoplanets around a variety of host stars at distances of 1, 3, and 5 AU. From this grid, we identify spectral and photometric signatures associated with planetary gravity, cloudiness, and composition that can used to select promising new targets as they are discovered. This work will help to guide the development and initial interpretation of a range of direct imaging exoplanet studies that will shed new light on important physical processes underlying giant planet formation and evolution.

Author(s): ***Nikole Lewis (MIT)***, Mark Marley (NASA/Ames), Jonathan Fortney (UCSC)

202 – Solar Surface and Interior I

Meeting-in-a-Meeting – America Ballroom South – 03 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Rudolf Komm (National Solar Obs.)

202.01 – A Helioseismic Survey of Emerging Active Regions Using HMI-SDO Data

A survey of the subsurface properties of approximately 100 emerging active regions, determined from the application of helioseismic holography to Dopplergrams obtained with the HMI instrument onboard the Solar Dynamics Observatory, is being carried out. The goal of this research is to use helioseismology and numerical simulations to identify and understand possible signatures, in the form of acoustic travel time shifts, due to rising magnetic flux concentrations prior to their emergence at the solar photosphere. The status of the project and current results will be discussed. We make use of ensemble averages of travel-time shift measurements as proxies for near-surface depth-integrated wave-speed changes and flows. The latter include horizontal components of the flows as well as their horizontal divergence and the vertical component of the flow vorticity. A control sample of a similar number of quiet-Sun regions is used for comparison and for identifying potential systematic effects. Preliminary results confirm previous suggestions (obtained from a prior survey using GONG data) that emergence sites are associated with converging photospheric flows, such as the boundaries of supergranulation. This work is supported by the NASA Heliophysics Supporting Research program through contract NNH12CF23C.

Author(s): ***Douglas Braun (NorthWest Research Associates, Inc.)***, Hannah Schunker (Max-Planck-Institut für Sonnensystemforschung), Aaron Birch (Max-Planck-Institut für Sonnensystemforschung)

202.02 – Using SDO/HMI Observations to Detect Pre-emergence Signatures of Large Active Regions

It was shown that large active regions can be detected by helioseismology in the deep convection zone before they become visible in the photosphere. The detection method is based on computations of cross-covariances between oscillation signals observed at pairs of locations on the solar surface. We present in this study the results of a thorough helioseismic investigation of large emerging active regions observed with SDO/HMI. For each one of these regions, we monitor the subsurface acoustic perturbations at various depths up to about 75 Mm and for several days before the emergence of magnetic field in the photosphere. The same set of measurements is also applied to quiet regions to obtain estimates of the noise level and evaluate the statistical significance of the perturbations measured in emerging-flux regions. We show examples of positive detection with the corresponding confidence levels, and we discuss perspectives of using this method with near real-time data from SDO/HMI to forecast the emergence of large active regions.

Author(s): ***Stathis Ilonidis (Stanford University)***, Junwei Zhao (Stanford University)

202.03 – Comparing helioseismic measurements over a numerically simulated sunspot with ray-tracing method

We perform helioseismic analysis over numerically simulated data by Rempel et al. (2009 Science), and compare the measured acoustic travel-time shifts with the expected values. We calculate the synthetic acoustic travel time using ray-tracing method on the sunspot model with all necessary field properties of the subsurface, including sunspot geometry, sound-speed perturbation, magnetic field,and flow velocity. Comparing with travel times in the quiet region, each of these properties contributes to a -80, +40,-20, +/-5 sec time shift, respectively, for a distance of ~20Mm. The helioseismic measurements from the simulated data using the same sunspot model are comparable to the measurements from observed sunspots. There is a clear travel-time asymmetry in waves traveling into and out from the sunspot, and this cannot be solely due to the flow velocity according to the ray-tracing method. We discuss possibilities of how to explain this travel-time asymmetry.

Author(s): ***Ruizhu Chen (Stanford Univ.)***, Junwei Zhao (Stanford Univ.)

202.04 – Numerical simulations of sunspot decay: On the role of a penumbra and subsurface field structure

We present high-resolution simulations of decaying sunspots that cover a time span of up to 100 hours. The simulations reach 18Mm deep into the convection zone and use open boundaries that do not maintain the initial field structure against decay driven by convective motions. We discuss three experiments: A sunspot simulation with penumbra, a "naked-spot" simulation in which we removed the penumbra after 20 hours, and a sunspot simulation with penumbra, but a less coherent subsurface field structure. In all three simulations we study the decay process and large-scale flows in proximity of the spots. Over the time span covered by the simulation the spot with penumbra is almost stationary with regard to the total flux content, but shows a steady decay of the flux present in the umbra area at a rate comparable to the "naked-spot" experiment. A less coherent sub-surface magnetic field structure leads within 12-24 hours to a less coherent surface appearance, i.e. details of the subsurface structure do not remain hidden from the photosphere. In all three experiments the dominant subsurface flow patterns are outflows.

Author(s): ***Matthias Rempel (NCAR)***

Contributing teams: NASA SDO-Science Center

202.05 – North-South Flow Asymmetries in the Rising Phase of Solar Cycle 24

Sub-surface solar flows can be inferred using acoustic waves measured at the solar surface, and making these measurements is one of the principal applications of helioseismology. Four years of high-duty-cycle, high-cadence, high-resolution data from the Helioseismic and Magnetic Imager (HMI) on the Solar Dynamics Observatory (SDO) provides an ideal data set to which to apply local helioseismic techniques and study spatially resolved structures in sub-surface flows. In this work, we attempt to characterize the differences in near-surface flows between the north and south solar hemispheres using data from HMI's ring-diagram analysis pipeline. It is well-known that solar surface activity in the North and South hemispheres is out of phase, and it is of particular interest to determine how deep this asymmetry penetrates.

Author(s): ***Charles Baldner (Stanford University)***, Richard Bogart (Stanford University)

202.06 – Influence of Magnetic and Thermal Effects on Helioseismic Travel-time Shifts in Sunspot Models

Sunspots are one of the most prominent manifestations of solar magnetic activity and have been studied using local helioseismology for decades. Recent modeling and observational studies indicate that the interpretation of travel-time shifts is still subject to uncertainties regarding the physical causes of the wave perturbations. Numerical wave propagation has proved useful in addressing this problem. In this work, we have analyzed travel-time shifts obtained from three dimensional numerical simulations of wave propagation in a magnetohydrostatic sunspot-like atmosphere. In particular, we isolate the individual effects of the magnetic field and thermal perturbations on the measurements by means of simulations where only one kind of perturbation (magnetic or thermal) is included. The resulting travel-time shift maps, obtained by applying helioseismic holography to the photospheric Doppler signals in the simulated domain, will be compared and discussed. We plan to make the artificial data available to the community for the development and validation of other helioseismic methods. This work is supported by the NASA SDO Science Center program (through contract NNH09CE41C) and by the NASA Living With a Star Program (through grant NNX14AD42G).

Author(s): ***Tobias Felipe (NorthWest Research Associates)***, Douglas Braun (NorthWest Research Associates), Ashley Crouch (NorthWest Research Associates), Aaron Birch (Max-Planck-Institut fur Sonnensystemforschung)

203 – History of Solar Physics

Meeting-in-a-Meeting – Staffordshire – 03 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Jay Pasachoff (Williams College)

203.01 – The Discovery of the Solar 5-minute Oscillations and the Supergranulation

The summer of 1960 marked the discovery, from the Mt. Wilson 60-foot solar tower telescope, of both the solar 5-minute oscillation and the supergranulation. We review the history of how, starting in 1955, Robert Leighton at Caltech carried out studies of the sun at high resolution from the Mt. Wilson 60-foot solar tower telescope. In 1958 he developed a method to map the spatial distribution of solar magnetic fields by photographically subtracting pairs of spectroheliograph images differing only in the sign of their Zeeman-effect sensitivity to longitudinal magnetic fields, and showed for the first time that photospheric magnetic fields trace out the heating of the overlying chromosphere as revealed by the pattern of the Ca II emission network. Leighton then developed a variation of the technique to measure velocity fields and their spatial and temporal variation, and in the summer of 1960 he and his students made a series of discoveries that changed the face of solar physics. One of these was the discovery that the velocity field of the sun exhibits a very strong quasi-periodic vertical oscillation with a period of about 5 minutes; this discovery represents the dawn of helioseismology, which over the past 50 years has grown to embrace research lines in solar and stellar astrophysics that were unimaginable at the time. A parallel discovery made by Leighton and his students during that same summer was the "large cells", later to be termed the supergranulation, which show a complex pattern of flow fields, evidently produced by large-scale convective motions that are still not well-understood, but which create the magnetic network and hence the pattern of heating in the overlying chromosphere.

Author(s): ***Robert Noyes (Center for Astrophysics)***

203.02 – Origin of the Wang-Sheeley-Arge Solar Wind Model

A correlation between solar wind speed at Earth and the amount of field line expansion in the corona was verified in 1989 using 22 years of solar and interplanetary observations. This talk will trace the history of this discovery from its birth 15 years earlier in the Skylab era to its current use as a space weather forecasting technique. This research was supported by NASA and ONR.

Author(s): ***Neil Sheeley (Naval Research Laboratory)***

203.03 – Lockheed Solar Observatory and the Discovery of Moreton-Ramsey Waves

Moreton Waves are high-speed disturbances seen traveling away from large solar flares in H-alpha movies of the solar chromosphere. They were discovered by the observer Harry Ramsey in the late 1950s, and then published and publicized by the director Gail Moreton, both of the Lockheed Solar Observatory in the Hollywood Hills of Southern California. These efforts established the scientific reputation and secured continuing funding of the observatory, whose present-day successor is the Lockheed Martin Solar and Astrophysics Lab in Palo Alto. Moreton waves are rare, and there was limited interest in them until the EIT instrument on SOHO began seeing large numbers of similar waves in the corona in the late 1990s. The exact relation between the two observations is still a research topic today. This talk will describe some of the history of the observatory and the discovery and early interpretation of the waves.

Author(s): ***Theodore Tarbell (Lockheed Martin Solar and Astrophysics Laboratory)***

203.04 – On the Naming and Dscovery of the Solar Chromosphere

The chromosphere was discovered by Lockyer and Janssen in 1868, and named by Lockyer. It is often stated that his motivation for associating this region of the solar atmosphere with "color" was because of its bright red appearance at eclipses due to the predominance of H-alpha. However, Lockyer had never seen a total solar eclipse at the time he gave the name and does not appear to have provided this justification himself. It is more likely that the "color" refers to the plethora of different colored emission lines he saw and identified with his spectrograph. I also discuss the Padre Angelo Secchi's observation of the 1860 eclipse in Spain, His accurate description of the chromosphere as a complete, theretofore unseen layer enveloping the Sun predates Lockyer and Janssen by eight years.

Author(s): ***Kevin Reardon (National Solar Observatory)***

203.05 – Constructing 'Black Sun': the Documentary Film of the 2012 Eclipses

2012 offered an opportunity that was not to be missed: two solar eclipses. Drs Alphonse Sterling and Hakeem Oluseyi began doing collaborative research during total solar eclipses in 2006 in Ghana. Since then they have continued to do eclipse observation when funds and whether permitted. As a filmmaker, the opportunity to film Sterling and Oluseyi during the 2012 eclipses in Tokyo and Cairns fulfilled the goal of showing the excitement of time-sensitive research, the lives of astrophysicists, and diversity within the astronomy community. As an astrophysicist who did not specialize in solar astrophysics, it was an opportunity for me both to learn and to solidify for the audience what we know about the sun and the importance of eclipse observation. Clips of the film will be included.

Author(s): ***Jarita Holbrook (University of the Western Cape)***

203.06 – Howard Russell Butler's Oil Paintings of Solar Eclipses and Prominences

Howard Russell Butler (1856-1934) was invited to join the US Naval Observatory expedition to the total solar eclipse of 1918 because of his ability to paint astronomical phenomena based on quickly-made notes about spatial and color details. His giant triptych of the total eclipses of 1918, 1923, and 1925 was proposed for a never-built astronomical center at the American Museum of Natural History and wound up at their Hayden Planetarium when it was constructed in the mid-1930s. Half-size versions are installed at the Fels Planetarium at the Franklin Institute in Philadelphia and at the Firestone Library of Princeton University, whose newly conserved canvases were recently hung; the Buffalo Museum of Science has another half-size version in storage. We discuss not only the eclipse triptychs but also the series of large oil paintings he made of solar prominences (in storage at the American Museum of Natural History) and of his 1932-eclipse and other relevant works. JMP was supported for this work in part by Division III Discretionary Funds and the Brandi Fund of Williams College. His current eclipse research is supported by grants AGS-1047726 from the Solar Research Program of the Atmospheric and Geospace Sciences Division of NSF and 9327-13 from the Committee for Research and Exploration of the National Geographic Society.

Author(s): ***Jay Pasachoff (Williams College)***, Roberta J. M. Olson (New-York Historical Society)

203.07 – Exceptional Portable Sundials at Harvard

The Collection of Historical Scientific Instruments at Harvard University has the largest assemblage of sundials in North America. The dials date from the 16th to the 19th centuries, and most are designed to be carried in one’s pocket or put on a window sill. They take advantage of the sun’s changing altitude, azimuth, hour angle, or a combination of the foregoing in order to find the time. Many are also usable at a wide range of latitudes, and therefore are suitable tools for travelers. Fashioned of wood, paper, ivory, brass, and silver, the sundials combine mathematical projections of the sun’s apparent motion with artistry, fashion, and exquisite craftsmanship. This paper will explore the wide variety of sundials and what they tell us about the people who made and used them.

Author(s): ***Sara Schechner (Harvard Univ.)***

204 – Black Holes, Pulsars, and Neutron Stars

Oral Session – St. George AB – 03 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Jonathan Grindlay (Harvard-Smithsonian, CfA)

204.01 – General relativistic simulations of optically thick accretion disks.

Only recently numerical codes solving accretion on black holes in full general relativity with approximated radiative transfer have been developed. Such tools make studies of thin and super-critical, optically thick accretion disks possible. I will report on recent developments in this field putting most attention to hyper-accreting disks.

Author(s): ***Aleksander Sadowski (Harvard-Smithsonian Center for Astrophysics)***, Ramesh Narayan (Harvard-Smithsonian Center for Astrophysics), Jonathan McKinney (University of Maryland), Alexander Tchekhovskoy (University of California)

204.02 – Particle Acceleration by Relativistic Frame Dragging of a Magnetised Black Hole

Black holes are considered to be a likely agent of acceleration of particles. Various processes have been proposed, however, the exact mechanism is still to be identified. It is conceivable that different mechanisms can operate, depending on parameters of the black hole (spin) and the environment to which the black hole is embedded (magnetic fields and plasma). We demonstrate that large-scale oblique magnetic field near a rotating (Kerr) black hole acts as an origin of magnetic layers, where the field direction changes abruptly (Karas, Kopacek, & Kunneriath 2012, 2013). Magnetic null points can develop near the ergosphere boundary by purely geometrical effects of the strong gravitational field and the frame-dragging mechanism. In consequence, particles can be accelerated efficiently by the gravito-magnetically induced electric component. The situation we discuss is relevant for starving nuclei of some galaxies which exhibit episodic accretion events, such as Sagittarius A* supermassive black hole surrounded by the large-scale structure of magnetic filaments. By the mass-scaling relation, the same process is expected to operate also near a stellar-mass black hole orbiting in a close binary system with a strongly magnetised neutron star.

Author(s): ***Vladimir Karas (Astronomical Institute, Academy of Sciences)***, Ondrej Kopacek (Astronomical Institute, Academy of Sciences), Devaky Kunneriath (Astronomical Institute, Academy of Sciences)

204.03 – A New Physical Model for Pulsars as Gravitational Shielding and Oscillating Neutron Stars

Pulsars are fast rotating neutron stars that synchronously emit periodic Dirac delta shape pulses of radio-frequency radiation and Lorentzian shape oscillations of X-rays. The acceleration of particles near the magnetic poles, which derivate from the rotating axis produces coherent beams of radio emissions that are viewed as pulses of radiation whenever the magnetic poles sweep the viewers. However, the conventional lighthouse model of pulsars is only conceptual. The physical mechanism through which particles are accelerated to produce coherent beams of radio emissions is still poorly understood. The process for periodically oscillating X-rays to emit from hot spots at the inner edge of accretion disks of pulsars is also remained as an unsolved mystery. Recently, a new physical model of pulsars is proposed by the author to quantitatively interpret the emission characteristics of pulsars, in accordance with his well-developed five-dimensional fully covariant Kaluza-Klein gravitational shielding theory and the physics of thermal and accelerating charged particle radiation. The results indicate that with the significant gravitational shielding by scalar field a neutron star nonlinearly oscillates and produces synchronous periodically Dirac delta shape pulse-like radio-frequency radiation (emitted by the oscillating or accelerating charged particles) as well as periodically Lorentzian shape oscillating X-rays (as the thermal radiation of neutron stars that temperature varies due to the oscillation). This physical model of pulsars as gravitational shielding and oscillating neutron stars broadens our understanding of neutron stars and develops an innovative mechanism to disclose the mystery of pulsars. In this presentation, I will show the results obtained from the quantitative studies of this new physical model of pulsars for the oscillations of neutron stars and the powers of radio pulse-like emissions and oscillating X-rays.

Author(s): ***Tianxi Zhang (Alabama A&M University)***

204.04 – General Relativistic Magnetohydrodynamic Simulations of Blandford-Znajek Jets and the Membrane Paradigm

Recently it has been observed that the scaling of jet power with black hole spin in galactic X-ray binaries is consistent with the predictions of the Blandford-Znajek (BZ) jet model. These observations motivate us to revisit the BZ model using general relativistic magnetohydrodynamic simulations of magnetized jets from accreting (h/r ~ 0.3), spinning (0 < a_* < 0.98) black holes. We have three main results. First, we quantify the discrepancies between the BZ jet power and our simulations: assuming maximum efficiency and uniform fields on the horizon leads to a ~10% overestimate of jet power, while ignoring the accretion disk leads to a further ~50% overestimate. Simply reducing the standard BZ jet power prediction by 60% gives a good fit to our simulation data. Our second result is to show that the membrane formulation of the BZ model correctly describes the physics underlying simulated jets: torques, dissipation, and electromagnetic fields on the horizon. This provides intuitive yet rigorous pictures for the black hole energy extraction process. Third, we compute the effective resistance of the load region and show that the load and the black hole achieve near perfect impedance matching. Taken together, these results increase our confidence in the BZ model as the correct description of jets observed from astrophysical black holes.

Author(s): ***Robert Penna (MIT)***, Ramesh Narayan (Harvard), Aleksander Sadowski (Harvard)

204.05 – A Link Between X-ray Emission Lines and Radio Jets in 4U 1630-47?

Recently, Díaz Trigo et al. reported an XMM-Newton detection of relativistically Doppler-shifted emission lines associated with steep-spectrum radio emission in the stellar-mass black hole candidate 4U 1630-47 during its 2012 outburst. They interpreted these lines as indicative of a baryonic jet launched by the accretion disk. We present a search for the same lines earlier in the same outburst using high-resolution X-ray spectra from the Chandra HETGS. While our observations (eight months prior to the XMM-Newton campaign) also coincide with detections of steep spectrum radio emission by the Australia Telescope Compact Array, we find a strong disk wind but no evidence for any relativistic X-ray emission lines. Indeed, despite ?5× brighter radio emission, our Chandra spectra allow us to place an upper limit on the flux in the blueshifted Fe XXVI line that is ?20× weaker than the line observed by Díaz Trigo et al. Thus we can conclusively say that radio emission is not universally associated with relativistically Doppler-shifted emission lines in 4U 1630-47. We explore several scenarios that could explain our differing results, including variations in the geometry of the jet or a mass-loading process or jet baryon content that evolves with the accretion state of the black hole. We also consider the possibility that the radio emission arises in an interaction between a jet and the nearby ISM, in which case the X-ray emission lines might be unrelated to the radio emission.

Author(s): ***Joseph Neilsen (MIT Kavli Institute)***, Mickaël Coriat (University of Cape Town), Rob Fender (Oxford University), Julia Lee (Harvard-Smithsonian Center for Astrophysics), Gabriele Ponti (Max Planck Institute fur Extraterrestriche Physik), A. Tzioumis (Australia Telescope National Facility), Phillip Edwards (Australia Telescope National Facility), Jess Broderick (University of Southampton)

204.06 – Polarimetry with the Event Horizon Telescope

The Event Horizon Telescope (EHT) is an effort to develop millimeter and submillimeter VLBI to image nearby black holes at resolutions comparable to their event horizons. Past work with the EHT has measured compact emission on such scales for Sgr A* and M87, and has also measured sub-parsec structure in more distant quasars. Polarimetry with the EHT enables a powerful extension of this work, mapping magnetic field structures via the highly polarized synchrotron emission. Polarization is also an excellent probe of rapid variability, especially for Sgr A*, and can convey rich astrometric information even with incomplete imaging. We report on results from our 2013 campaign, which demonstrate a sharp increase in the linear polarization fraction and variability with increasing baseline, and we demonstrate that current EHT data can potentially achieve microarcsecond relative astrometry of flaring regions on timescales of minutes.

Author(s): ***Michael Johnson (Harvard-Smithsonian Center for Astrophysics)***, Sheperd Doeleman (Massachusetts Institute of Technology), Vincent Fish (Massachusetts Institute of Technology), Richard Plambeck (University of California, Berkeley), Daniel Marrone (University of Arizona), Michael Kosowsky (Brandeis University), John Wardle (Brandeis University), Rusen Lu (Massachusetts Institute of Technology)

Contributing teams: EHT Collaboration

204.07 – A Survey for Cosmological Millisecond Radio Transients with the Very Large Array

Single-dish pulsar surveys have revealed a new population of millisecond radio transients that seem to originate at cosmological distances. If indeed cosmological, these "fast radio bursts" (FRBs) are orders of magnitude brighter than any known millisecond radio transient, yet about as frequent as core-collapse supernovae. That would make them powerful probes of the intergalactic medium and potentially tracers of exotic new physics, such as double neutron star systems that are expected to produce the first gravitational wave detections. We will present the latest results from an ongoing large survey for FRBs with the Very Large Array (VLA). Interferometric detection will definitively show these events are astrophysical and, if extragalactic, will uniquely associate FRBs with host galaxies to measure the baryon density of the IGM in an entirely new way. This campaign uses a new observing mode that produces 1 terabyte per hour and can image the sky with 5 ms cadence, making the VLA into a powerful platform for wide-field fast transient surveys.

Author(s): ***Casey Law (UC Berkeley)***, Geoffrey Bower (UC Berkeley), Sarah Burke-Spolaor (Caltech), Michael Rupen (NRAO), Bryan Butler (NRAO), Scott VanderWiel (LANL), Joseph Lazio (JPL), Earl Lawrence (LANL), Andrew Siemion (UC Berkeley), Chris Mattmann (JPL)

204.08 – Probing Relics of Galaxy Formation with Cosmic Clocks: Pulsars in Globular Clusters

Globular clusters are relics of galactic formation. There are more than a hundred of these star clusters in our own Galaxy. These spherical collection of stars are typically made up of very old stellar populations and therefore hold clues about the very early stages of galaxy evolution. Hence, understanding these clusters is critically important in solving the galactic jigsaw puzzle. It typically takes very long observational efforts to analyze thousands of individual stars in order to infer important kinematic parameters for each globular cluster. Here we show an analytically tractable method that enables us to probe these globular cluster properties with only a handful of pulsars. Additionally, probing the kinematics of globular clusters through a distinct population of compact stars has other advantages. It enables us to probe the very centers of these clusters that may harbor massive black holes.

Author(s): ***Bülent Kiziltan (Harvard-Smithsonian Center for Astrophysics)***

205 – Bridging Laboratory & Astrophysics: Dust & Ices

Meeting-in-a-Meeting – St. George CD – 03 Jun 2014 10:00 AM to 11:30 AM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This session will focus on the interplay between astrophysics with theoretical and experimental studies into the underlying dust and ice processes, which drive our Universe.

Chair(s):
Gianfranco Vidali (Syracuse Univ.)
Organizer(s):
Farid Salama (NASA Ames Research Center)

205.01 – Some Open Questions in the Physics of Interstellar Dust

Our efforts to understand interstellar dust proceed by trying to develop models that are consistent with the laws of physics as well as with the many observational constraints provided by astronomical observations, the meteoritic record, and observations of interstellar dust grains entering the solar system today. I will review some open questions in physics and surface chemistry that are important for current modeling of dust. Nature has provided us with hundreds of spectroscopic clues -- the diffuse interstellar bands -- and it is an embarrasment that we haven't yet been able to decipher them. Interstellar grains contain iron, which could be in ferromagnetic or ferrimagnetic materials. If so, does magnetic dissipation contribute significantly to emission from dust at microwave and submm frequencies? This can be addressed in the laboratory. We do know that interstellar grains are not spherical, but we don't know whether they are compact, or whether they are have extended "fluffy" structures. To find out, we will have to compare observed optical properties of interstellar dust with theoretical models. How can we calculate the optical properties of fluffy grains at wavelengths ranging from X-rays to far-infrared? Theoretical methods will be described. It seems very likely that interstellar grains are often destroyed in the ISM; if so, then the observed abundance of grains requires that new grain material be formed in interstellar space. How can grain materials "grow" in the ISM? In particular, is it possible to grow amorphous silicates in cold interstellar clouds? What about carbonaceous material, in particular the nanoparticles that are thought to be responsible for the strong "PAH" emission bands? The possibilities and limitations of laboratory studies will be discussed.

Author(s): ***Bruce Draine (Princeton University)***

205.02 – Formation of Molecules on Cosmic Dust Grains:From H2 to Astrobiology Frontiers

If the role of dust grains in the formation of molecules in the ISM is now well accepted (as suggested almost 50 years ago) numerous questions remain yet unresolved despite serious experimental and theoretical efforts. This is the case for H2 (after ~20 years research) and more recently for larger molecules. For the latter the topical hot problem is to find a link between astrophysics and astrobiology in search of the origin of life in the universe, obviously a key question of paramount interest and general fascination. Both laboratory experiments and theory are necessary to interpret the wealth of increasing observational results and their improvements through new instrumental developments. The aim is to derive from them the physical and chemical conditions (and/or their dynamic evolution) in the remote regions of the ISM. In the laboratory a variety of multi-disciplinary experimental approaches are used to study the large number of parameters involved in the catalytic role of dust grains in the formation process and its different stages. The first step is to manufacture analogs of a dust grain, using several techniques. The most important parameters of a dust surface (and volume) are its nature and morphology. Carbonaceous or siliceous grains are fabricated, either bare or covered by a variety of ices, which have to be well-characterized. The second step covers the study of the formation mechanism(s) of molecules on a dust surface. This will be illustrated with two examples: H2 and prebiotic molecules. The main interest in the case of H2 is to learn about the fate of the energy released (~4.5 eV per H2) in the formation process, due to its determinant role in star formation. In the case of prebiotic molecules the main interest is that they can be considered as precursors of the formation of complex organic compounds (like amino acids) which are subsequently at the origin of more complex biological material. The third and particularly important step is to establish a connection and feedback between observations and experimental results. An outlook on these three aspects will be presented. New perspectives will also be discussed.

Author(s): ***Jean Louis Lemaire (Paris-Meudon Observatory)***

205.03 – Atomic Oxygen Desorption from an Amorphous Silicate Surface

Oxygen is the third most abundant element in space. How oxygen-containing molecules form in space, and whether they form through gas-phase or grain-surface reactions, depends largely on the availability of atomic oxygen in gas-phase versus on surfaces of dust grains. The relative abundance of O in gas-phase versus on grain surfaces is determined by the residence time, or equivalently, desorption energy, of atomic oxygen on grain surfaces. Though important in astrochemical modeling, experimental investigations of atomic oxygen desorption from grain surfaces are lacking in the literature. In most astrochemical models, the O desorption energy value has been taken to be 800 K, which is a guessed value without experimental support. Based on this value, the predicted molecular oxygen abundance in space is at least 2 orders of magnitude higher than what space observations have found. This long running discrepancy of molecular oxygen abundance could be resolved if the O desorption energy is twice as the widely used value (Melnick, G., Tolls, V., et al. 2012, Astrophys. J., 752, 26). We performed TPD (thermal programmed desorption) experiments to study the ozone formation process via $O+O_2$ on an amorphous silicate surface that emulates interstellar conditions. A rate equation model was used to characterize the surface kinetics of both atomic and molecular oxygen. The O desorption energy was extracted from rate equation simulations that best fit the TPD data. The value was found to be 1764±232 K, which agrees with what Melnick et al. proposed. We suggest that the newly found value for the O desorption energy should be used in astrochemical modeling. This work is supported by NSF, Astronomy & Astrophysics Division (Grants No. 0908108 and 1311958), and NASA (Grant No. NNX12AF38G). We thank Dr. J.Brucato of the Astrophysical Observatory of Arcetri for providing the samples used in these experiments.

Author(s): ***Jiao He (Syracuse University)***, Gianfranco Vidali (Syracuse University)

205.04 – Photodesorption of Interstellar Ices: a Wavelength-dependent Approach to Unveil Molecular Mechanisms

In the cold and dense regions of the interstellar medium, non-thermal desorption of interstellar ices drives the ice-to-gas ratio of most molecules. More specifically, non-thermal desorption induced by UV photons has been proposed as the dominating mechanism responsible for the observation of cold molecular gas in various star-forming environments. In protoplanetary disks mid-planes, for example, UV photons from the pre-main sequence star can penetrate deep into the disk, reach the ice region and induce ice sublimation. In prestellar cores and in the outer parts of protostellar envelopes, it is the Lyman-alpha-dominated UV field generated locally by the interaction of cosmic rays with H_2 that can potentially interact with ice mantles and result in observable cold molecular gas. To constrain the photodesorption mechanism of interstellar ices and predict its efficiency for various UV fields, we have developed a novel wavelength-dependent approach using the vacuum UV beamline DESIRS at the French synchrotron facility SOLEIL. Monochromatic tunable UV light in the 7 - 14 eV window is used to irradiate interstellar ice analogues and the rates at which molecules photodesorb are simultaneously measured using mass-spectrometry. The frequency resolved photodesorption spectra of pure CO and N_2 ices show a clear UV-wavelength dependency, directly scaled to the absorption spectra of the condensed molecules, which hints for a Desorption Induced by Electronic Transition (DIET) process. The application of this technique to isotopically labeled layered ices and binary ice mixtures has further revealed that CO and N_2 ice photodesorption is an indirect process where it is the electronic excitation of sub-surface species that leads to the desorption of surface molecules. The photodesorption efficiency of a species is thus linked to its molecular environment and photodesorption rates are different for pure and mixed ices. This has strong implications for astrochemical modeling and could potentially explain the CO and N_2 (N_2H^+) abundance profiles in prestellar cores.

Author(s): ***Edith Fayolle (Harvard-Smithsonian Center for Astrophysics)***, Mathieu Bertin (Université Pierre et Marie Curie), Claire Romanzin (Université Paris-Sud), Xavier Michaut (Université Pierre et Marie Curie), Laurent Philippe (Université Pierre et Marie Curie), Karin Oberg (Harvard-Smithsonian Center for Astrophysics), Harold Linnartz (Leiden Observatory), Jean-Hugues Fillion (Université Pierre et Marie Curie)

206 – Evolution of Galaxies

Oral Session – Gloucester, 2nd Floor – 03 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Anna Sajina (Tufts University)

206.01 – Background Sky Obscuration by Cluster Galaxies as a Source of Systematic Error for Weak Lensing

Lensing magnification and lensing shear measurements of galaxy clusters rely on an accurate determination of the density of background galaxies behind the cluster. The dependence is indirect for shear (via photometric redshift correction schemes) but direct for magnification. Both of these calculations assume a full view of the background sky, but in fact some fraction of the background sky is obscured by the cluster galaxies themselves. We discuss the size of this effect for several current and upcoming cosmological surveys and forecast its impact on cluster mass determinations.

Author(s): ***Melanie Simet (Carnegie Mellon University)***, Rachel Mandelbaum (Carnegie Mellon University)

206.02 – Correlation Between Star Formation and Substructure in Galaxy Clusters using SDSS and WISE

We investigate the relationship between star formation (SF) and substructure in galaxy clusters. Several past studies of individual galaxy clusters have suggested that cluster mergers enhance cluster SF, while others find no such relationship, and so we aim to explore this relationship with a statistical study of large samples of clusters. We first study 107 spectroscopically-identified clusters from SDSS, and find that the SF fraction in multi-component clusters (0.228 +/- 0.007) is higher than that in single-component clusters (0.175 +/- 0.016) for galaxies with M^0.1_r < -20.5. Furthermore, multi-component clusters show a higher SF fraction than single-component clusters at almost all clustercentric distances and local densities, and we find weak but marginally significant correlations between SF fraction and the level of cluster substructure. In a further investigation of this relationship, we study a much larger sample of over 600 photometrically-selected clusters using data from SDSS and WISE. We again find higher amounts of SF in less-relaxed clusters, which agrees with our previous findings. These results could indicate that cluster mergers may cause weak but significant SF enhancement in clusters, or that unrelaxed clusters exhibit slightly stronger SF due to their less evolved states relative to relaxed clusters.

Author(s): ***Seth Cohen (Dartmouth College)***, Ryan Hickox (Dartmouth College), Gary Wegner (Dartmouth College)

206.03 – Chandra and XMM-Newton Observations of the Bimodal Planck-detected Cluster G345.40-39.34 showing High and Low Entropy Subcluster Cores

The recent Sunyaev-Zel'dovich (SZ) surveys (from the Planck mission, the ground based SPT and ACT) have provided complete, nearly mass-limited samples of clusters of galaxies. Through extensive X-ray (Chandra and XMM-Newton) follow-up observations of these SZ cluster samples, one can characterize each cluster in terms of its total mass, X-ray luminosity, gas mass, gas temperature, entropy, central cooling time, and morphology. Here, we present results of Chandra and XMM-Newton observations of G345.40-39.34, a Planck detected cluster. We show that G345.40-39.34 is a nearby (z=0.045) double cluster with its southern subcluster presenting an interesting thermodynamical characteristic: low global gas temperature and very high central entropy. Because these two simultaneous conditions are rare, we selected clusters that exhibit similar properties to compare with G345. Finally, we present discussions of the physical processes that could lead to this unusual thermodynamic state.

Author(s): ***Felipe Andrade-Santos (Harvard-Smithsonian Center for Astrophysics)***, Christine Jones (Harvard-Smithsonian Center for Astrophysics)

Contributing teams: Chandra Planck Collaboration

206.04 – Chandra and JVLA observations of the HST Frontier Cluster MACSJ0717.5+3745

Massive merging clusters are excellent laboratories to investigate cluster formation and growth, to explore how the particles that produce cluster-scale diffuse radio emission are accelerated, and to study the nature of dark matter. Massive clusters, particularly merging clusters with multiple superposed subhalos, are also powerful cosmic telescopes, capable of magnifying high-z galaxies, thus providing a probe of the high-z universe. We present Chandra and JVLA observations of the HST Frontier Cluster MACSJ0717.5+3745. This very disturbed cluster is undergoing multiple merger events resulting in shocks and turbulence. Evidence for shocks is also found from the extended radio synchrotron emission observed with the JVLA. In addition, we find several lensed radio and X-ray sources behind the cluster. This result demonstrates the feasibility of deep radio and X-ray studies through the power of lensing.

Author(s): ***Reinout Van Weeren (Harvard-Smithsonian Center for Astrophysics)***, Christine Jones (Harvard-Smithsonian Center for Astrophysics), Felipe Santos (Harvard-Smithsonian Center for Astrophysics), William Forman (Harvard-Smithsonian Center for Astrophysics), Scott Randall (Harvard-Smithsonian Center for Astrophysics), Elke Roediger (Hamburger Sternwarte, Hamburg University), Annalisa Bonafede (Hamburger Sternwarte, Hamburg University), Ralph Kraft (Harvard-Smithsonian Center for Astrophysics), G. Esra Bulbul (Harvard-Smithsonian Center for Astrophysics)

Contributing teams: Chandra Frontier Cluster Team

206.05 – A Targeted, Distant Galaxy Cluster Survey Using Bent, Double-Lobed Radio Sources

We are conducting a large survey of distant clusters of galaxies using bent, double-lobed radio sources as tracers. Bent, double-lobed radio sources are driven by AGN and achieve their morphologies through interaction with the surrounding gas found in clusters. The lobes can become swept back during large-scale cluster mergers that set the intracluster medium in motion, or through more gentle sloshing motions of cluster cores driven by more minor interactions. These types of radio sources may be found in clusters that are highly disturbed as well as those that are relatively relaxed. In addition, they are found in clusters with a large range of masses. By the nature of their selection, all of the clusters will contain radio-loud active galaxies, so they are expected to be sites of AGN feedback. Based on low-redshift studies, these types of sources can be used to identify rich clusters with a success rate of ~60% (or ~80% if poor clusters and groups are included). We present our survey of 653 bent-double radio sources with optical hosts too faint to appear in the SDSS. The sample was observed in the infrared with Spitzer, and we estimate it will reveal ~400 distant clusters or proto-clusters in the redshift range z ~ 0.7 -- 3.0. The sample of bent-doubles contains both quasars and radio galaxies enabling us to study both radiative and kinetic mode feedback in cluster and group environments at a wide range of redshifts.

Author(s): ***Elizabeth Blanton (Boston Univ.)***, Rachel Paterno-Mahler (Boston Univ.), Joshua Wing (Harvard-Smithsonian Center for Astrophysics), Matthew Ashby (Harvard-Smithsonian Center for Astrophysics), Mark Brodwin (University of Missouri - Kansas City)

206.06 – Spherical accretion and AGN feedback

For a supermassive black hole accreting from a hot, quasi-spherical atmosphere, it is almost inevitable that the fluid approximation fails inside some point within the Bondi radius, but well outside the black hole event horizon. Within the region where the particle mean free paths exceed the radius, the flow must be modeled in terms of the Fokker-Planck equation. In the absence of magnetic fields, it is analogous to the "loss cone" problem for consumption of stars by a black hole. The accretion rate is suppressed well below the Bondi accretion rate and a significant power must be conveyed outward for the flow to proceed. This situation is complicated significantly by the presence of a magnetic field, but I will argue that the main outcomes are similar. I will also argue that the power emerging from such a flow, although generally far too little to suppress cooling on large scales, is an important ingredient of the AGN feedback cycle on scales comparable to the Bondi radius.

Author(s): ***Paul Nulsen (SAO)***

206.07 – Are local and high-z (U)LIRGs different? A comparison of morphological and kinematic properties of local and high-z IR-luminous galaxies

Galaxy interactions/mergers are known to dominate the population of infrared luminous galaxies in the local universe (z<0.3), yet it is unclear if this is still the case at high-z. To test the relative importance of galaxy interaction in the IR-luminouos galaxies, we have carried out a comparison of optical morphological properties between local and z~1 (U)LIRGs based on the same sample selection, morphology classification scheme, and optical morphology at similar rest-frame wavelengths. Meanwhile, we quantify the systematics in comparing local and z~1 datasets by constructing an artificially redshifted dataset from local (U)LIRGs, in which its data quality mimics the z~1 dataset. Based on automatic morphology indicators - Gini and M20, we find that the fraction of interacting systems are similar between local, redshifted, and (U)LIRGs at z<1. Using detailed visual classifications, we show that the merger frequency of (U)LIRGs decreases by ~20% from local to z~1, which is comparable to the loss of merger fraction due to data degradation (~15%). These analysis demonstrate that no strong evolution of merger frequencies in (U)LIRGs at least out to z~1. In parallel, we test the robustness of the merger/disk classification scheme developed based on the kinematic properties of galaxies (e.g. kinemetry analysis). Using a subset of GOALS galaxies with IFU observations, we examine the dependence of kinematic classifications on the data quality. Since these galaxies cover a wide range of interaction sequence, we can also test if the kinematic classifications are able to accurately determine the merger/disk nature of interacting systems at different merger stages.

Author(s): ***Chao-Ling Hung (Institute for Astronomy, University of Hawaii)***, David Sanders (Institute for Astronomy, University of Hawaii), Caitlin Casey (Department of Physics and Astronomy, University of California at Irvine), Michael Koss (Institute for Astronomy, ETH Zurich), Kirsten Larson (Institute for Astronomy, University of Hawaii), Nicholas Lee (Institute for Astronomy, University of Hawaii), Yanxia Li (Institute for Astronomy, University of Hawaii), Kelly Lockhart (Institute for Astronomy, University of Hawaii), Hsin-Yi Shih (Institute for Astronomy, University of Hawaii), Howard Smith (Harvard-Smithsonian Center for Astrophysics)

206.08 – Massive galaxies at z~1-6 from the Spitzer-SERVS plus VISTA-VIDEO surveys

We exploit the uniqueness of the Spitzer Representative Volume Survey (SERVS), which provides Spitzer IRAC 3.6 and 4.5um imaging down to AB~23 for a total area of 18 sq.deg., to probe massive galaxies out to z~6 within a representative cosmic volume. We focus on the 1.5 sq.deg. area inside the XMM-LSS field, where we combine SERVS with VISTA-VIDEO ZYJHK_S data (down to AB~24 at H and K_S). We select extremely red galaxies as either those with H-m3.6>1.6 (HIEROs) and/or K_S-m4.5>1.6 (KIEROs), and calculate their photometric redshifts and stellar population properties using different stellar population models and fitting codes. We find that (H/K)IEROs have a redshift distribution that covers z~1-6; are massive (median log(Mstar/Msun)=10.8); and dusty (median E(B-V)=0.4). They have significant star-formation rates (typically 10-100Msun/yr) based on both our stellar population fitting and the fact that ~50% have MIPS24\um and/or SPIRE250um detections. A comparison with recent stellar mass function estimates, suggests that (H/K)IERO samples contain a large fraction of the Mstar>10^11Msun galaxies at z~2-5. Our study also reveals five z>5 candidates, all with Mstar>10^11Msun. Our results suggest that, over the full area of overlap between SERVS and VIDEO, we will find >10,000 (H/K)IEROs, including a few tens of z>5 massive galaxies, allowing an exceptional probe into the build-up of the stellar mass in the universe.

Author(s): ***Anna Sajina (Tufts University)***, Diego Capozzi (University of Portsmouth), Mark Lacy (National Radio Astronomy Observatory), Claudia Maraston (University of Portsmouth), Janine Pforr (National Optical Astronomy Observatory), Hugo Messias (Universidad de Concepcion), Duncan Farrah (Virginia Tech), Eduardo Gonzales-Solares (University of Cambridge), Matt Jarvis (Oxford University), Danilo Marchesini (Tufts University), Lucia Marchetti (Padova University), Jean-Claude Mauduit (IPAC), Mattia Vaccari (Padova University)

207 – Arne Henden: Citizen Science in the Age of Surveys

Plenary Session – America Ballroom North/Central – 03 Jun 2014 11:40 AM to 12:30 PM

Chair(s):
Paula Szkody (Univ. of Washington)

207.01 – Citizen Science in the Age of Surveys

Paid professional astronomers are a new phenomenon - most of astronomical history has been written by amateurs. Modern technology has again leveled the playing field, with quality equipment, computers, software and the Internet giving amateurs the ability to match or exceed the data quality and quantity achievable by professionals. The Internet in particular has come into play, with crowd-sourcing through projects like Zooniverse, worldwide installation of private robotic observatories, and rapid dissemination of information leading the way. The future only shows more of these collaborative activities ahead, as all proposed surveys will require significant input from citizen scientists in order to achieve their goals. How the public is currently helping professional astronomers, how researchers can get involved, and some of the future opportunities will be presented.

Author(s): ***Arne Henden (AAVSO)***

210 – On the Shoulders of Giants: Planets Beyond the Reach of Kepler II: Demographics

Meeting-in-a-Meeting – America Ballroom North/Central – 03 Jun 2014 02:00 PM to 03:30 PM

What kind of planets lie at orbit radii of 1-2 AU - beyond the reach of Kepler? In the last two decades we have explored a large sample of RV-detected and transit-detected planets, discovered distant planets with microlensing and several hot young planets at large radii using direct imaging, as well as the debris disks that provide clues to formation and evolution. In these 4 sessions, we explore the near future, and how we can expect to learn much more about the demographics and properties of cold outer planets. WFIRST-AFTA will open up this area, with a microlensing survey to probe the population of long-orbit planets, and coronagraphy to take images and spectra of large planets in orbits at a few AU. Session II covers the demographics of the exoplanet population, based on what we know from RV surveys, Kepler, direct imaging, and microlensing.

Chair(s):
Christopher Stark (Carnegie Institution of Washington)

Organizer(s):
Stephen Unwin (JPL)

210.01 – Demographics of Giant Planets--Insights from Theory

The demographics of giant planets arise from a combination of the physical properties and evolution of protoplanetary disks, the planet formation process itself, and the dynamical evolution of planets post-formation. In this talk, I will review each of these contributions to giant planet demographics with an emphasis on how future discoveries can be used to separate and constrain their effects. I will particularly discuss how giant planet demographics will constrain the mechanism by which giant planets form, an old theoretical problem on the cusp of an observational breakthrough.

Author(s): ***Ruth Murray-Clay (Harvard-Smithsonian Center for Astrophysics)***

210.02 – Characterizing Cold Giant Planets in Reflected Light: Lessons from 50 Years of Outer Solar System Observation and Exploration

A space-based coronagraph, whether as part of the WFIRST/AFTA mission or on a dedicated space telescope such as Exo-C or -S concepts, will be able to obtain photometry and spectra of multiple giant planets around nearby stars, including many known from radial velocity detections. Such observations will constrain the masses, atmospheric compositions, clouds, and photochemistry of these worlds. Giant planet albedo models, such as those of Cahoy et al. (2010) and Lewis et al. (this meeting), will be crucial for mission planning and interpreting the data. However it is equally important that insights gleaned from decades of solar system imaging and spectroscopy of giant planets be leveraged to optimize both instrument design and data interpretation. To illustrate these points we will draw on examples from solar system observations, by both HST and ground-based telescopes, as well as by Voyager, Galileo, and Cassini, to demonstrate the importance clouds, photochemical hazes, and various molecular absorbers play in sculpting the light scattered by solar system giant planets. We will demonstrate how measurements of the relative depths of multiple methane absorption bands of varying strengths have been key to disentangling the competing effects of gas column abundances, variations in cloud height and opacity, and scattering by high altitude photochemical hazes. We will highlight both the successes, such as the accurate remote determination of the atmospheric methane abundance of Jupiter, and a few failures from these types of observations. These lessons provide insights into technical issues facing spacecraft designers, from the selection of the most valuable camera filters to carry to the required capabilities of the flight spectrometer, as well as mission design questions such as choosing the most favorable phase angles for atmospheric characterization.

Author(s): ***Mark Marley (NASA Ames Research Center)***, Heidi Hammel (AURA)

210.03 – The Occurrence Rate of Giant Planets around M-dwarf Stars

The TRENDS high-contrast imaging program is a dedicated survey based at Keck Observatory that uses high-contrast imaging observations to follow-up stars showing long-term radial velocity accelerations. In this talk, I will present a new technique invented to determine the occurrence rate of gas giant planets on wide orbits (0-20 AU) around low-mass stars.

Author(s): ***Justin Crepp (Notre Dame)***, Benjamin Montet (Harvard), John Johnson (Harvard), Andrew Howard (U. Hawaii), Geoffrey Marcy (Berkeley)

Contributing teams: California Planet Search

210.04 – Planet frequency beyond the snow line from MOA-II microlensing survey

Ground-based microlensing surveys enable us to detect planets down to Earth masses just beyond the snow line, where temperatures are cold enough for ices to condense. This area of the parameter space is not only out of reach for Kepler but also a key part for planetary formation theory because the surface density of the proto-planetary disk increases by a factor four to five beyond the snow line. It is thus important to understand the planet distribution beyond the snow line. Giant planets located just beyond the snow line also have been discovered by RV and direct imaging, but detecting planets in this parameter space region is still very difficult, in particular as we go down to the super Earth regime. We present the result of the statistical analysis of microlensing survey data by Microlensing Observations in Astrophysics (MOA) during 2007-2012. In this period, the MOA collaboration issued 3300 microlensing alerts. Using the online data, we reject events with poor quality data and stellar binary lens events. Using these quality criteria, about 1500 single lens and 20 planetary candidate events remain and are used for the statistical analysis. In order to derive the planet abundance, an averaged number of planets per star, beyond the snow line, we calculate the detection efficiency for planets in each selected event. Using the calculated detection efficiencies, we derive the planet mass-ratio function and planet mass function. We calculate the planet abundance within the mass and semi-major axis ranges where our data has sufficient sensitivity to detect planets. We will discuss the planet abundance and compare them with previous microlensing and RV results.

Author(s): ***Daisuke Suzuki (Osaka University)***

Contributing teams: MOA collaboration

210.05 – Free-floating planets from microlensing

Gravitational microlensing has an unique sensitivity to exoplanets at outside of the snow-line and even exoplanets unbound to any host stars because the technique does not rely on any light from the host but the gravity of the lens. MOA and OGLE collaborations reported the discovery of a population of unbound or distant Jupiter-mass objects, which are almost twice (1.8_{-0.8}^{+1.7}) as common as main-sequence stars, based on two years of gravitational microlensing survey observations toward the Galactic Bulge. These planetary-mass objects have no host stars that can be detected within about ten astronomical units by gravitational microlensing. However a comparison with constraints from direct imaging suggests that most of these planetary-mass objects are not bound to any host star. The such short-timescale unbound planetary candidates have been detected with the similar rate in on-going observations and these groups are working to update the analysis with larger statistics. Recently, there are also discoveries of free-floating planetary mass objects by the direct imaging in young star-forming regions and in the moving groups, but these objects are limited to massive objects of 3 to 15 Jupiter masses.They are more massive than the population found by microlensing. So they may be a different population with the different formation process, either similar with that of stars and brown dwarfs, or formed in proto-planetary disks and subsequently scattered into unbound or very distant orbits. It is important to fill the gap of these mass ranges to fully understand these populations. The Wide Field Infrared Survey Telescope (WFIRST) is the highest ranked recommendation for a large space mission in the recent New Worlds, New Horizons (NWNH) in Astronomy and Astrophysics 2010 Decadal Survey. Exoplanet microlensing program is one of the primary science of WFIRST. WFIRST will find about 3000 bound planets and 2000 unbound planets by the high precision continuous survey 15 min. cadence. WFIRST can complete the statistical census of planetary systems in the Galaxy, from super-Earths beyond the snow-line to gravitationally unbound planets – a discovery space inaccessible to other exoplanet detection techniques.

Author(s): ***Takahiro Sumi (Osaka University)***

Contributing teams: MOA collaboration

211 – Solar Surface and Interior II

Meeting-in-a-Meeting – America Ballroom South – 03 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Jason Jackiewicz (New Mexico State University)

211.01D – The Dynamic Evolution of Active-Region-Scale Magnetic Flux Tubes in the Turbulent Solar Convective Envelope

The manner by which bundles of magnetic field, or flux tubes, traverse the convection zone to eventual emergence at the solar surface is not well understood. To provide a connection between dynamo-generated magnetic fields and sunspots, I have performed simulations of magnetic flux emergence through the bulk of a turbulent, solar convective envelope by employing a thin flux tube model subject to interaction with flows taken from a hydrodynamic convection simulation computed through the Anelastic Spherical Harmonic (ASH) code. Through performing these simulations, much insight has been gained about the influence of turbulent solar-like convection on the flux emergence process and resulting active region properties. I find that the dynamic evolution of flux tubes change from convection dominated to magnetic buoyancy dominated as the initial field strength of the flux tubes increases from 15 kG to 100 kG. Additionally, active-region-scale flux tubes of 40 kG and greater exhibit properties similar to those of active regions on the Sun, such as: tilt angles, rotation rates, and morphological asymmetries. The joint effect of the Coriolis force and helical motions present in convective upflows help tilt the apex of rising flux tubes toward the equator in accordance with Joy’s Law. Additionally, rotationally aligned, columnar convective structures called giant cells present in the ASH simulation organizes flux emergence into a large-scale longitudinal pattern similar to the active longitude trend on the Sun and other solar-like stars. The effect of radiative diffusion across the radiation zone-convection zone interface on the buoyant rise of magnetic flux tubes is also studied, as well as the possibility of an induced twist of flux tube magnetic fields lines due to the Coriolis force induced tilting of the flux tube apex, presence of turbulent convection, and the conservation of helicity. Flux emergence simulations through the convection zone of a Sun rotating at 5 times the current solar rate are also conducted to explore the rotation-convection relationship as it relates to flux emergence.

Author(s): ***Maria Weber (High Altitude Observatory)***, Yuhong Fan (High Altitude Observatory), Mark Miesch (High Altitude Observatory)

211.02 – A Possible Role of Neutrinos in Stimulating Beta Decays and its Significance for Solar Physics

We find evidence from measurements of Ag108, Ba133, Eu152, Eu154, Ra226 and Sr90 (Physikalisch-Technische Bundesanstalt, Germany), Rn222 (Geological Survey of Israel), Co60, Pu239, and Sr90 (Lomonosov Moscow State University, Russia), Cl36 and Si32 (Brookhaven National Laboratory, USA) and Mn54 (Purdue University, USA) that beta-decay rates tend to be variable, and that the Sun is responsible for some – perhaps all – of the variability. One variation is an annual oscillation with amplitude about 0.1% and maximum in January or February, presumably related to the annually varying Sun-Earth distance. We also find evidence for two rotational modulations, one with a measured (synodic) frequency of about 12.5 year-1 (an absolute, sidereal frequency of 13.5 year-1), due perhaps to processes in the radiative zone, and another with a synodic frequency of about 11 year-1 (12 year-1 sidereal), due perhaps to processes in an inner tachocline between the core and the radiative zone. A steep gradient in angular velocity (as in a tachocline) is known to be unstable and generate r-mode oscillations. These may be detectable as Rieger-type oscillations in the outer tachocline, and to similar oscillations (with correspondingly lower frequencies, in proportion to the sidereal rotation frequencies) in the inner tachocline. We find evidence for such r-mode oscillations not only in beta-decay data, but also in solar diameter data. A possible explanation of the apparent beta-decay variability is that decays may be stimulated by neutrinos. Since the flavor composition of the neutrino flux can be modified by the Sun’s internal magnetic field (via Resonant Spin Flavor Precession), magnetohydrodynamic processes in the deep solar interior may be detectable on Earth as neutrino-stimulated beta-decay fluctuations. Experiments suggest that a nuclide such as 32Si has a beta-decay-equivalent-cross-section of order 10-25 cm2, larger than the neutrino-equivalent-cross-section of an electron or proton by about 1019. If this proves to be correct, then less than 1 picogram of 32Si would yield the same solar-neutrino-induced event rate as the Super-Kamiokande Observatory.

Author(s): ***Peter Sturrock (Stanford Univ.)***, Ephraim Fischbach (Purdue University), Jere Jenkins (Texas A&M), Gideon Steinitz (Geological Survey of Israel)

211.03 – From the Tachocline Into the Heliosphere: Coupling a 3D kinematic dynamo to the CCMC

During the last decade, axisymmetric kinematic dynamo models have contributed greatly to our understanding of the solar cycle. However, with the advent of more powerful computers the limitation to axisymmetry has been lifted. Here we present a 3D kinematic dynamo model where active regions are driven by velocity perturbations calibrated to reproduce observed active region properties (including the size and flux of active regions, and the distribution of tilt angle with latitude), resulting in a more consistent treatment of flux-tube emergence in kinematic dynamo models than artificial flux deposition. We demonstrate how this technique can be used to assimilate active region observations obtained from the US National Solar Observatory/Kitt Peak (NSO/KP) synoptic magnetograms and how our model couples naturally with heliospheric models, paving the way for the simultaneous study of the evolution of the magnetic field in the solar interior as well as its impact on the heliosphere.

Author(s): ***Andres Munoz-Jaramillo (University of California)***, Anthony Yeates (Durham University), Petrus Martens (Montana State University), Edward DeLuca (Harvard-Smithsonian Center for Astrophysics)

211.04 – Towards a Unified Simulation of Convective Dynamo Action and Flux Emergence in the Sun

Our global 3D simulations of convection and dynamo action in a Sun-like star reveal that persistent wreaths of strong magnetism can be built within the bulk of the convention zone. Our recent simulations have achieved sufficiently high levels of turbulence to permit portions of these wreaths to become magnetically buoyant and rise through the simulated convective layer through a combination of magnetic buoyancy and advection by convective giant cells. Here we examine the characteristics of buoyant magnetic structures that are self-consistently created by dynamo action and turbulent convective motions. These buoyant loops originate within sections of the magnetic wreaths in which turbulent flows amplify the fields to much higher values than is possible through laminar processes. Examining many such loops over a simulated magnetic activity cycle, we measure statistical trends in the polarity, twist, and tilt of these loops that mimic Hale’s Law, Joy’s Law, and the hemispheric helicity rule observed in sunspots. We further show that these magnetic structures are primarily generated by non-axisymmetric turbulent amplification on timescales of about 15 days and not by the ?-effect which primarily generates the large-scale wreaths.

Author(s): ***Nicholas Nelson (Los Alamos National Laboratory)***, Benjamin Brown (UC-Santa Barbara), Mark Miesch (National Center for Atmospheric Research), Juri Toomre (Univ. of Colorado)

211.05 – Insights on the solar dynamo from stellar observations

A successful dynamo model should not only explain the broad characteristics of the magnetic field cycle for the Sun (22-year sunspot cycle with polarity reversals, migration of active latitudes toward the poles throughout the cycle, and Joy’s law), but should also be able to explain the cycling behavior observed in Solar-analog stars, which are very close to the Sun in essential characteristics. Our aim is to develop a set of constraints on dynamo models from the observed behavior of solar-analog stars obtained from a number of long-running synoptic surveys of cycling activity (Mount Wilson Observatory HK survey, Lowel Observatory Solar-Stellar Spectrograph, and the Fairborn Observatory Automatic Photoelectric Telescope survey), in conjuncture with stellar rotation and differential rotation data obtained by the Kepler Mission and other sources. By carefully piecing together the best data available today, we will provide an improved understanding of the parameter space in which Solar-like dynamos operate.

Author(s): ***Ricky Egeland (Montana State University)***, Petrus Martens (Montana State University), Philip Judge (High Altitude Observatory)

211.06 – Solar/Stellar Granulation as the Key Lower Boundary Condition for Coronal Heating and Wind Acceleration

Much of the hot plasma that eventually becomes the supersonic solar wind appears to have its origin in small (100 km diameter) magnetic flux tubes that sit in the downflowing lanes between convective granules in the Sun's photosphere. Convective overturning motions jostle these flux tubes and induce kink-mode oscillations that can grow into Alfven waves in the corona. A great deal of recent work has been done to explore how these Alfvenic fluctuations may drive a turbulent cascade, heat the plasma by gradual dissipation, and provide direct acceleration to a wind via wave pressure gradients. This presentation will outline this work and show how an accurate description of granulation is a key input to self-consistent models of coronal heating and solar wind acceleration. These self-consistent models have also been applied successfully to predicting: (1) high-energy emission from accreting T Tauri stars, (2) the mass loss rates of cool dwarfs and red giants, and (3) the combined X-ray, radio, and submillimeter emission from a young nearby M dwarf. In addition, a recent analysis of stellar granulation with Kepler photometry has shown that our understanding of the shallow convection zones of F-type stars still requires additional refinement. In all cases, the combination of multiple types of observational data has been crucial to improving our understanding. For the Sun, the next-generation capabilities of ATST/DKIST are expected to provide much more precise knowledge about this important lower boundary condition to the heliosphere.

Author(s): ***Steven Cranmer (Harvard-Smithsonian CfA)***

212 – CME I

Meeting-in-a-Meeting – Staffordshire – 03 Jun 2014 02:00 PM to 03:30 PM
Chair(s):
Sophie Masson (NASA/GSFC)

212.01 – The Rayleigh-Taylor Instability and the role of Prominences in the Chromosphere-Corona Mass Cycle

We review recent results in the study of so-called "prominence bubbles", a buoyant instability discovered in quiescent solar prominences by the Hinode/SOT instrument in 2007. Analysis of the plasma flows along the boundary of the bubbles indicates that shear flows leading to Kelvin-Helmholtz instability waves can develop into the seed perturbations triggering the Rayleigh-Taylor instability. The non-linear phase of the RT instability leads to the formation of large turbulent plumes that transport the bubble plasma (and presumably magnetic flux) into the overlying coronal flux rope. We propose that the upward turbulent transport of hot bubble plasma and the downflows of cooler chromospheric plasma in the prominence are related aspects of a large-scale "chromosphere-corona mass cycle" in which hot plasma and magnetic flux and helicity from the chromosphere are transported upwards while the cooler prominence plasma downflows, which decouple from the magnetic field they are originally frozen-into, represent the condensation return flows of the cycle. This cycling enables a mechanism by which magnetic flux and helicity build up in the coronal flux rope while mass drains out of the flux rope, eventually triggering a "loss of confinement" eruption in the form of a CME.

Author(s): ***Thomas Berger (National Solar Observatory)***, Wei Liu (Stanford Lockheed Institute for Space Research), Andrew Hillier (Kyoto University), Eamon Scullion (Trinity College), Boon Chye Low (High Altitude Observatory)

212.02 – New Aspects of a Lid-Removal Mechanism in the Onset of a SEP-Producing Eruption Sequence

We examine a sequence of two ejective eruptions from a single active region on 2012 January 23, using magnetograms and EUV images from SDO/HMI and SDO/AIA, and EUV images from STEREO. Cheng et al. (2013) showed that the first eruption's (``Eruption 1'') flux rope was apparent only in ``hotter'' AIA channels, and that it removed overlying field that allowed the second eruption (``Eruption 2'') to begin via ideal MHD instability; here we say Eruption 2 began via a ``lid removal'' mechanism. We show that during Eruption-1's onset, its flux rope underwent ``tether weakening'' (TW) reconnection with the field of an adjacent active region. Standard flare loops from Eruption 1 developed over Eruption-2's flux rope and enclosed filament, but these overarching new loops were unable to confine that flux rope/filament. Eruption-1's flare loops, from both TW reconnection and standard-flare-model internal reconnection, were much cooler than Eruption-2's flare loops (GOES thermal temperatures of ~9 MK compared to ~14 MK). This eruption sequence produced a strong solar energetic particle (SEP) event (10 MeV protons, >10^3 pfu for 43 hrs), apparently starting when Eruption-2's CME blasted through Eruption-1's CME at 5---10 R_s. This occurred because the two CMEs originated in close proximity and in close time sequence: Eruption-1's fast rise started soon after the TW reconnection; the lid removal by Eruption-1's ejection triggered the slow onset of Eruption 2; and Eruption-2's CME, which started ~1 hr later, was three times faster than Eruption-1's CME.

Author(s): ***Alphonse Sterling (NASA/MSFC)***, Ronald Moore (NASA/MSFC), David Falconer (NASA/MSFC), Javon Knox (Norfolk State University)

212.03 – MHD simulations of homologous and cannibalistic coronal mass ejections

We present magneto-hydrodynamic simulations of the development of a homologous sequence of coronal mass ejections (CMEs) and demonstrate their so-called cannibalistic behavior. These CMEs originate from the repeated formations and partial eruptions of kink unstable flux ropes as a result of the continued emergence of a twisted flux rope across the lower boundary into a pre-existing coronal potential arcade field. The simulations show that a CME erupting into the open magnetic field created by a preceding CME has a higher speed, and therefore tends to be cannibalistic, catching up and merging with the preceding one into a single fast CME. All the CMEs attained speeds of about 1000 km/s as they exit the domain. The reformation of a twisted flux rope after each CME eruption during the sustained flux emergence can naturally explain the X-ray observations of repeated reformations of sigmoids and “sigmoid-under-cusp” configurations at a low-coronal source of homologous CMEs.

Author(s): ***Yuhong Fan (HAO/NCAR)***, Piyali Chatterjee (HAO/NCAR)

212.04 – A Method for Embedding Circular Force-Free Flux Ropes in Potential Magnetic Fields

We propose a method for constructing approximate force-free equilibria in pre-eruptive configurations that locally are a bipolar-type potential magnetic field with a thin force-free flux rope embedded inside it. The flux rope is assumed to have a circular-arc axis, circular cross-section, and electric current that is either concentrated in a thin layer at the boundary of the rope or smoothly distributed across it with a maximum of the current density at the center. The entire solution is described in terms of the magnetic vector potential in order to facilitate the implementation of the method in numerical magnetohydrodynamic (MHD) codes that evolve the vector potential rather than the magnetic field itself. The parameters of the flux rope can be chosen so that its subsequent MHD relaxation under photospheric line-tied boundary conditions leads to nearly exact numerical equilibria. To show the capabilities of our method, we apply it to several cases with different ambient magnetic fields and internal flux-rope structures. These examples demonstrate that the proposed method is a useful tool for initializing data-driven simulations of solar eruptions.

Author(s): ***Viacheslav Titov (Predictive Science, Inc.)***, Tibor Torok (Predictive Science, Inc.), Zoran Mikic (Predictive Science, Inc.), Jon Linker (Predictive Science, Inc.)

212.05 – A plasma ? transition within a propagating flux rope

We present a 2.5D MHD simulation of a magnetic flux rope (FR) propagating in the heliosphere and investigate the cause of the observed sharp plasma ? transition. Specifically, we consider a strong internal magnetic field and an explosive fast start, such that the plasma ? is significantly lower in the FR than the sheath region that is formed ahead. This leads to an unusual FR morphology in the first stage of propagation, while the more traditional view (e.g. from space weather simulations like Enlil) of a `pancake' shaped FR is observed as it approaches 1AU. We investigate how an equipartition line, defined by a magnetic Weber number, surrounding a core region of a propagating FR can demarcate a boundary layer where there is a sharp transition in the plasma ?. The substructure affects the distribution of toroidal flux, with the majority of the flux remaining in a small core region which maintains a quasi-cylindrical structure. Quantitatively, we investigate a locus of points where the kinetic energy density of the relative inflow field is equal to the energy density of the transverse magnetic field (i.e. effective tension force). The simulation provides compelling evidence that at all heliocentric distances the distribution of toroidal magnetic flux away from the FR axis is not linear; with 80% of the toroidal flux occurring within 40% of the distance from the FR axis. Thus our simulation displays evidence that the competing ideas of a pancaking structure observed remotely can coexist with a quasi-cylindrical magnetic structure seen in situ

Author(s): ***Neel Savani (NASA GSFC)***, Angelos Vourlidas (Naval Research Laboratory), Daikou Shiota (Nagoya University), Mark Linton (Naval Research Laboratory), Kanya Kusano (Nagoya University), Noe Lugaz (University of New Hampshire), Alexis Rouillard (Universit de Toulouse)

212.06 – Rapid CME Cavity Formation and Expansion

A cavity is supposed to be a general feature of well-developed CMEs at the stage they can be imaged by white-light coronagraphs (in the outer corona and solar wind). The cavity is interpreted as the cross section of the CME flux rope in the plane of sky. Preexisting cavities are observed around some quiescent erupting prominences, but usually not in active regions. Observations of CME cavities in the inner corona, where most of them appear to form, have become possible only with the STEREO and SDO missions. These reveal a very rapid formation and expansion of "EUV cavities" in fast and impulsively commencing eruptions early in the phase of main CME acceleration and impulsive flare rise. Different from the white-light observations, the EUV cavity initially appears to be larger than the CME flux rope. However, it evolves into the white-light cavity subsequently. MHD simulations of flux rope eruptions conform to this picture of initially larger cavity but subsequently approaching cavity and flux rope size. The initial expansion of ambient flux can be understood as a "reverse pinch effect", driven by decreasing flux rope current as the rope rises.

Author(s): ***Bernhard Kliem (University of Potsdam)***, Terry Forbes (University of New Hampshire), Spiros Patsourakos (University of Ioannina), Angelos Vourlidas (Naval Research Laboratory)

213 – The Galactic Center and Nearby Galaxies

Oral Session – St. George AB – 03 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Rafael Martinez

213.01 – Winds from the S-Star Cluster Reduce the Accretion Rate onto Sgr A*

High-resolution radio continuum images of the region within a few arcseconds of Sgr A* at wavelengths of 7 and 12 mm show three new radio structures. One is a 2-3'' hollow teardrop-shaped structure centered on Sgr A*. Highly blue-shifted [NeII] and [FeIII] line emission is detected along the boundary of this teardrop-shaped bubble, ~2.2'' south of Sgr A*. The second structure is a faint, incomplete ring surrounding Sgr A* with typical surface brightness at 7 mm of ~0.1 mJy per ~0.04'' x 0.08'' beam. This partial ring coincides with the outer boundary of the S-star cluster which consists of ~30 B dwarfs orbiting within 1'' of Sgr A*. Lastly, on a scale of ~20'' to the N of Sgr A*, a balloon-shaped structure is detected. We interpret that the new morphological and kinematic structures result from the dynamical effects of a combined cluster wind. This wind is created at a rate ~3 x 10^{-5} solar mass per year by the merging of individual stellar winds from the B stars in the S-star cluster. What is significant about this interpretation is that the expanding wind excludes the shocked winds from O and WR stars in the central parsec of the Galaxy. Meanwhile Sgr A* accretes material from within the S cluster at a rate less than or equal 3 x 10^{-7} solar mass per year, thus explaining the low luminosity of Sgr A* without the ejection of a large fraction of the accreted material.

Author(s): ***Farhad Yusef-Zadeh (Northwestern Univ.)***, M. Wardle (Macquarie), D. Roberts (Northwestern Univ.), Daryl Haggard (Northwestern Univ.), John Lacy (University of Texas), Marc Royster (Northwestern Univ.), William Cotton (NRAO)

213.02D – Probing the Extreme Environment of the Galactic Center with Observations from SOFIA/FORCAST

In this thesis we present a study of the inner 40 pc of the Galactic center addressing the dense, dusty torus around Sgr A*, dust production around massive stars, and massive star formation. Observations of warm dust emission from the Galactic center were performed using the Faint Object Infrared Camera for the SOFIA Telescope (FORCAST). A dense, molecular torus referred to as the Circumnuclear Disk (CND) orbits Sgr A* with an inner radius of ~1.4 pc and extending to ~7 pc. The inner edge of the CND, which we refer to as the Circumnuclear Ring (CNR), exhibits features of a classic HII region and appears consistent with the prevailing paradigm in which the dust is heated by the Central cluster of hot, young stars. We do not detect any star formation occurring in the CNR; however, we reveal the presence of density “clumps” along the inner edge of the CNR. These clumps are not dense enough to be stable against tidal shear from Sgr A* and will be sheared out before completing a full orbit (~10^5 yrs). Three Luminous Blue Variables (LBVs) are located in and near the Quintuplet Cluster 40 pc in projection from Sgr A*: qF362, the Pistol star, G0.120-0.048 (LBV3). FORCAST observation reveal the asymmetric, compressed shell of hot dust surrounding the Pistol Star and provide the first detection of the thermal emission from the symmetric, hot dust envelope surrounding LBV3. However, no detection of hot dust associated with qF362 is made. We argue that the Pistol star and LBV3 are identical “twins” that exhibit contrasting nebulae due to the external influence of their different environments. G-0.02-0.07, a complex consisting of three compact HII regions and one ultracompact HII region, is located at the edge of a molecular cloud 6 pc in projection to the east of Sgr A* and contains the most recent episode of star formation in the Galactic center. We probe the dust morphology, energetics, and composition of the regions to study the star forming conditions of a molecular cloud in the strong gravitational potential of Sgr A*.

Author(s): ***Ryan Lau (Cornell University)***, Terry Herter (Cornell University), Mark Morris (UCLA), Joseph Adams (Cornell University), Eric Becklin (UCLA)

213.03 – Spitzer observations of Sgr A* and cloud G2

The supermassive black hole at the center of our Galaxy is a fluctuating source of electromagnetic radiation derived from its accretion flow. For the past decade, the black hole’s ingestion has been modest, but its accretion rate and luminosity are predicted to surge as the cloud G2 swings by and feeds Sgr A* with a helping of fresh gas. We have started a program to monitor Sgr A* with Spitzer/IRAC at a wavelength of 4.5 microns as the anticipated elevated accretion episode proceeds. Near-infrared wavelengths are where the black hole’s emission has been best characterized in the past, and IRAC observations will complement planned observations with other observatories at X-ray, radio, and submillimeter wavelengths. The variability of Sgr A* is a random red-noise process, but the limited duration of continuous ground-based observations (<6 hr) has prevented direct measurement of the correlation timescale. This timescale corresponds to a thermal or viscous timescale associated with the inner radius of the accretion disk, and knowing it is critical for the black hole accretion physics. The Spitzer observing plan is to monitor Sgr A* continuously at 4.5 microns for >23.5 hours at each of six epochs. Epochs include one in 2013 Dec, three more in 2014 Jun-Jul, and two more in 2014 Nov-Dec. These will enable us to follow the initial stages of what has been predicted to be an extended accretion episode. In the 2013 Dec epoch we detected emission from Sgr A* in excess of the noise level for approximately 40% of the period observed, with individual maxima having peak levels of 1-10 milliJanskys.

Author(s): ***Joseph Hora (Harvard-Smithsonian, CfA)***, Giovanni Fazio (Harvard-Smithsonian, CfA), Steven Willner (Harvard-Smithsonian, CfA), Sean Carey (Spitzer Science Center), James Ingalls (Spitzer Science Center), Matthew Ashby (Harvard-Smithsonian, CfA), Eric Becklin (SOFIA Science Center), Andrea Ghez (UCLA), Leo Meyer (UCLA), Mark Morris (UCLA), Howard Smith (Harvard-Smithsonian, CfA), Gunther Witzel (UCLA), Jiasheng Huang (Harvard-Smithsonian, CfA), Zhong Wang (Harvard-Smithsonian, CfA)

213.04 – Leptonic v.s. Hadronic Origin of the Gamma-ray Emission of the Fermi bubbles: Updates from Fermi-LAT and Forecast for Future Gamma-ray Telescopes

Data from the Fermi-LAT revealed two large gamma-ray bubbles, extending 50 degrees above and below the Galactic center, with a width of about 40 degrees in longitude. Such structure has been confirmed with multi-wavelength observations. With the most up to date Fermi-LAT data analysis, I will show that the Fermi bubbles have a spectral cutoff at both low energy < 1 GeV and high energy > 150 GeV. Detailed analysis of the spectral features will help us to distinguish the leptonic origin from hadronic origin of the gamma-ray emission from the bubbles. I will also describe what we expect to learn about the bubbles from future gamma-ray telescopes after Fermi, with an emphasis on Dark Matter Particle Explorer and Pair Production Gamma-ray Unit.

Author(s): ***Meng Su (MIT)***

213.05 – Tidal Streams Near and Far

The Pandas survey of stars in M31's disk and halo is crisscrossed by numerous tidal features from both M31 and the Milky Way. Here I focus on two narrow stellar streams visible in the survey. They have comparable angular extent in the survey (10-13 degrees long versus only 0.3 degree wide), but one is a local Milky Way stream at about 30 kpc and one is in M31, roughly 25 times more distant. I estimate the stellar mass and metallicity in the streams and the distance gradient along them. The kinematics of the M31 stream is sparsely sampled by red giant stars and globular clusters. Bayesian modeling of the stream data yields accurate constraints on the orbital parameters of the streams.

Author(s): ***Mark Fardal (University of Massachusetts)***

Contributing teams: PAndAS

213.06 – The black hole mass at the center of NGC 5419

We measured the black hole mass at the center of the massive core elliptical NGC 5419 using SINFONI adaptive optics spectra combined with SALT long slit kinematics. We detect an elongated blue central structure, possibly a disk of young stars orbiting the black hole.

Author(s): ***Gary Wegner (Dartmouth College)***, X. Mazzalay (Max-Planck Institut fuer extraterrestrische Physik), Jens Thomas (Max-Planck Institut fuer extraterrestrische Physik), Roberto Saglia (Max-Planck Institut fuer extraterrestrische Physik), Ralf Bender (Max-Planck Institut fuer extraterrestrische Physik), Peter Erwin (Max-Planck Institut fuer extraterrestrische Physik), M. Fabricius (Max-Planck Institut fuer extraterrestrische Physik), M. Nowak (Max-Planck Institut fuer extraterrestrische Physik)

214 – Bridging Laboratory and Astrophysics: Planetary

Meeting-in-a-Meeting – St. George CD – 03 Jun 2014 02:00 PM to 03:30 PM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This session will focus on the interplay between astrophysics with theoretical and experimental studies into the underlying planetary science processes, which drive our Universe.

Chair(s):
Farid Salama (NASA Ames Research Center)

214.01 – Haze Formation in Planetary Atmospheres: Lessons from the Lab

For more than 50 years, haze formation in planetary atmospheres has been simulated in the laboratory. Of particular interest are simulations of haze formation in the atmosphere of Titan, the largest moon of Saturn. These simulation experiments have provided a wealth of knowledge about the possible composition and optical properties of haze particles, informed efforts to understand the transition between gas phase and particle chemistry, and provide “analogue” materials to aid in the selection and testing of the next generation of spacecraft based analytical techniques. In this talk I will review the current state of knowledge from Titan atmosphere simulation experiments, discuss difficulties that have arisen from knowledge gained from the Cassini-Huygens mission to the Saturn system, and present particular areas where laboratory studies could provide much needed guidance for the observation and modeling communities studying atmospheres in our solar system and beyond.

Author(s): ***Sarah Horst (University of Colorado)***

214.02 – Laboratory Astrophysics with Primitive Extraterrestrial Materials: The Origin and Early Evolution of Our Planetary System

The planets in our Solar System formed from a protoplanetary disk of gas and dust, the solar nebula. Due to billions of years of evolution, the planets themselves do not preserve many signatures of the earliest stages of their formation. However, records of the nebula and of the earliest planetary formation epoch are preserved in asteroids and comets, and samples of these are available for laboratory study in the form of meteorites and interplanetary dust particles, as well as asteroidal and cometary dust returned by spacecraft. Primitive extraterrestrial materials contain pristine samples of the earliest solids that formed the building blocks of the planets including both ‘’presolar’’ materials from prior generations of stars and the interstellar medium as well as early-formed solar nebular dust. Detailed laboratory analyses (e.g., isotopic, elemental and microstructural studies) of these materials provide unique insights into a wide range of astrophysical processes, including stellar nucleosynthesis, galactic chemical evolution, interstellar dust processing and chemistry, and mixing and accretion processes in protoplanetary disks. This talk will review many of these topics with a focus on how meteorites constrain the astrophysical setting for solar system formation, the starting materials of the planets, timescales of planet formation, and the origin and distribution of water and carbon, the essential ingredients for life.

Author(s): ***Larry Nittler (Carnegie Inst. Of Washington)***

214.03 – Optical Constants of the Methane-Nitrogen Binary Ice System: Implications for Methane-Dominated Transneptunian Objects

Pluto, Eris, and Makemake, unlike most Transneptunian objects (TNOs) with water-ice rich or featureless surfaces (Barucci et al., 2008), display infrared spectra dominated by methane ice (Brown, 2008). These three TNOs are often compared with Neptune's large satellite Triton, since its spectrum is similarly dominated by methane ice and it is thought to have formed similarly to Pluto, Eris, and Makemake, prior to its capture into a retrograde orbit around Neptune. In addition to methane ice, nitrogen ice has been directly detected on Pluto and Triton via the 2.148 micron absorption band (Cruikshank et al., 1984; Owen et al., 1993). Thermodynamic equilibrium dictates that if methane and nitrogen ices are both present, for most of the range of possible nitrogen/methane relative abundances, two distinct phases must coexist at temperatures relevant to the surfaces of these icy dwarf planets (Prokhvatilov and Yantsevich, 1983; Lunine and Stevenson, 1985): methane ice saturated with nitrogen and nitrogen ice saturated with methane. We present infrared absorption coefficient spectra in the wavelength range 0.8 - 2.5 micron of methane diluted in nitrogen and nitrogen diluted in methane at temperatures between 40 and 90 K and at different mixing ratios, allowing a proper model to be constructed for any TNO where the methane/nitrogen ratio falls between the two solubility limits such that both phases are present.

Author(s): ***Silvia Protopapa (Department of Astronomy University of Maryland)***, William Grundy (Lowell Observatory), Stephen Tegler (Department of Physics and Astronomy, Northern Arizona University), Justin Bergonio (Department of Physics and Astronomy, University of Hawai'i)

214.04 – The THS experiment: probing Titan's atmospheric chemistry at low temperature

In Titan's atmosphere, a complex chemistry between N2 and CH4 occurs at temperatures lower than 200K and leads to the production of heavy molecules and subsequently solid aerosols that form the haze surrounding Titan. The Titan Haze Simulation (THS) experiment has been developed at the NASA Ames COSmIC facility to study Titan's atmospheric chemistry at low temperature in order to help interpret Cassini's observational data. In the THS, the chemistry is simulated by plasma in the stream of a supersonic expansion. With this unique design, the gas is jet-cooled to Titan-like temperature (~150K) before inducing the chemistry by plasma, and remains at low temperature in the plasma discharge (~200K). Different N2-CH4-based gas mixtures can be injected in the plasma, with or without the addition of heavier precursors present as trace elements on Titan. Both the gas phase and solid phase products resulting from the plasma-induced chemistry can be monitored and analyzed using a combination of complementary in situ and ex situ diagnostics. Here we present the complementary results of two studies of the gas and solid phase. A Mass spectrometry analysis of the gas phase has demonstrated that the THS experiment is a unique tool to probe the first and intermediate steps as well as specific chemical pathways of Titan's atmospheric chemistry at Titan-like temperature. The more complex chemistry, observed in the gas phase when adding trace elements to the initial N2-CH4 mixture, has also been confirmed by an extensive study of the solid phase products: Scanning Electron Microscopy images have shown that aggregates produced in N2-CH4-C2H2-C6H6 mixtures (up to 5 ?m in diameter) are much larger than those produced in N2-CH4 mixtures (0.1-0.5 ?m), and Nuclear Magnetic Resonance results support a growth evolution of the chemistry when adding acetylene to the N2-CH4 mixture, resulting in the production of more complex hydrogen bonds than with a simple N2-CH4 mixture. These complementary studies show the high potential of THS to better understand Titan's chemistry and the origin of aerosol formation.
Acknowledgments This research is supported by NASA SMD PATM.

Author(s): ***Ella Sciamma-O'Brien (Bay Area Environmental Research Institute)***, Kathleen Upton (California Institute of Technology), Jack Beauchamp (California Institute of Technology), Farid Salama (NASA Ames Research Center)

215 – Star Formation and Interstellar Medium

Oral Session – Gloucester, 2nd Floor – 03 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Julia Roman-Duval (Space Telescope Science Institute)

215.01 – Pressure in the Diffuse Interstellar Medium from Observations of CO and [CII]

The pressure of the diffuse interstellar medium plays an important role in determining the balance between different regions, the formation and evolution of interstellar clouds, and possibly regulating star formation. We here report use of UV absorption data of CO taken from the literature and [CII] observations taken with Herschel to determine the thermal pressure of diffuse line of sight clouds. An average value in the range 5000 - 6000 K/cm3 characterizes both sets of observations, somewhat higher than generally found in the literature.

Author(s): ***Paul Goldsmith (JPL)***, Maryvonne Gerin (LERMA & ENS)

215.02 – Gas Kinematics in Filamentary Infrared Dark Clouds

Many infrared dark clouds (IRDCs) have filamentary structures, and some of them present converging filaments to a central hub, known as hub-filament systems (HFSs). These filaments could play a crucial role in feeding gas to the star forming regions at the hub. With the Submillimeter Array in the compact and sub-compact configurations, we conducted a mini-survey of five high-mass (>10^3 Msolar) HFSs, and obtained the dust emission and spectra lines at 1.3 mm. We found filamentary structures in both dust continuum and spectral line emission, with a characteristic width of 0.1 pc and length of 1 pc. The dust emission is consistent with the infrared extinction features, indicating the existence of dense and cold gas, while massive dust cores are usually associated with the hubs. Complex organic molecules including CH3OH are found towards the dust cores. In particular, optically-thin intermediate density gas tracers, such as C18O, reveal a possible trend of gas infall along filaments towards hubs. This is consistent with the scenario that dense gas is accreted onto dense cores through filaments and form high-mass star clusters.

Author(s): ***Xing Lu (Harvard-Smithsonian Center for Astrophysics)***, Qizhou Zhang (Harvard-Smithsonian Center for Astrophysics), Hauyu Liu (Academia Sinica Institute of Astronomy and Astrophysics)

215.03 – Diagnosing the Star Formation Rate in Massive Galactic Star Forming Regions

In extragalactic studies many different observables are used to trace the star formation history averaged over galaxy or kiloparsec scales. By studying star formation in our Galaxy we are able to resolve individual sources and directly count up the young stars in a star forming complex. The star formation rates that are determined from this method rely on the input assumptions. I will describe how different assumptions and variables alter the derived star formation rate for a sample of massive galactic star forming regions and how these star formation rates compare to those derived using methods developed in the study of external galaxies.

Author(s): ***Sarah Willis (Iowa State University)***, Massimo Marengo (Iowa State University), Howard Smith (Harvard-Smithsonian CfA), Lori Allen (National Optical Astronomy Observatories), Andres Guzman (Harvard-Smithsonian CfA), Rafael Martinez (Harvard-Smithsonian CfA)

215.05 – Gaining Insight into Star Formation: Resolved Star Formation Laws

Until recently astronomers have used star formation laws to measure the star formation rate and star formation efficiency of galaxies only on global scales because of the poor resolution of available data. What I am now capable of producing is a spatially resolved star formation law that can provide direct insight into the physical processes that govern star formation and assess the short-term nature of bursts of star formation and the longer-term nature of larger-scale events that can dictate the global distribution of stars and the ultimate fate of a galaxy as a whole. I am using exquisite narrowband optical data from a variety of sources, including the Hubble Space Telescope, and Kitt Peak National Observatory, etc., in conjunction with infrared data from the Spitzer Infrared Nearby Galaxy Survey and the Spitzer Local Volume Legacy survey, neutral gas data from The HI Nearby Galaxy Survey, and molecular gas data from the Berkeley-Illinois-Maryland Association Survey of Nearby Galaxies, to provide star formation rates and star formation efficiencies on previously inaccessible small spatial scales across a suite of galaxies that represent a range of star formation environments and scales. My sample includes 18 spiral galaxies ranging from 2.1 to 15.1 Mpc in distance and offers a large range of morphological types (i.e. a large range of star formation environments). I am using these data to test different models of star formation modes under a variety of physical conditions and relate the variations I observe to the known local physical conditions and the associated star formation histories for each locale within each galaxy. This is the heart of the matter – that the nature and evolution of the local physical environment intimately influences how stars can form, how quickly and how massive those stars are allowed to form, and as a result how they shape the local conditions for subsequent star formation. It is this tracking of the stellar ecology that is vital for insight into the star formation process, but also to understand the conditions that can result in star and planet formation, or conversely what conditions prevent this. Such an analysis is only possible with the kind of datasets I am producing.

Author(s): ***Kelley Liebst (Arizona State University)***, Paul Scowen (Arizona State University)

215.06 – Galaxies on FIRE: Stellar Feedback Explains Inefficient Star Formation

Many of the most fundamental unsolved questions in star and galaxy formation revolve around star formation and "feedback" from both massive stars and accretion onto super-massive black holes. I'll present new simulations which attempt to realistically model the diverse physics of the interstellar medium, star formation, and feedback from stellar radiation pressure, supernovae, stellar winds, and photo-ionization. These mechanisms lead to 'self-regulated' galaxy and star formation, in which global correlations such as the Schmidt-Kennicutt law and the global inefficiency of star formation -- the stellar mass function -- emerge naturally. Within galaxies, feedback regulates the structure of the interstellar medium, and many observed properties of the ISM, star formation, and galaxies can be understood as a fundamental consequence of super-sonic turbulence in a rapidly cooling, self-gravitating medium. But feedback also produces galactic super-winds that can dramatically alter the cosmological evolution of galaxies, their behavior in galaxy mergers, and structure of the inter-galactic medium: these winds depend non-linearly on multiple feedback mechanisms in a way that explains why they have been so difficult to model in previous "sub-grid" approaches.

Author(s): ***Philip Hopkins (Caltech)***

Contributing teams: The FIRE Team

215.07 – Star formation in interacting galaxies: A tale of compactness

At intermediate redshifts, a correlation has been found by Magnelli et al. between the dust temperature in star-forming galaxies, their specific star formation rate, and their distance from the so-called main sequence in the SFR-M* plane. This result has been interpreted in terms of a difference in the ISM physics between galaxies on and off the main sequence. In this contribution we attempt to characterize the ISM physics in interacting systems with different levels of specific star formation in terms of the compactness parameter, which is related to the average heating flux irradiated onto the dust particles surrounding individual HII regions. We use *CHIBURST*, a Monte Carlo Bayesian algorithm to fit the multiwavelength SEDs of a set of simulated and observed nearby interactions from Lanz et al. 2014 and derive physical parameters of the ISM. We find that compactness is related to the evolutionary stage of the interactions: early interactions (older starbursts) have low compactness, whereas systems near coalescence (younger starbursts) have the highest possible compactness. After coalescence, compactness decreases as the HII regions continue to expand without replenishment of hot dust by new star formation activity. Interestingly, main sequence galaxies show on average a smaller compactness as compared to their starburst counterparts. This link between the overall SED properties of starbursts and the internal physics of the ISM at the HII region level is a promising tool in the characterization of unresolved starbursts, and points to a physically based definition of the main sequence of star formation in galaxies.

Author(s): ***Juan Rafael Martinez-Galarza (Smithsonian Astrophysical Observatory)***, Lauranne Lanz (Caltech), Christopher Hayward (Max-Planck-Institut für Astronomie), Andreas Zezas (Smithsonian Astrophysical Observatory), Howard Smith (Smithsonian Astrophysical Observatory), Matthew Ashby (Smithsonian Astrophysical Observatory), Chao-Ling Hung (Smithsonian Astrophysical Observatory)

215.08 – STAR CLUSTERS IN INTERACTING GALAXIES : FORMATION AND EVOLUTION

Galaxy mergers are vast stellar nurseries where star clusters form, but the immense tidal disruption forces are also at work, which causes destruction of the cluster systems. This simultaneous formation and destruction of the clusters leads to selective survival of clusters. Here, we investigate the formation and evolution of star clusters in interacting galaxies using a suite of high-resolution smoothed particle hydrodynamics simulations. In the simulations, star clusters are identified using the cluster finding algorithm, the Amiga Halo Finder. We found that the mass function of the star clusters change significantly during the course of galaxy merger, and the peak of density probability distribution shifts from high mass to ~7x10^5 Msun at late times. Furthermore, we found that the survived clusters are those that have the highest specific binding energy. Our results suggest that high-mass clusters are more easily destroyed than the low-mass ones, and that the observed peak of globular cluster mass function at 3x10^5 Msun may be a result of such selective survival of clusters.

Author(s): ***Moupiya Maji (The Pennsylvania State University)***, Qirong Zhu (The Pennsylvania State University), Yuexing Li (The Pennsylvania State University), Jane Charlton (The Pennsylvania State University)

215.09 – Astrochemical Correlations in Molecular Clouds

We investigate the spectral correlations between different chemical tracers used to observe molecular clouds. We study a 600 Solar Mass molecular cloud with Mach number 6.6 modeled using the magnetohydrodynamic code ORION. The chemical abundances are calculated by 3D-PDR, a three-dimensional astrochemical code using a full network of 3300 reactions and 215 species. We take synthetic observations of 16 different species using the non-LTE radiative transfer code RADMC-3D. The effects of different lines of sight and spatial resolution on the emission maps of the 16 different species will be discussed in this talk. We use the Spectral Correlation Function to quantify the structure of the simulated cloud in position-position-velocity space, which measures the average rms velocity between spectra separated by a given length scale. This statistic has been shown to be sensitive to global hydrodynamic parameters, such as the sonic Mach number and velocity dispersion. The SCF is analytically fit by a power law, with the slope being the one free parameter. We verify that the SCF is generally insensitive to the sightline through the cloud. We discover that the beam size has a distinct effect on different chemical tracers. However, the change is not large enough to move the SCF slopes into different parts of the parameter space. This is the first quantitative 3D study of the spectral similarity of a variety of species. We predict the observed SCF for a broad range of observational tracers, and thus, identify complementary species. In particular, we show that the pairs C and CO, C+ and CN, NH3 and H2CS have very similar SCFs. The results from this study will also give observers a guide for selecting which chemical tracers would be best for observing different length scales.

Author(s): ***Brandt Gaches (University of Massachusetts - Amherst)***, Stella Offner (University of Massachusetts - Amherst)

216 – Karen Harvey Prize, Alexis Rouillard: Probing the Origin of Slow Solar Wind, Coronal Mass Ejections and Solar Energetic Particles by Combining Solar and Heliospheric Imagery with In-situ Measurements

Plenary Session – America Ballroom North/Central – 03 Jun 2014 03:40 PM to 04:30 PM

Chair(s):
Leon Golub (SAO)

216.01 – Probing the origin of slow solar wind, coronal mass ejections and solar energetic particles by combining solar and heliospheric imagery with in-situ measurements.

The Solar-Terrestrial Relations Observatory (STEREO), launched in 2006, is equipped with cameras that are observing the Sun and heliosphere from two vantage points. The orbital configuration of the spacecraft changed rapidly during the course of the current solar cycle permitting a wide range of different studies to be carried out on various timescales. Combined STEREO observations have provided new insights on the origin of the variable slow solar wind, the global topology of CMEs and their shocks and the origin of high-energy solar energetic particles. We will review these recent discoveries and then focus on a series of analyses that combine ultraviolet and white-light images to track in 3-D the spatial and temporal evolution of coronal pressure waves associated with the onset of CMEs. We will then combine coronal imagery of these shocks with in-situ measurements of solar energetic particle events (SEPs) to study the acceleration and propagation mechanisms of high-energy particles in the solar corona.

Author(s): ***Alexis Rouillard (Universite de Toulouse)***

217 – Margaret Meixner: The Life Cycle of Dust in the Magellanic Clouds: Insights from Spitzer and Herschel

Plenary Session – America Ballroom North/Central – 03 Jun 2014 04:30 PM to 05:20 PM

Chair(s):
Edward Churchwell (Univ. of Wisconsin)

217.01 – The Life Cycle of Dust in the Magellanic Clouds: Insights from Spitzer and Herschel

The life cycle of dust in a galaxy involves the exchange of material between the interstellar medium (ISM) and stars. Dust is formed in the winds of dying stars, such as asymptotic giant branch (AGB) and red supergiant (RSG) stars, and the explosion of supernovae. In the ISM, the dust may be shattered and vaporized by supernova blast waves or accreted onto seed grains in the denser ISM. Dust is consumed in the star formation process and appears in the circumstellar environments of newly forming stars. By tracing the lifecycle of dust, we gain insights into the dust evolution processes and the origin of galactic dust. The Spitzer Space Telescope and Herschel Space Observatory provide a sensitive probe of circumstellar and interstellar dust. The Spitzer Surveying the Agents of Galaxy Evolution (SAGE; the ISM and stars) and the Herschel Inventory of the Agents of Galaxy Evolution (HERITAGE) surveys of the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC) focus on the lifecycle of dust. The LMC and SMC are ideal astrophysical laboratories for this study because their proximity to us permits detailed studies of the stars and their relation to the ISM from local to galaxy wide scales. For example, the masses of the circumstellar dust shells of stars and ISM dust clouds can be determined producing a more precise dust budget than possible for our own Milky Way galaxy. I will present key results from the SAGE and HERITAGE projects that quantify the stellar origin of dust, its evolution in the ISM and its consumption by star formation. Our measurements of dust mass-loss rates from entire populations of AGB and RSG stars and the discovery of ~0.5 solar masses of dust in the ejecta of supernova, SN1987A, provide the dust production rates by the stars. The maps of dust masses and gas-to-dust ratios of the ISM reveal how dust is destroyed and possibly created in the ISM. Our discovery of thousands of young stellar object candidates shows us locations of active star formation and enables us to quantify the star formation rate. I will end with a brief summary of the potential of the James Webb Space Telescope to extend this research.

Author(s): ***Margaret Meixner (Johns Hopkins University)***

Contributing teams: SAGE, HERITAGE

300 – Rosanne DiStefano: New Opportunities in Gravitational Microlensing and Mesolensing

Plenary Session – America Ballroom North/Central – 04 Jun 2014 08:30 AM to 09:20 AM

Chair(s):
Chryssa Kouveliotou (NASA/MSFC)

300.01 – NEW OPPORTUNITIES IN GRAVITATIONAL MICROLENSING AND MESOLENSING

It took more than fifty years and the development of computer technology to transform Einstein's theoretical work on what we now call "gravitational microlensing" into an active and successful field of observational research. The first microlensing events were announced in 1993, and today's monitoring teams discover roughly 2000 candidate events each year. Binaries and planets have been discovered, and the masses of nearby stars and brown dwarfs have been measured. The total numbers of planets discovered through lensing is still small, but the field is young, and new methods and techniques are being developed. I will summarize the successes to date, and will then focus on some intriguing new opportunities. One of these opportunities is suggested by theoretical work that will allow observers to search for planets in a wider range of orbits, thereby increasing the discovery rate. Another opportunity is provided by counterpart searches and parallax signatures in the lensing light curves, which are helping us to identify those events caused by nearby lenses (mesolenses), located within about a kiloparsec. We can learn a great deal more about mesolenses, and therefore expect to systematically discover and measure masses of nearby brown dwarfs, neutron stars and black holes, and also to find nearby planets that can be be studied with other techniques as well. Finally, mesolensing events can be predicted in advance, providing a new avenue to measure the masses and multiplicity of nearby stars. Gravitational lensing events have a rich potential to contribute to astronomy, and we are presently exploring new possibilities and establishing the framework that will allow more of this potential to be realized.

Author(s): ***Rosanne Di Stefano (Harvard-Smithsonian CfA)***

– LAD Posters Wednesday

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

318 – Structure of the Early Universe Posters

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

318.01 – HERA: Illuminating Our Early Universe

The Hydrogen Epoch of Reionization Arrays (HERA) roadmap is a staged plan for using the unique properties of the 21cm line from neutral hydrogen to probe our cosmic dawn, from the birth of the first stars and black holes, through the full reionization of the primordial intergalactic medium (IGM). HERA is a collaboration between the Precision Array Probing the Epoch of Reionization (PAPER), US-Murchison Widefield Array (MWA), and MIT Epoch of Reionization (MITEOR) teams. The first phase of the HERA roadmap entailed the operation of the PAPER and MWA telescopes to explore techniques and designs required to detect the primordial HI signal in the presence of radio continuum foreground emission some four orders of magnitude brighter. Studies with PAPER and the MWA have led to a new understanding of the interplay of foreground and instrumental systematics in the context of a three-dimensional cosmological intensity-mapping experiment. We are now able to remove foregrounds to the limits of our sensitivity with these instruments, culminating in the first physically meaningful upper limits on the power spectrum of 21~cm emission from reionization. Building on this understanding, the next stage of HERA entails a new 14m diameter antenna element that is optimized both for sensitivity and for minimizing foreground systematics. Arranging these elements in a compact hexagonal grid yields an array that facilitates calibration, leverages proven foreground removal techniques, and is scalable to large collecting areas. The HERA phase II will be located in the radio quiet environment of the SKA site in Karoo, South Africa, and have a sensitivity close to two orders of magnitude better than PAPER and the MWA, with broader frequency coverage, HERA can paint an uninterrupted picture through reionization, back to the end of the Dark Ages. This paper will present a summary of the current understanding of the signal characteristics and measurements and describe this planned HERA telescope to be built to detect and characterize the EoR power spectrum.

Author(s): ***David DeBoer (University of California)***

Contributing teams: HERA Collaboration

318.02 – Polarization Results from PAPER

Epoch of Reionization (EoR) experiments seeking a detection of the power spectrum face daunting challenges in the form of extremely bright foregrounds. One of the least well-characterized is that of polarization emission at meter wavelengths, both from our own Galaxy and from extragalactic radio sources. Faraday rotation of polarized sources produces frequency structure in the observed spectrum, and leakage of the polarized emission into estimates of Stokes I can be confused with the fluctuations due to reionization. Here we present recent results on characterizing the power spectrum of polarized emission the Precision Array for Probing the Epoch of Reionization (PAPER). PAPER is a focused experiment aimed at detecting the spatial power spectrum of neutral hydrogen emission during the EoR. PAPER is an interferometer operating from 100 - 200 MHz, with antennas measuring linear polarization and a correlator producing full-Stokes output. The science array is located at the site of the future Square Kilometre Array (SKA) site in South Africa, with a prototyping and test facility in Green Bank, WV. A staged build-out of PAPER South Africa (PSA) began in late 2009. PAPER has been obtaining science-grade observations since late 2011, when 32 dipoles (PSA-32) began taking data full-Stokes data, and is currently at its final size with 128 dipoles taking data since November 2013. We present power spectrum and imaging data from PSA-32 quantifying the brightness of foreground emission. We consider lessons learned from this experience in the design of the Hydrogen Epoch of Reionization Array.

Author(s): ***James Aguirre (University of Pennsylvania)***

Contributing teams: PAPER Collaboration, HERA Collaboration

318.03 – Epoch of Reionization Power Spectrum Measurements from PAPER to HERA

In the next few years, low-frequency radio interferometer arrays will achieve a first detection of the highly redshifted 21cm line of neutral hydrogen. These measurements will act as the first direct probe of the IGM between redshifts 20 and 6, enabling a new understanding of the physical processes at play during Cosmic Dawn and the Epoch of Reionization. We present upper limits on the 21cm power spectrum at z = 7.7 from the Precision Array for Probing the Epoch of Reionzation (PAPER), a current-generation instrument, as well as forecasts for the Hydrogen Epoch of Reionization Array (HERA), a planned next-generation experiment. We also discuss the tight constraints that HERA will place on astrophysical parameters pertaining to the first luminous objects (such as their ionizing efficiency) and the environments in which they form. Finally, we illustrate how systematics such as foreground emission can be overcome.

Author(s): ***Adrian Liu (University of California Berkeley)***, Jonathan Pober (University of California Berkeley), Joshua Dillon (Massachusetts Institute of Technology), Aaron Parsons (University of California Berkeley)

Contributing teams: HERA collaboration

318.04 – Power Spectrum Estimation for 21 cm Cosmology

Tomography with the 21 cm line of neutral hydrogen presents the opportunity to directly probe a vast fraction of the comoving volume of the observable universe at times when more established techniques are unavailable. The power spectrum of 21 cm brightness temperature fluctuations from the Epoch of Reionization and preceding eras will likely be the first key measurement for comparing theory and observation and constraining models of astrophysics and cosmology during the Cosmic Dawn. In this poster, I will present the statistical and algorithmic challenges presented by making this measurement in the presence of foregrounds that are orders of magnitude stronger than the signal. I will also show progress that has been made to overcome these challenges with data from the Murchinson Widefield Array and the implication for future experiments and analysis techniques.

Author(s): ***Joshua Dillon (Massachusetts Institute of Technology)***

318.05 – Constraining the population of radio-loud active galactic nuclei at high redshift with the power spectrum of the 21 cm Forest

The 21 cm forest, the absorption by the intergalactic medium (IGM) towards a high redshift radio-loud source, is a probe of the thermal state of the IGM. To date, the literature has focused on line-of-sight spectral studies of a single quasar known to have a large redshift. We instead examine many sources in a wide field of view, and show that the imprint from the 21 cm forest absorption of these sources is detectible in the power spectrum. The properties of the power spectrum can reveal information on the population of the earliest radio loud sources that may have existed during the pre-reionization epoch at $z>10$. Using semi-numerical simulations of the IGM and a semi-empirical source population, we show that the 21 cm forest dominates, in a distinctive region of Fourier space, the brightness temperature power spectrum that many contemporary experiments aim to measure. In particular, the forest dominates the diffuse emission on smaller spatial scales along the line of sight. Exploiting this separation, one may constrain the IGM thermal history, such as heating by the first X-ray sources, on large spatial scales and the absorption of radio loud active galactic nuclei on small ones. Using realistic simulations of noise and foregrounds, we show that planned instruments on the scale of the Hydrogen Epoch of Reionization Array (HERA) with a collecting area of one tenth of a square kilometer can detect the 21cm forest in this small spatial scale region with high signal to noise. We develop an analytic toy model for the signal and explore its detectability over a large range of thermal histories and potential high redshift source scenarios.

Author(s): ***Aaron Ewall-Wice (MIT)***, Joshua Dillon (MIT), Andrei Mesinger (Scuola Normale Superiore), Jacqueline Hewitt (MIT)

318.06 – Measuring antenna tile beampatterns with high dynamic range for the Murchison Widefield Array using 137 MHz ORBCOMM satellites

Detection of the redshifted 21cm fluctuations from the Epoch of Reionization in thousand hour integrations poses stringent requirements on calibration and image quality, both of which necessitate accurate primary beam models. The Murchison Widefield Array (MWA) uses phased array antenna elements designed to maximize collecting area at the expense of modeling complexity. To quantify their performance, we have developed a novel beam measurement system using the 137 MHz ORBCOMM satellite constellation and a reference dipole antenna. Using power ratio measurements, we measure the in situ relative beampattern of the MWA antenna tile, evading variation of satellite flux or polarization with time. We employ angular averaging to mitigate multipath effects (ground scattering), and assess environmental systematics with a "null experiment” in which the MWA tile is replaced with a second reference dipole. We achieve beam measurements with 30 dB dynamic range over a large field of view, far wider and deeper than drift scans through astronomical sources allow. We verify an analytic model for the MWA tile within few percent statistical scatter in the main lobe. Towards the edges of the main lobe and in the sidelobes, we measure tens of percent systematic deviations, in rough agreement with modeled beamforming errors. We discuss requirements for possible future calibration systems deployed on unmanned aerial vehicles or low Earth orbit satellites.

Author(s): ***Abraham Neben (MIT Kavli Institute for Astrophysics and Space Research)***, Richard Bradley (National Radio Astronomy Observatory), Jacqueline Hewitt (MIT Kavli Institute for Astrophysics and Space Research)

318.07 – MITEoR: scalable interferometer technology for precision cosmology

We describe the instrument design and calibration results of MITEoR, a path-finder 21 cm interferometer focusing on precision calibration and scalability. 21 cm cosmology is a growing field aiming to probe a large and previously inaccessible volume of our high redshift universe. However, the resulting constraints on cosmological parameters will only be as good as the instrumental calibration. We have successfully demonstrated several novel and scalable precision calibration techniques, which can help next generation experiments like HERA achieve unprecedented precision in 21 cm measurements.

Author(s): ***Haoxuan Zheng (MIT)***

Contributing teams: MITEoR

318.08 – The HI Mass Function and Velocity Width Function of Void Galaxies in the Arecibo Legacy Fast ALFA Survey

We measure the HI mass function (HIMF) and velocity width function (WF) across environments over a range of masses and profile widths using a catalog of ~7,300 HI-selected galaxies from the ALFALFA Survey, located in the region of sky where ALFALFA and SDSS (Data Release 7) North overlap. We divide our galaxy sample into those that reside in large-scale voids (void galaxies) and those that live in denser regions (wall galaxies). We find the void and wall HIMFs are well fit by Schechter functions. We conclude that void galaxies typically have lower HI masses than their non-void counterparts, which is in agreement with the dark matter halo mass function shift in voids; and the void low-mass slope is shallower than that of the wall HIMF suggesting that there is either no excess of low-mass galaxies in voids or there is an abundance of intermediate HI mass galaxies. We fit a modified Schechter function to both the ALFALFA void and wall WFs. Because of large uncertainties on the void and wall WFs, we cannot conclude whether these functions are dependent on environment.

Author(s): ***Crystal Moorman (Drexel University)***, Michael Vogeley (Drexel University), Fiona Hoyle (Pontifica Universidad Catolica de Ecuador), Danny Pan (Shanghai Astronomical Observatory), Martha Haynes (Cornell University), Riccardo Giovanelli (Cornell University)

318.09 – Galactic Extinction, Cepheid Distances, and the Hubble Constant

Galactic interstellar extinction is tested using reddening line parameters for several Galactic plane fields in conjunction with reddening slope X = E(U-B)/E(B-V) values and stellar equivalent widths W(?4430). The extinction parameter R_V(observed}) displays a quadratic variation with reddening slope X, with a minimum at $R_V = 2.82\pm0.06$ for X = 0.83. ?4430 absorption also displays a dependence on reddening slope, with no absorption for stars with X = 0.83, increasing with decreasing X, and saturating near X=0.75. Galactic extinction therefore appears to follow a relation described by A(?) ? ?$^{-1.375}$, which differs in several respects from generally adopted laws but matches expectations from Zagury (2013) for forward scattering of starlight by hydrogen in the Galactic plane. Extinction towards other galaxies should therefore be similar to that in regions where X = 0.83 and $R_V = 2.82$, implying slightly underestimated distances to extragalactic Cepheids. A reworking of data for Cepheids in the megamaser galaxy M106 using a Wesenheit formulation of the PL relation with $R_V = 3$ (appropriate for Cepheids) rather than 3.3 yields: (i) reasonably close agreement of the galaxy’s distance from Cepheids both close to and distant from the galactic core, (ii) a new estimate of 7.98±0.41 Mpc for the distance to the galaxy, and (iii) implied values for the Hubble constant of $H_0 = 61.7\pm3.2$ km/s/Mpc for the motion of M106 relative to a Milky Way/LMC barycenter of the Local Group, or $H_0 = 64.7\pm3.4$ km/s/Mpc if infall of M106 towards the Virgo cluster is included. The corresponding values relative to a Milky Way/M31 barycenter are 63.6±3.3 km/s/Mpc and 66.6±3.4 km/s/Mpc, respectively. Differences with respect to previously published values emphasize the importance of reddening corrections and Local Group dynamics in using Cepheids to establish the local rate of expansion of the Universe.

Author(s): ***David Turner (Saint Mary's Univ.)***

318.10 – Identifying a Damped Lyman Alpha Source in the Spectrum of Quasar SDSS J233544.18+150118.3

We present the nebular properties of a DLA along the line-of-sight of the quasar SDSS J233544.18+150118.3. We obtained two IFU spectra with UH 2.2m/SNIFS approximately 4 arcseconds south of the quasar. A careful analysis of the sky spectra surrounding the DLA then allowed us to generate a high SNR sky spectrum. Through a close examination of our reduced images, we have successfully identified a faint but distinct source of [OII] emission at the same redshift reported elsewhere for the damped Lyman-Alpha absorption lines in the quasar's spectrum. Further investigation also revealed the presence of lower intensity H-beta emission lines at the same redshift. Based on the relative intensities of the [OII] and H-beta lines in the spectrum of this relatively dim intervening galaxy, we present some initial conclusions regarding nebular abundance and star formation rate in this newly identified galaxy, and how its properties compare with a representative sample of galaxies at similar redshifts and luminosities.

Author(s): ***Benjamin Browning (Department of Physics and Astronomy, University of Hawaii at Hilo)***, Marianne Takamiya (Department of Physics and Astronomy, University of Hawaii at Hilo), Mark Chun (Institute for Astronomy, University of Hawaii at Manoa), Varsha Kulkarni (Department of Physics and Astronomy, University of South Carolina), Soheila Gharanfoli (Department of Physics and Astronomy, University of South Carolina)

318.11 – Environmental factors affecting Galaxy Morphology - a study using COSMOS

According to our current understanding, galaxy shapes and morphologies should depend on various factors such as the local environment. Realistic image simulations for calibration of weak lensing analysis methods that use training samples from the Hubble Space Telescope can therefore be affected by these trends, due to the limited volume of the universe that has been surveyed by Hubble. I will show how redshift slices in a volume-limited subsample of COSMOS can be classified as overdense or underdense (or neither), and how the statistical properties of various morphological parameters such as ellipticity, Sersic n, bulge-to-total ratio and color differ in these bins. This study requires a careful distinction between environment effects from large-scale structure, which we do not wish to include in simulations, and general trends in the galaxy population with redshift. We conclude with some guidance for how upcoming surveys can use COSMOS data as the basis for weak lensing simulations without having their conclusions overly affected by cosmic variance.

Author(s): ***Arun Jayaraman (Carnegie Mellon University)***, Rachel Mandelbaum (Carnegie Mellon University), Claire Lackner (Kavli Institute for the Physics and Mathematics of the Universe (WPI), Todai Institutes for Advanced Study, the University of Tokyo)

318.12 – Effects of Multiple Weak Deflections on the Galaxy-Galaxy Lensing Signal

Galaxy-galaxy lensing is a powerful tool with which the dark mass distribution around galaxies can be constrained directly. One potential complication to the interpretation of an observed galaxy-galaxy lensing signal, however, is the effect of multiple weak deflections. A number of previous studies have shown that for a typical deep data set, background source galaxies will have been lensed at a comparable level by two or more foreground galaxies. Contrary to naive expectations, these multiple weak deflections that are undergone by the images of the source galaxies do not generally cancel out, nor can they usually be ignored. Previous work as shown that at large angular scales the net shear experienced by distant source galaxies due to all foreground lenses generally exceeds the shear due to the single lens with the smallest impact parameter (the "closest lens"). When multiple deflections that have occurred in the observational data are not included in the interpretation of the observed shear profile, systematic errors in the constraints on the lens masses can occur. Here we explore the effects of multiple deflections on the galaxy-galaxy lensing signal using various toy models. We show that the main cause for the difference between the shear profile resulting from all foreground weak lenses and the shear profile resulting from the single closest weak lens is the fact that galaxies have a broad distribution in redshift space. That is, it is not correct to consider realistic galaxy-galaxy lensing as being confined primarily to a single lens plane in redshift space. We also explore the effect of multiple weak deflections on the surface mass density inferred for foreground lenses when the net mean tangential shear (i.e., the shear that results when all multiple weak deflections are taken into account) is used.

Author(s): ***Tereasa Brainerd (Boston Univ.)***, Kelly Blumenthal (Boston Univ.)

318.13 – Detectability of Radio Afterglows from Compact Binary Coalescence

Electromagnetic (EM) follow-up of gravitational wave (GW) candidates are both important and valuable for the verification of their astrophysical nature and the study of their physical properties. While the next generation of GW detectors will have improved sensitivities expected to make the first detection of GW events, their ability to localize these events on the sky will remain poor during the early phases of operation. This makes EM follow-up challenging for most telescopes. Many new low frequency radio telescopes have recently come online or will come online over the next few years, and their wide fields of view allow them to cover large areas of the sky in a short time. Here, we study the detectability of radio afterglows from compact binary coalescence, a predicted GW source and the most promising progenitor of short gamma-ray bursts (SGRB). We explore the properties of simulated SGRB afterglow lightcurves for a range of energies, densities, observing angles and frequencies, then we use these lightcurves to estimate the expected rates of detection for different low frequency radio instruments and survey methods. Most of these instruments will be able to detect SGRB afterglows or constrain the rates of compact binary coalescence.

Author(s): ***Lu Feng (MIT)***, Ruslan Vaulin (MIT), Jacqueline Hewitt (MIT)

319 – Surveys and Large Programs Posters

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

319.01 – The Blanco DECam Bulge Survey (BDBS): Current status and progress

We present a progress update on a large multi-epoch photometric survey we have undertaken with DECam towards the Southern Bulge of the Milky Way galaxy and also the Sgr dwarf spheroidal galaxy. Our survey has sufficient depth to reach below the main sequence turn-off in SDSS ugrizY filters for just over 200 square degrees over the Southern Bulge (i.e. (-10 < l < +10 and -13 < b < -2). While we easily detect the bulge main sequence turn-off in single image-pairs despite the high degree of crowding, initial analysis suggests we are also achieving sufficient astrometric repeatability to enable useful kinematic investigations through proper motions. This communication focuses on results and techniques from our campaign in 2013A (NOAO program N0529-2013A, P.I. Rich), which covers the inner 10x8 degrees of the bulge as well as a 4-degree wide strip along the Bulge minor axis down to b = -13 degrees. Our survey is thus already laying down the early epochs for future proper motion-enabled LSST studies of the galactic plane, and will provide hard data on the likely performance of LSST towards the Bulge - and thus how to optimize planned Galactic Plane science with LSST. The lessons of our campaign for existing and future large-telescope photometric surveys of the plane will be discussed.

Author(s): ***William Clarkson (University of Michigan-Dearborn)***, Robert Rich (University of California, Los Angeles), Christian Johnson (Harvard-Smithsonian Center for Astrophysics), Andrea Kunder (Astronomisches Institut Potsdam), Scott Michael (Indiana University, Bloomington), Michael Young (Indiana University, Bloomington), Catherine Pilachowski (Indiana University, Bloomington), Zachary Belanger (University of Michigan-Dearborn), Elizabeth Clyne (University of Michigan-Dearborn), Zeljko Ivezic (Astronomy Department, University of Washington), Rodrigo Ibata (Strasbourg Observatory), Michael Irwin (Institute of Astronomy), Roberto de Propris (Cerro Tololo Inter-American Obseratory), Andreas Koch (Zentrum fur Astronomie, University of Heidelberg), Annie Robin (Besancon Observatory), Mario Soto (Space Telescope Science Institute), Katherina Vivas (Centro de Investigaciones de Astrobnomia (CIDA))

319.02 – The Blanco DECam Bulge Survey (BDBS): Pushing to highly crowded fields with an LSST-like imager

We are using DECam to undertake a large, multi-cycle photometric survey of the Southern Milky Way Bulge and the core of the Sgr dwarf spheroidal galaxy, with sufficient depth to reach below the main sequence turn-off in SDSS ugrizY filters for just over 200 square degrees over the Southern Bulge (i.e. (-10 < l < +10 and -13 < b < -2). The high degree of crowding towards the Bulge puts our project in a different region of parameter-space to that of the main Dark Energy Survey (DES), and thus our reduction and analysis methods differ in some aspects from the main program (for example, in a number of our fields the DES community pipeline produced erroneous astrometric solutions, or failed to converge altogether). We present here our efforts and methods to push our photometry as deep as possible in these highly crowded fields, including estimates of measurement error and completeness. As LSST will also be seeing-limited, our faint limits are likely to be similar to those encountered by LSST galactic-plane observations.

Author(s): ***Zachary Belanger (University of Michigan-Dearborn)***, William Clarkson (University of Michigan-Dearborn), Robert Rich (UCLA), Christian Johnson (Harvard-Smithsonian Center for Astrophysics), Andrea Kunder (Astronomsche Institut Potsdam), Scott Michael (Indiana University, Bloomington), Michael Young (Indiana University, Bloomington), Catherine Pilachowski (Indiana University, Bloomington)

319.03 – SURVEYING BAADE'S WINDOW FOR POSSIBLE X-RAY COUNTERPARTS TO GRAVITATIONAL LENSING EVENTS AND OTHER OPTICAL VARIABLES

We present the first results from our Chandra HRC-I intermediate-depth survey of a ~1.5 square degree area in Baade's Window. Over the past ~20 years, this area of the sky has been extensively monitored by both the MOA and OGLE microlensing monitoring teams. It includes ~8500 stars in the OGLE-III variable star catalog and ~800 microlensing events. We will present a preliminary list of x-ray sources brighter than ~0.5-1E-14 erg/cm^2/s, and report on the current status of our search for optical counterparts from catalogs of both optical variables and lensing events.

Author(s): ***Francis Primini (Harvard-Smithsonian, CfA)***, Rosanne Di Stefano (Harvard-Smithsonian, CfA), Sebastien Lepine (Georgia State University), Ling Zhu (MPIA), Jifeng Liu (Eureka Scientific), Jochen Greiner (MPE), Takahiro Sumi (Osaka University), Andrzej Udalski (Warsaw University Observatory)

319.04 – Establishing a Network of Next Generation SED Standards with DA White Dwarfs

Photometric calibration systematic uncertainties are the dominant source of error in current type Ia supernova dark energy studies, as well as other forefront cosmology efforts, e.g. photo-redshift determinations for weak lensing mass tomography. Current and next-generation ground-based all-sky surveys require a network of calibration stars that 1) have known spectral energy distributions (SEDs) to properly and unambiguously account for differences in as-built filters, and 2) are on a common photometric zero-point scale. We exploit the well understood SEDs of DA white dwarf stars to establish a network of faint equatorial primary spectrophotometric standards. We present the measurements and analysis of 9 hot DA white dwarfs near 18th mag. The analysis of high S/N spectra from Gemini yields T_{eff} and log(g), which in turn delivers the model SEDs from their pure hydrogen atmospheres. These model SEDs are compared against pan-chromatic photometry from HST WFC3 imaging to determine their reddening, and to establish their absolute flux scales without hindrance from the terrestrial atmosphere. This network of stars will directly calibrate and cross-validate the data products of current and future surveys. This precision photometric heritage from HST will benefit existing and upcoming survey projects (such as DES, Pan-STARRS and LSST), and directly addresses one of the current barriers to understanding the nature of dark energy.

Author(s): ***Abhijit Saha (NOAO)***, Gautham Narayan (Harvard University), Thomas Matheson (NOAO), Jay Holberg (University of Arizona), Christopher Stubbs (Harvard University), Susana Deustua (STSci), Ralph Bohlin (STSci), Edward Olszewski (University of Arizona), Ronald Gilliland (STSci), Tim Axelrod (University of Arizona), Armin Rest (STSci)

319.05 – A deep X-ray view of the Small Magellanic Cloud

We present the first results from the Chandra Deep Survey of the Small Magellanic Cloud (SMC). This project aims to identify the nature of X-ray sources detected in the 1.1 Ms Chandra survey of the SMC, down to a detection threshold of a few times 10^32 erg/s, in 11 fields representing young (10-100 Myr) stellar populations of different ages. We will obtain the deepest X-ray luminosity functions (XLF) for X-ray binaries (XRBs) in a star-forming galaxy. The main scientific driver behind these observations is to study how accreting XRBs form and evolve. We will be able to provide observational constraints on their mass-transfer mechanisms and the physical properties of the different XRB types in the low-metallicity (Z~0.2Z?) environment of the SMC. We detect 50 to 90 X-ray sources in each field and measure the X-ray photometric and spectroscopic parameters for each of them. Analysis of their light-curves is used to identify accreting pulsars and flaring objects. The initial X-ray source lists have been cross-correlated with comprehensive optical and IR photometric and spectroscopic catalogs (such as OGLE and SAGE) to determine the most likely optical counterparts. Based on the combination of their X-ray and optical/IR properties, we identify candidate Be-XRBs and interlopers such as foreground stars and AGN. We study the population of high-mass XRBs, their clustering with star-forming regions and OB associations, and the long-term variability of identified sources based on a comparison with previous shallow surveys of the SMC by XMM-Newton and Chandra.

Author(s): ***Vallia Antoniou (Smithsonian Astrophysical Observatory)***, Andreas Zezas (Smithsonian Astrophysical Observatory), Jeremy Drake (Smithsonian Astrophysical Observatory), Paul Plucinsky (Smithsonian Astrophysical Observatory)

Contributing teams: SMC XVP Collaboration

319.06 – Legacy ExtraGalactic UV Survey (LEGUS): Revolutionary UV astronomy

The Treasury program LEGUS (HST/GO-13364) is a 154-orbit Hubble Space Telescope survey that is obtaining HST/WFC3 and HST/ACS NUV, U, B, V, and I-band imaging of 50 star-forming galaxies at distances of 4-12 Mpc. The LEGUS targets have been carefully selected to uniformly sample a full range of global galaxy properties such as morphology, star formation rate, mass, metallicity, internal structure, and interaction state. We provide a first taste of the type and quality of the data products that will be made available to the community through the website legus.stsci.edu. The data includes: state of the art science-ready mosaics in five wavelengths; band-merged catalogs of stellar sources (including location and photometry), band-merged catalogs of star clusters (locations, photometry, aperture corrections), catalogs of star cluster properties (ages, masses, extinction). and ancillary data available for this galaxy sample such as GALEX, Spitzer and WISE imaging. The above catalogs will enable a wide range of scientific applications, including color-magnitude diagrams and color-color diagrams of both stars and clusters, to derive star formation histories, cluster formation histories, the evolution of stars/association /cluster clustering, and the dependence of these on galactic environment. These are only a few of the potential applications enabled by a diverse sample like LEGUS.

Author(s): ***Leonardo Ubeda (Space Telescope Science Institute)***

Contributing teams: LEGUS

319.07 – First Results from the Spitzer Exploration Program Spitzer-CANDELS

In this contribution, we introduce the Spitzer-Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey (S-CANDELS), a Cycle 8 Spitzer Exploration program. S-CANDELS has recently completed a very deep survey of five premier extragalactic survey fields: COSMOS, the EGS, the UDS, HDF-N, and ECDFS. S-CANDELS benefits from coextensive imaging in multiple near-infrared bands by the Multi-Cycle HST Treasury Program CANDELS. The S-CANDELS observations reach to 27 AB mag in both bands of warm Spitzer's Infrared Array Camera (IRAC). Here we present the S-CANDELS survey strategy and parameters, and describe the deepest source counts ever measured at these wavelengths, surpassing the SEDS counts by a full magnitude. Finally, we touch upon the implications for source confusion for upcoming planned and proposed missions such as JWST and WISH.

Author(s): ***Matthew Ashby (SAO)***, Giovanni Fazio (SAO), Steven Willner (SAO)

Contributing teams: the S-CANDELS Team

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320 – Education and History Posters

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

320.01 – A Status Report on the AAS Astronomy Ambassadors Program

The American Astronomical Society, in partnership with the Astronomical Society of the Pacific (ASP), has launched a series of professional-development workshops and a community of practice designed to improve early-career astronomers' ability to communicate effectively with students and the public. Called AAS Astronomy Ambassadors, the program provides training and mentoring for young astronomers, from advanced undergraduates to beginning faculty; it also provides them access to resources and a network of contacts within the astronomy education and public outreach (EPO) community. Ambassadors are provided with a library of outreach activities and resource materials suitable for a range of venues and audiences. For much of this library we are using resources developed by organizations such as the ASP, the Pacific Science Center, and the Center for Astronomy Education for other outreach programs, though some resources have been created by one of us (AF) specifically for this program. After a period of evaluation and revision, the program's "Menu of Outreach Opportunities for Science Education" (MOOSE) is now posted on the AAS website at http://aas.org/outreach /moose-menu-outreach-opportunities-science-education. The first two Astronomy Ambassadors workshops were held at AAS meetings in January 2013 and January 2014; each served 30 young astronomers chosen from about twice that many applicants. Web-based follow-up activities are being provided through a website at the ASP designed to keep cohorts of educators trained in their programs in touch with one another. The AAS is exploring ways to fund additional workshops at future winter meetings; suggestions are most welcome. Meanwhile, the Astronomy Ambassadors trained to date have logged more than 150 outreach events, reaching many thousands of children and adults across the U.S. and Canada.

Author(s): ***Richard Fienberg (American Astronomical Society)***, Andrew Fraknoi (Foothill College), Suzanne Gurton (Astronomical Society of the Pacific), Anna Hurst (Astronomical Society of the Pacific), Dennis Schatz (Pacific Science Center)

320.02 – New FINESSE Faculty Institutes for NASA Earth and Space Science Education

In a systematic effort to improve the preparation of future science teachers, scholars coordinated by the CAPER Center for Astronomy & Physics Education Research are providing a series of high-quality, 2-day professional development workshops, with year-round follow-up support, for college and university professors who prepare future science teachers to work with highly diverse student populations. These workshops focus on reforming and revitalizing undergraduate science teaching methods courses and Earth and Space science content courses that future teachers most often take to reflect contemporary pedagogies and data-rich problem-based learning approaches steeped in authentic scientific inquiry, which consistently demonstrate effectiveness with diverse students. Participants themselves conduct science data-rich research projects during the institutes using highly regarded approaches to inquiry using proven models. In addition, the Institute allocates significant time to illustrating best practices for working with diverse students. Moreover, participants leave with a well-formulated action plan to reform their courses targeting future teachers to include more data-rich scientific inquiry lessons and to be better focused on improving science education for a wide diversity of students. Through these workshops faculty use a backwards faded scaffolding mechanism for working inquiry into a deeper understanding of science by using existing on-line data to develop and research astronomy, progressing from creating a valid and easily testable question, to simple data analysis, arriving at a conclusion, and finally presenting and supporting that conclusion in the classroom. An updated schedule is available at FINESSEProgram.org

Author(s): ***Timothy Slater (CAPER Center for Astronomy & Physics Education Research)***, Stephanie Slater (CAPER Center for Astronomy & Physics Education Research), Sunette Sophia Marshall (Toogalo College), Debra Stork (University of Wyoming), J. Richard Pomeroy (University of California - Davis)

320.03 – Interdisciplinary Professional Development: Astrolabes for Medievalists

Astronomers and astronomy educators have significantly broadened the intended audience for their outreach activities, from the traditional venues of public schools, libraries and planetariums to national parks, coffee houses, and concert halls. At the same time, significant attention has been paid to improving the quality and relevance of professional development directed toward preservice and inservice science teachers. Many of our outreach and professional development programs have also become increasingly creative in their use of interdisciplinary connections to astronomy, such as cultural astronomy and the history of astronomy. This poster describes a specific example of interdisciplinary professional development directed at a different audience, humanities faculty and researchers, through hands-on workshops on the basic astronomical background and usage of an astrolabe conducted at the International Congress on Medieval Studies at Western Michigan University in 2013 and 2014. The goal was to explain the basic astronomy behind astrolabes (as well as their cultural relevance) to medieval scholars in history, literature, and other disciplines. The intention was to increase their comfort with manipulating and explaining astrolabes to a basic level where they could share their knowledge with their own college classes. In this way the relevance of astronomy to myriad human endeavors could be reinforced by humanities faculty within their own courses.

Author(s): ***Kristine Larsen (Central Connecticut State University)***

320.04 – Boston University Pre-Majors Program (BU Pre-Map): Promoting Diversity through First-Year Undergraduate Research

One of largest points of attrition for underrepresented minorities in STEM fields is the transition from high school to college. A report from Building Engineering and Science Talent (BEST) demonstrates that underrepresented minorities begin college interested in STEM fields at rates equal to (if nor slightly above) their representation in both college and the population (25%). However, by the time they graduate, underrepresented minorities make up only 15% of STEM majors and only 9% of the STEM advanced degrees. Most of the attrition occurs during the first year of college, when large classes, a lack of mentors and challenging courses lead many students (from all backgrounds) to consider other majors. In 2011 I started the Boston University Pre-Majors Program (or BU Pre-MaP), which is modeled after the University of Washington Pre-Majors in Astronomy Program (UW Pre-MAP), a program for recruiting, mentoring and training underrepresented, first-year introductory astronomy students (and of which I was an architect). As a significant part of the Pre-MAP (or Pre-MaP) model, first-year students are engaged in a research project with a faculty or grad-student mentor and learn many of the skills needed to be successful in science. The BU Pre-MaP uses weekly seminars to introduce students to BU and the college environment, discuss ways to be successful in and out of the classroom, highlights the importance of peer mentoring and cohort building and serves as a mechanism to introduce first-year students to research skills. In teams of two, the Pre-MaP students select (with assistance) a research mentor and work with him/her on a original research project. In addition, Pre-MaP students attend several field trips including (but not limited to) viewing original science documents at the Boston Public Library (including a first edition Copernicus) and an observing run at Lowell Observatory in Arizona.

Author(s): ***Andrew West (Boston Univ.)***

320.05 – Harvard Observing Project (HOP): Undergraduate and graduate observing opportunities

The Harvard Observing Project (HOP) engages undergraduate students in observational astronomy and gives graduate students extra teaching experience beyond their required teaching fellowships. This project offers students opportunities to see if they are interested in astronomy, introduces them to scientific research, and provides an opportunity for them to interact with graduate students in an informal setting. Observations are made using the 16” Clay Telescope atop the Science Center at Harvard University in Cambridge, MA. We have observed as part of the Pro-Am White dwarf Monitoring (PAWM) and Target Asteroids! projects, and most recently we have been monitoring SN2014J in the Messier 82 galaxy (see poster by M. McIntosh).

Author(s): ***Allyson Bieryla (Harvard Univ.)***, Elisabeth Newton (Harvard Univ.)

320.06 – A Visual Galaxy Classification Interface and its Classroom Application

Galaxy morphology is an important topic in modern astronomy to understand questions concerning the evolution and formation of galaxies and their dark matter content. In order to engage students in exploring galaxy morphology, we developed a web-based, graphical interface that allows students to visually classify galaxy images according to various morphological types. The website is designed with HTML5, JavaScript, PHP, and a MySQL database. The classification interface provides hands-on research experience and training for students and interested clients, and allows them to contribute to studies of galaxy morphology. We present the first results of a pilot study and compare the visually classified types using our interface with that from automated classification routines.

Author(s): ***Stefan Kautsch (Nova Southeastern University)***, Chau Phung (Nova Southeastern University), Michael VanHilst (Nova Southeastern University), Victor Castro (Nova Southeastern University)

320.07 – Shaping and Shifting Worldviews: An Analysis of What Astro 101 Students Learned About the Role of Science in Society

A group of graduate and undergraduate students and researchers with the Center for Astronomy Education (CAE) have been analyzing general education introductory astronomy (Astro 101) students' written responses to questions that probe their ideas about the role and relevance of science in our society and in their lives. At the end of the semester, students were asked several questions to elicit their ideas about the positive and potential negative impacts that science has on our society's prosperity and their quality of life. Students were asked to provide examples and justifications for the most important discoveries in science, advancements in health and medicine and innovations in technology over the past century. Students were also asked to comment on which facet of the course (lecture, homework, in-class writings, Think-Pair-Share questions and/or Lecture-Tutorials) contributed to changing their understanding of their world and society.

Author(s): ***Samantha Becker (University of Arizona)***, Dalton Hirst (University of Arizona), Angelica Barron-Santella (University of Arizona), Edward Prather (University of Arizona), Benjamin Mendelsohn (West Valley College), Colin Wallace (University of Arizona)

320.08 – Initial Development and Pilot Study Design of Interactive Lecture Demonstrations for ASTRO 101

Interactive lecture demonstrations (ILDs) have repeatedly shown to be effective tools for improving student achievement in the context of learning physics. As a first step toward systematic development of interactive lecture demonstrations in ASTRO 101, the introductory astronomy survey course, a systematic review of education research, describing educational computer simulations (ECSs) reveals that initial development requires a targeted study of how ASTRO 101 students respond to ECSs in the non-science majoring undergraduate lecture setting. In this project we have adopted the process by which ILDs were designed, pilot-tested, and successfully implemented in the context of physics teaching (Sokoloff & Thornton, 1997; Sokoloff & Thornton, 2004). We have designed the initial pilot-test set of ASTRO 101 ILD instructional materials relying heavily on ECSs. Both an instructor's manual and a preliminary classroom-ready student workbook have been developed, and we are implementing a pilot study to explore their effectiveness in communicating scientific content, and the extent to which they might enhance students' knowledge of and perception about astronomy and science in general. The study design uses a pre-/post-test quasi-experimental study design measuring students' normalized gain scores, calculated as per Hake (1998) and Prather (2009), using a slightly modified version of S. Slater's (2011) Test Of Astronomy STandards TOAST combined with other instruments. The results of this initial study will guide the iterative development of ASTRO 101 ILDs that are intended to both be effective at enhancing student achievement and easy for instructors to successfully implement.

Author(s): ***Andria Schwortz (Quinsigamond Community College)***, D. French (University of Wyoming), Joseph Gutierrez (University of Wyoming), Richard Sanchez (University of Wyoming), Timothy Slater (University of Wyoming), Coty Tatge (University of Wyoming)

320.09 – Skype Me! Astronomers, Students, and Cutting-Edge Research

A primary goal of many university science courses is to promote understanding of the process of contemporary scientific inquiry. One powerful way to achieve this is for students to explore current research and then interact directly with the leading scientist, the feasibility of which has recently increased dramatically due to free online video communication tools. We report on a program implemented at Dartmouth College in which students connect with a guest astronomer through Skype (video chat). The Skype session is wrapped in a larger activity where students explore current research articles, interact with the astronomer, and then reflect on the experience. The in-class Skype discussions require a small time commitment from scientists (20-30 minutes, with little or no need for preparation) while providing students direct access to researchers at the cutting edge of modern astronomy. We outline the procedures used to implement these discussions, and present qualitative assessments of student's understanding of the process of research, as well as feedback from the guest astronomers.

Author(s): ***Ryan Hickox (Dartmouth College)***, Adrienne Gauthier (Dartmouth College)

320.10 – Essays in the Non-Science Major Astrobiology Course

The non-science major "Life in the Universe" class offers students many opportunities to explore topics such as whether or not to send manned missions to Mars, which jovian moon is a suitable candidate for harboring life, etc. Some of these topics are suited to being offered as projects. At Joliet Junior College, Joliet, IL, we offer this general education class every semester to around 40 students. We expect our students to complete three short essays in a semester, instead of doing one or two large projects. The essays enable students to be engaged more deeply with some aspects of the course than is usually possible in the classroom. Some of our essay topics are based on suggestions in the textbook, others have been developed by us. In this poster, we will report on the essay topics and the attitudes of our Fall 2013 and Spring 2014 students to such essays.

Author(s): ***Noella D'Cruz (Joliet Junior College)***

320.11 – Changing perceptions one classroom at a time: Evaluation results from the Solar Dynamics Observatory formal Education and Public Outreach programs

The Solar Dynamics Observatory's (SDO) education and public outreach (EPO) team has developed and implemented a number of formal education programs for K-12 students and teachers. Programs include the Day At Goddard field trip for high school students, SDO Ambassador in the Classroom outreach to elementary classrooms, and teacher support materials for solar science education. These programs have been designed to foster student interest and engagement in science especially solar science, and increase their awareness and interest in NASA and STEM careers. Magnolia Consulting, who worked closely with the SDO EPO team to both design a substantive evaluation program, as well as improve the education programs offered, has extensively evaluated these programs. Evaluation findings indicate that teachers highly value the opportunities and resources provided by SDO EPO and that student impacts include increased interest and engagement in solar science topics and awareness of STEM careers. This presentation will be a summary of the results of the evaluation of these formal education programs including lessons learned that can be of value to the STEM EPO community.

Author(s): ***Martha Wawro (NASA/GSFC)***, Carol Haden (Magnolia Consulting)

320.12 – Frontier Fields: Bringing the Distant Universe into View

The Frontier Fields is a multi-cycle program of six deep-field observations of strong-lensing galaxy clusters that will be taken in parallel with six deep "blank fields." The three-year long collaborative program centers on observations from NASA's Great Observatories, who will team up to look deeper into the universe than ever before, and potentially uncover galaxies that are as much as 100 times fainter than what the telescopes can typically see. Because of the unprecedented views of the universe that will be achieved, the Frontier Fields science program is ideal for informing audiences about scientific advances and topics in STEM. For example, the program provides an opportunity to look back on the history of deep field observations and how they changed (and continue to change) astronomy, while exploring the ways astronomers approach big science problems. As a result, the Space Telescope Science Institute's Office of Public Outreach has initiated an education and public outreach (E/PO) project to follow the progress of the Frontier Fields program – providing a behind-the-scenes perspective of this observing initiative. This poster will highlight the goals of the Frontier Fields E/PO project and the cost-effective approach being used to bring the program's results to both the public and educational audiences.

Author(s): ***Bonnie Eisenhamer (STScI)***, Brandon Lawton (STScI), Frank Summers (STScI), Holly Ryer (STScI)

320.13 – Elizabeth Brown and the Classification of Sunspots in the 19th Century

British amateur astronomers collected solar observation data as members of organizations such as the British Astronomical Association (BAA) and Liverpool Astronomical Society (LAS) in the late 1800s. Amateur astronomer Elizabeth Brown (1830-99) served as Solar Section Director of both groups, and not only aggregated solar observations (including hand-drawn illustrations) from observers from around the globe, but worked closely with solar astronomer Edward Maunder and other professionals in an attempt to garner specific types of observations from BAA members in order to answer a number of astronomical questions of the day. For example, she encouraged the monitoring of the growth and decay of sunspot groups and published a number of her own observations of particular groups, urging observers to note whether faculae were seen before the birth of sunspots in a given region, a topic of controversy at that time. She also developed a system for classifying sunspots and sunspot groups based on their appearance, dividing then into 11 types: normal, compound, pairs, clusters, trains, streams, zigzags, elliptical, vertical, nebulous, and dots. This poster will summarize Brown's important contributions to solar observing in the late 19th century and situate her classification scheme relative to those of A.L. Cortie (1901), M. Waldmeier (1938; 1947) and the modified Zurich system of McIntosh (1966; 1969; 1989).

Author(s): ***Kristine Larsen (Central Connecticut State University)***

321 – The Sun and The Solar System Posters

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

321.02 – Forward Modeling of Coronal Emission

In this work, we present simulations of the coronal emission in Extreme Ultraviolet wavelengths, subject to the possible physical models of how the solar corona is heated. In order to maximize the match of the simulations with the observations, we also use models of coronal magnetic field which are constructed to match the observed coronal features (see Malanushenko et al, 2014). While we utilize the 1D quasi-steady atmosphere approach (as in Schrijver & van Ballegoijen, 2005), we take a step away from the commonly used assumption about circular cross-sections of magnetic flux tubes, as our previous research (Malanushenko & Schrijver, 2013) suggests that this assumption might lead to substantial artefacts when comparing the simulations to the observations. In this work, we explore how such treatment of magnetic flux tubes is capable of producing realistic coronal features. Using these two major advances, the realistic field model and the realistic treatment of the cross-section of flux tubes, we test a wide range of possible heating scenarios, ruling out possibilities by comparing the simulations with data from a wide range of EUV channels onboard SDO/AIA spacecraft.

Author(s): ***Anna Malanushenko (Lockheed Martin Advanced Technology Center)***, Carolus Schrijver (Lockheed Martin Advanced Technology Center), Adriaan Van Ballegooijen (Harvard-Smithsonian Center for Astrophysics)

321.03 – Chandra Observations and Modeling of Geocoronal Charge Exchange X-Ray Emission During Solar Wind Gusts

Solar wind charge exchange (SWCX) X-rays are emitted when highly charged solar wind ions such as O7+ collide with neutral gas. The best known examples of this occur around comets, but SWCX emission also arises in the Earth's tenuous outer atmosphere and throughout the heliosphere as neutral H and He from the interstellar medium flows into the solar system. This geocoronal and heliospheric emission comprises much of the soft X-ray background and is seen in every X-ray observation. Geocoronal emission, although usually weaker than heliospheric emission, arises within a few tens of Earth radii and therefore responds much more quickly (on time scales of less than an hour) to changes in solar wind intensity than the widely distributed heliospheric emission. We have studied a dozen Chandra observations when the flux of solar wind protons and O7+ ions was at its highest. These gusts of wind cause correspondingly abrupt changes in geocoronal SWCX X-ray emission, which may or may not be apparent in Chandra data depending on a given observation's line of sight through the magnetosphere. We compare observed changes in the X-ray background with predictions from a fully 3D analysis of SWCX emission based on magnetospheric simulations using the BATS-R-US model.

Author(s): ***Marc Kornbleuth (Harvard-Smithsonian Center for Astrophysics)***, Bradford Wargelin (Harvard-Smithsonian Center for Astrophysics), Michael Juda (Harvard-Smithsonian Center for Astrophysics)

321.04 – Monitoring of Transient Lunar Phenomena

Transient Lunar Phenomena (TLP's) are described as short-lived changes in the brightness of areas on the face of the Moon. TLP research is characterized by the inability to substantiate, reproduce, and verify findings. Our current research includes the analysis of lunar images taken with two Santa Barbara Instrument Group (SBIG) ST8-E CCD cameras mounted on two 0.36m Celestron telescopes. On one telescope, we are using a sodium filter, and on the other an H-alpha filter, imaging approximately one-third of the lunar surface. We are focusing on two regions: Hyginus and Ina. Ina is of particular interest because it shows evidence of recent activity (Schultz, P., Staid, M., Pieters, C. Nature, Volume 444, Issue 7116, pp. 184-186, 2006). A total of over 50,000 images have been obtained over approximately 35 nights and visually analyzed to search for changes. As of March, 2014, no evidence of TLPs has been found. We are currently developing a Matlab program to do image analysis to detect TLPs that might not be apparent by visual inspection alone.

Author(s): ***Timothy Barker (Wheaton College)***, Ryan Farber (Wheaton College), Gary Ahrendts (Wheaton College)

321.05 – Hydrogen Abundance and Escape at Mars: Where we are Now and Where we are Going

The Space Telescope Imaging Spectrograph (STIS) instrument on board the Hubble Space Telescope (HST) has been used to make high resolution observations of Lyman-alpha hydrogen (H) and deuterium (D) emissions of Mars in April 2001 and April 2012. These data show the altitude profiles of emission across the martian disc, from which a radiative transfer model can be applied to derive densities and temperatures. D was also detected in the 2001 spectra. The Mars Atmosphere and Volatile Evolution (MAVEN) mission is on the way to orbiting Mars and will be making similar measurements of Lyman-alpha emissions from within the martian atmosphere. The more recent MAVEN measurements will be used in conjunction with HST observations to determine the hydrogen densities and temperatures, the H escape rate, and the D/H ratio at various epochs. Implications for the of the variability of planetary hydrogen properties on planetary water loss will be discussed.

Author(s): ***Majd Mayyasi-Matta (Boston University)***, John Clarke (Boston University)

321.06 – HST Observations of Mars and Venus Supra-thermal Thermospheric Oxygen

The loss of water from Venus and Mars is an ongoing topic of study in planetary astronomy. One method for considering this loss is to examine the loss of volatiles, specifically hydrogen and oxygen, from the thermospheres of the two planets. One process by which oxygen atoms escape the Mars atmosphere is by a creation of a suprathermal population of oxygen from the dissociative recombination of O2+, the dominant ion in the Mars and Venus ionospheres. On Venus, the same process occurs, but due to the larger planetary mass the suprathermal corona has not been observed as an escape mechanism by itself. Observations of hot oxygen in the Venus atmosphere date back as far as 1978 (Bertaux et al.), though observational confirmation of the hot population of Mars was only published as recently as 2011 (Feldman et al.) Re-analysis of the understanding of the Venus thermosphere has been performed after Venus Express results seemed to contrast to the Pioneer Venus observations (Lichtenegger et al., 2009). The observations presented in this work were taken of Mars using HST STIS and a low-resolution grating in 2007 and of Venus using HST STIS and an echelle grating in November 2013. The UV spectroscopic observations of resonantly-scattered sunlight from the 1304 Å oxygen emission are compared with modeled thermospheric populations.Comparisons are made with previous data sets and modeled populations, in order to better describe the temporal variation of the suprathermal neutral oxygen populations.

Author(s): ***Carol Carveth (Boston Univ.)***, John Clarke (Boston Univ.), Jean-Yves Chaufray (LATMOS - IPSL), Jean-Loup Bertaux (Boston Univ.)

321.07 – The Dynamics of Centaurs in the 2:1 Mean Motion Resonance of Neptune

8,026 massless test particles placed in or near the 2:1 mean motion resonance of Neptune are integrated for 3 Myrs subject only to the gravitational forces of a motionless Sun and the Jovian planets Jupiter, Saturn, Uranus, and Neptune. The RMVS method of integration is used. Initial inclinations and eccentricities of test particles are chosen from random from a range of 0 to 40 degrees for inclination and 0 to 0.7 for eccentricity. The time each test particle spends librating in the resonance is determined. The morphology of the semi-major axes of the test particles over time is observed. Statistics are taken on the amount of time test particles spend being classified as different small objects of the solar system such as SDOs, KBOs, Centaurs, short-period comets, main-belt asteroids and NEAs. Test particles are removed from the simulation by colliding with a planet, approaching too close to the Sun (~0.005 AU), obtaining a hyperbolic or parabolic orbit, or by entering the Oort Cloud at 1,000 AU. Common dynamical pathways that Centaurs take to the inner solar system are sought for. Finally, case studies of interesting test particles are examined.

Author(s): ***Jeremy Wood (Hazard Community and Technical College)***

Contributing teams: Center for Astrophysics and Computing at Melbourne, Australia

321.08 – Origin and mineralogy of olivine-dominated near-Earth Asteroids

Dynamical lifetimes of near-Earth asteroids (NEAs) are shorter than the age of the Solar System thus necessitating resupply from the Main Belt. The NEA population, because of its proximity, allows us to explore asteroids at a size-range not possible among asteroids further away in the Main Belt. There are very few olivine-dominated asteroids, identified as spectroscopic A-types (Bus & Binzel 2002, DeMeo et al. 2009), among the near-Earth population (Binzel et al. 2004). While a number of NEAs were labeled olivine-rich from visible wavelength data, near-infrared observations of these objects prove the olivine-rich population is exceedingly rare. We identify (1951) Lick, (5261) Eureka, and a new third A-type object, (5131) 1990 BG. Using a radiative transfer model (Shkuratov et al. 1999) and band parameter analysis we mineralogically characterize and compare these three olivine-rich A-type asteroids. Additionally, using the model from Bottke et al. 2002, we present main-belt source regions for these bodies. Finally, we compare these NEA A-types to the main belt A-type population.

Author(s): ***Brian Burt (Massachusetts Institute of Technology)***, Francesca DeMeo (Harvard-Smithsonian Center for Astrophysics), Richard Binzel (Massachusetts Institute of Technology)

321.09 – The distribution of mantle material among main-belt asteroids

We expect there to have been many bodies in the Main Asteroid Belt (MB) sufficiently heated at the time of solar system formation to allow their interiors to differentiate into an iron core and silicate-rich crust and mantle. Evidence for early solar system differentiation includes the diversity of iron meteorites that imply the existence of over 60 distinct parent bodies (Mittlefehldt et al. 2006). Searches have been performed to identify silicate-rich basaltic crust material (spectral V-type asteroids) in the outer MB have been successful (e.g., Roig et al. 2006, Masi et al. 2008, Moskovitz et al. 2008, Solontoi et al. 2012). The olivine-rich mantles of differentiated asteroids should have produced substantially greater volumes (and therefore substantially greater numbers) of remnant asteroids compared with basaltic and iron samples. Yet olivine-rich asteroids (A-types) are one of the rarest asteroid types (Bus & Binzel 2002, DeMeo et al. 2009). An alternative way to search for differentiated bodies that have been heavily or completely disrupted is to identify these spectral A-type asteroids, characterized by a very wide and deep 1 micron absorption indicative of large amounts (> 80%) of olivine. Burbine et al. (1996) proposed that these asteroids are only found among the largest because most were "battered to bits" due to collisions, so smaller A-types were below our detection limit. Using the Sloan Digital Sky Survey Moving Object Catalog to select A-type asteroid candidates, we have conducted a near-infrared spectral survey of asteroids over 12 nights in the near-infrared in an effort to determine the distribution and abundance of crustal and mantle material across the Main Asteroid Belt (MB). From three decades of asteroid spectral observations only ~10 A-type asteroids have been discovered. In our survey we have detected >20 A-type asteroids thus far throughout the belt, tripling the number of known A-types. We present these spectra and their distribution throughout the MB. We estimate the total mass of mantle material present in the belt today and discuss the implications.

Author(s): *Francesca DeMeo (Massachusetts Institute of Technology)*, Benoit Carry (Institut de Mecanique Celeste et de Calcul des Ephemerides), Richard Binzel (Massachusetts Institute of Technology), Nicholas Moskovitz (Lowell Observatory), David Polishook (Massachusetts Institute of Technology), Brian Burt (Massachusetts Institute of Technology)

321.10 – The Need for Speed: Characterizing Near Earth Asteroids

The current discovery rate of Near Earth Asteroids (NEAs) is set to increase dramatically in the next few years from ~900/year to 2,000-3,000/year thanks to new and upgraded surveys. Characterization of this population is crucial to science, space missions, and planetary hazard assessment. Despite this, the rate of followup observations is expected to remain the same, at ~100 spectra and a few dozen light curves collected per year. At this rate it would take up to a century to characterize just the NEA population with sizes above 100m. Herein we discuss the challenges of NEA followup observations, and we show quantitatively why these are optimally made within days of discovery. We describe how a semi-dedicated 4m-class telescope can keep better pace with projected discoveries and allow us to constrain NEA compositions, constructions, sizes, spins, and orbits.

Author(s): *Kim McLeod (Wellesley College)*, Jose Luis Galache (Smithsonian Astrophysical Observatory), Charlie Beeson (University of Southampton), Martin Elvis (Smithsonian Astrophysical Observatory)

321.11 – REgolith X-Ray Imaging Spectrometer (REXIS) Aboard NASA's OSIRIS-REx Mission

The REgolith X-Ray Imaging Spectrometer (REXIS) is a student-led instrument being designed, built, and operated as a collaborative effort involving MIT and Harvard. It is a part of NASA's OSIRIS-REx mission, which is scheduled for launch in September of 2016 for a rendezvous with, and collection of a sample from the surface of the primitive carbonaceous chondrite-like asteroid 101955 Bennu in 2019. REXIS will determine spatial variations in elemental composition of Bennu's surface through solar-induced X-ray fluorescence. REXIS consists of four X-ray CCDs in the detector plane and an X-ray mask. It is the first coded-aperture X-ray telescope in a planetary mission, which combines the benefit of high X-ray throughput of wide-field collimation with imaging capability of a coded-mask, enabling detection of elemental surface distributions at approximately 50-200 m scales. We present an overview of the REXIS instrument and the expected performance.

Author(s): *JaeSub Hong (Harvard Univ.)*, Branden Allen (Harvard Univ.), Jonathan Grindlay (Harvard Univ.), Richard Binzel (MIT), Rebecca Masterson (MIT), Niraj Inamdar (MIT), Mark Chodas (MIT), Matthew Smith (MIT), Mark Bautz (MIT), Steven Kissel (MIT), Jesus Noel Villasenor (MIT), Antonia Oprescu (Harvard Univ.)

322 – Stars and Stellar Populations Posters

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

322.01 – A Novel Tool for the Spectroscopic Inference of Fundamental Stellar Parameters

We present a novel approach for making accurate and unbiased inferences of fundamental stellar parameters (e.g., effective temperature, surface gravity, metallicity) from spectroscopic observations, with reference to a library of synthetic spectra. The forward-modeling formalism we have developed is generic (easily adaptable to data from any instrument or covering any wavelength range) and modular, in that it can incorporate external prior knowledge or additional data (e.g., broadband photometry) and account for instrumental and non-stellar effects on the spectrum (e.g., parametric treatments of extinction, spots, etc.). An approach that employs adaptive correlated noise is used to account for systematic discrepancies between the observations and the synthetic spectral library, ensuring that issues like uncertainties in atomic or molecular constants do not strongly bias the parameter inferences. In addition to extracting a set of unbiased inferences of the (posterior) probability distributions for basic stellar parameters, our modeling approach also "maps" out problematic spectral regions in the synthetic libraries that could be used as a basis for improving the models. As a demonstration, we present some preliminary results from modeling optical spectra of well-characterized exoplanet host stars and nearby pre-main sequence stars. A basic set of adaptable software that performs this modeling approach will be released publicly.

Author(s): ***Ian Czekala (Harvard Smithsonian Center for Astrophysics)***, Sean Andrews (Harvard Smithsonian Center for Astrophysics), David Latham (Harvard Smithsonian Center for Astrophysics), Guillermo Torres (Harvard Smithsonian Center for Astrophysics)

322.02 – Probing Stellar Populations in the Virgo and Fornax Clusters with Infrared Surface Brightness Fluctuations

Surface brightness fluctuations (SBF) are a useful tool for measuring extragalactic distances. At infrared wavelengths, SBF break the age-metallicity degeneracy and are useful for probing the properties of the most luminous stars in a galaxy, even when individual stars are not resolved. We present a detailed comparison of F110W and F160W SBF measurements made using the Hubble Space Telescope WFC3/IR camera to a variety of stellar population models, including those with solar-scaled and alpha-enhanced compositions and models incorporating convective core overshoot for younger populations. We use these model comparisons to assess the star formation histories of 16 galaxies spanning a wide range in color and luminosity in the Virgo and Fornax clusters, measured as a function of distance from the galaxy center in elliptical apertures. We discuss the implications of population variations on the fluctuation magnitudes and distance measurements.

Author(s): ***Joseph Jensen (Utah Valley University)***, Zachary Gibson (Utah Valley University), Hyun-chul Lee (The University of Texas Pan-American), John Blakeslee (Herzberg Astrophysics)

322.03 – Coronae at 3 Gyr: First Results from a Chandra Observation of the Open Cluster Ruprecht 147

Ruprecht 147 is the oldest nearby star cluster, with an age of 3 Gyr and a distance of 300 pc. This makes it an important benchmark in exploring activity-age-rotation relationships, bridging the gap between the Hyades and M67. We present the first results from a deep 250 ksec ACIS-I observation of the cluster. Analysis of the longest (81 ksec) pointing detects more than half of the known members in the field, with spectral types ranging from F6 to K5. The star most like the Sun in our sample, a G2V, has an X-ray luminosity (0.2-7 keV) of $L_X \sim 1.1e28$ ergs/s, which suggests a scaling with age t of $\log L_X \sim -b \log t$ where $1.25 < b < 4$, possibly steeper than seen at younger ages. This research was supported by Chandra grant G02-13022X.

Author(s): ***Steven Saar (Harvard-Smithsonian, CfA)***, Jason Curtis (Penn State), Jason Wright (Penn State)

322.04 – gPhoton: A Time-Tagged Database of Every GALEX Photon and Early Science Results

The Galaxy Evolution Explorer (GALEX) mission observed a large fraction of the sky in FUV and NUV at time resolutions of five thousandths of a second, spanning a decade of operation. Due to technical limitations when the data were first archived, the ability to use GALEX data at such high time resolutions was limited: the primary data products were images that were combined into several-minute integrations, along with source catalogs. MAST is pleased to introduce gPhoton, a time-tagged database of every photon event detected by GALEX during its lifetime; some 1.5 trillion events in total. This database is accompanied by both a python-based software package and a web interface. These tools allow users to create calibrated lightcurves, intensity maps, and animated movies from any set of photons selected across any tile. Users can specify custom apertures sizes, coordinates, and time steps down to the level of seconds. We present some early science cases with gPhoton, which include studies of flare stars, Be stars, and unique opportunities with objects in the Kepler field.

Author(s): ***Scott Fleming (Space Telescope Science Institute)***, Chase Million (Million Concepts, Inc), Bernie Shiao (Space Telescope Science Institute), Randy Thompson (Space Telescope Science Institute), Shui-Ay Tseng (Space Telescope Science Institute), Anthony Rogers (Space Telescope Science Institute), Myron Smith (NOAO), Richard White (Space Telescope Science Institute), Karen Levay (Space Telescope Science Institute)

322.06 – Identifying Solar Analogs in the Kepler Field

Since human beings live on a planet orbiting a G2 V star, to us perhaps the most intrinsically interesting category of stars about which planets have been discovered is solar analogs. While Kepler has observed more than 26000 targets which have effective temperatures within 100K of the Sun, many of these are not true solar analogs due to activity, surface gravity, metallicity, or other considerations. Here we combine ground-based measurements of effective temperature and metallicity with data on rotational periods and surface gravities derived from 16 quarters of Kepler observations to produce a near-complete sample of solar analogs in the Kepler field. We then compare the statistical distribution of stellar physical parameters, including activity level, for subsets of solar analogs consisting of KOIs and those with no detected exoplanets. Finally, we produce a list of potential solar twins in the Kepler field.

Author(s): ***Derek Buzasi (Florida Gulf Coast University)***, Andrew Lezcano (Florida Gulf Coast University), Heather Preston (Florida Gulf Coast University)

322.07 – Characterization of Small Exoplanet Solar-like Host Stars in the Kepler Field

This poster will discuss the stellar characteristics of over 200 Kepler exoplanet host stars. The sample contains stars of V magnitude 11 to 16, spans F2 to K3 dwarfs and subgiants, and ranges in metallicity -0.25<[Fe/H]<+0.3. These stars are solar-like in mass and radius and each harbors at least one exoplanet of radius <2.6 R_Earth. We determine the distances to the stars and find that most lie within the thin disk of the Galaxy. Using Kepler light curves of the sample, we examine their variability on ``transit" time scales (6-12 hr) and conclude that, to date, there is a strong bias whereby Kepler discovered small planets are only found orbiting the photometrically quietest stars. Additionally, we show that there appears ot be no relationship between the quietest stars and their spectral type or luminosity class and subgiants showing RV jitter can be photometrically quiet.

Author(s): ***Steve Howell (NASA ARC)***, Mark Everett (NOAO), David Ciardi (NASA Exoplanet Inst), David Silva (NOAO), Paula Szkody (University of Washington)

322.08 – SOLAR ANALOGS AND TWINS SHED A NEW LIGHT ON THE RELATION BETWEEN ROTATION PERIODS AND CYCLE LENGTHS OF STELLAR ACTIVITY

The question of how typical the Sun is within the class of solar-type stars has been the subject of active investigation over the past three decades. Some previous work has suggested that the Sun's magnetic cycle period Pcyc is unusual compared with similar stars, falling between sequences of active and inactive stars. The HARPS planet-search has been gathering high-precision Ca II H&K chromospheric activity measurements for about 7 years, and has measured a large number of new Pcyc. We collect the most robust cycles among these for stars which are solar analogs (main-sequence stars with 0.8 Msun < mass < 1.2 Msun) or solar twins twins (stars with Teff, [Fe/H] and mass indistinguishable from the Sun). Combining this new sample with older data, we revisit the relation between rotation periods Prot and Pcyc. Our preliminary analysis shows that the Sun does not has a special position between the active and inactive sequences, but instead follows the a new solar-analog sequence proposed here.

Author(s): ***José-Dias Do Nascimento (Universidade Federal do Rio Grande do Norte, UFRN, Dep. de Fisica Teorica e Experimental, DFTE)***, Steven Saar (Harvard-Smithsonian Center for Astrophysics), Francys Anthony (Harvard-Smithsonian Center for Astrophysics)

322.10 – *WISE* Infrared Excess Detections for SDSS M Dwarfs: Cool Field Stars with Evidence of Warm Circumstellar Material

We investigate the mid-infrared properties of low-mass field dwarfs, combining M dwarfs from the SDSS DR7 spectroscopic and DR10 photometric catalogs with photometry from the AllWISE source catalog. For the spectroscopic sample, we developed SDSS and *WISE* color-color selection criteria to select 300 M dwarfs (from the 70,841 in the DR7 catalog) that exhibit infrared flux above typical M dwarf photosphere levels at 12 and/or 22 ?m. We also find 30 stars within the footprint of the Orion OB1 association that have not been previously identified. Using synthetic photometry, we characterize the dust populations inferred from each infrared excess, and find high fractional infrared luminosities (~10^{-2} $L_?$) and orbital distances within the snow line (< 1 AU). Using the SDSS spectra, we measure surface gravity dependent features, and examine tracers of youth (H?, UV emission, and Li absorption). Less than 3% of our sample shows a reliable indication of youth, implying a stellar population with ages > 1 Gyr. Our results imply that, due to the orbital distances of our inferred dust populations and the penchant for low-mass stars to create terrestrial planets, the most likely cause of dust in these systems is planetary collisions. A similar result has been used to explain the dust population observed around the older field star BD+20 307 (? 1 Gyr; Weinberger et al. 2011). We also present preliminary results using the DR10 photometric M dwarf sample. This sample, consisting of millions of M dwarfs, allows us to examine the phenomena of field M dwarfs exhibiting infrared excesses in a Galactic context.

Author(s): ***Christopher Theissen (Boston University)***, Andrew West (Boston University)

322.11 – M Dwarf Stellar Activity as Noise in Exoplanet Detection

A habitable-zone (HZ) planet orbiting a 0.5 solar mass M dwarf would have a ~3 times higher likelihood of transiting, ~4 times the transit depth, and a Doppler shift 3 to 4 times stronger than the same planet orbiting in the Sun's HZ. These factors, combined with the abundance of M dwarfs in the galaxy—up to ~70% of stars—make M dwarfs ideal targets in the search for nearby, habitable planets. However, the high levels of magnetic activity exhibited by many M dwarf stars, and the resulting noise introduced into observations, could thwart this effort. Specifically, dark spots on the stellar surface—one manifestation of stellar activity—result in radial velocity (RV) "jitter", which can mimic or drown out planetary signatures. In this study, we have investigated the effects of activity-induced RV jitter on planetary system parameters derived from RV fitting. We modeled the RV jitter using realistic spot models, improving on previous jitter studies by including active latitude and longitude ranges, evidence of which has been seen in observations of spot distributions on low-mass stars. We add a planetary RV curve to the jitter data and then use an MCMC algorithm to fit RV variations and derive planetary system parameters. We quantify the error introduced to the derived parameters as a result of the RV jitter, focusing on planetary period, eccentricity, and semi-major axis of orbit. We find that, on average, the measured period of the planet is not significantly affected for filling factors of up to ~10%, although higher filling factors result in derived periods that deviate significantly from the input period of the model. We show that with a zero-eccentricity model, the measured eccentricities are all non-zero and increase with increasing spot filling-factor. Using the Kopparapu (2013) Habitable Zone estimates, we show that at high filling factors for an M dwarf with a planet in the habitable zone, it is possible for the derived planetary orbits to scatter outside of the HZ. Our results demonstrate that stellar RV jitter can contribute an important source of noise to planetary measurements that must be accounted for both when searching for and characterizing potentially habitable planets around active stars.

Author(s): ***Jan Marie Andersen (University of Copenhagen)***, Heidi Korhonen (University of Turku)

322.12 – Examining Flare Rates in Close M Dwarf + White Dwarf Binary Pairs

We present a preliminary study to examine the statistical flare rates for M dwarfs with a close white dwarf companion (WD+dM; typical separations < 1 AU). Previous studies show a strong correlation between M dwarfs that are active (showing H? in emission) and their stellar flare rates. Our previous analysis of M dwarfs with close WD companions demonstrated that the M dwarfs are more active than their field counterparts. One implication of having a close binary companion is presumed to be increased stellar rotation through disk-disruption, tidal effects, and/or angular momentum exchange; increased stellar rotation has long been attributed to an increase in stellar activity for stars. We examine the difference between the flare rates observed in close WD+dM binary systems and field M dwarfs. Our sample consists of a subset of 202 (70 of which are magnetically active) close WD+dM pairs from Morgan et al. that were observed in the Sloan Digital Sky Survey Stripe 82, a transient observing mode where multi-epoch observations in the Sloan ugriz bands were obtained.

Author(s): ***Dylan Morgan (Boston Univ.)***, Andrew West (Boston Univ.)

322.13 – Brown Dwarfs, Dusty Photospheres, and Surface Gravity

We present new spectroscopic, photometric, and astrometric measurements of two nearby unusually dusty brown dwarfs. We show that the dusty photosphere in WISE 0047+68 is due to intermediate surface gravity (between most field brown dwarfs and planets) and not caused by high metallicity. We determine the luminosity and show that it implies an effective temperature of ~1300K, normally typical of T dwarfs. On the other hand, we confirm that other red L dwarfs do not have low surface gravity.

Author(s): ***John Gizis (Univ. Of Delaware)***, Katelyn Allers (Bucknell), Michael Liu (Carnegie), Jacqueline Faherty (Hawaii), Adam Burgasser (UC San Diego), Hugh Harris (USNO)

322.14 – A Sample of Fast Moving M Dwarfs in the Milky Way

In the past decade, several high-mass stars have been discovered to have high enough velocities to escape the Milky Way (dubbed hypervelocity stars), yet until recently, stars with similar velocities were not observed for Solar- and lower-mass stars. There has been an observational paucity of hypervelocity M dwarfs, which account for ~70% of the stars in the Milky Way. While some of the shortage of low-mass, high-velocity stars may be due to the specific mechanisms accelerating these stars, it is also possible that the M dwarfs have been overlooked due to their faint luminosities. We present results from a study that uses the Sloan Digital Sky Survey (SDSS) Data Release 7 (DR7) M Dwarf Spectroscopic Catalog (70,841 M dwarfs) to identify and characterize several hundred M dwarfs with velocities greater than 400 km/s relative to the Galactic center. Our study marks the first step in demonstrating that there is a significant sample of low-mass, high-velocity stars. We examined the 3D kinematics of M dwarfs in the SDSS DR7 catalog with velocities > 400 km/s relative to the Galactic center. Stars with poor photometry or a SNR (near H-alpha) < 3 were excluded, as well as stars that were flagged in the original data set as being possible M dwarf-white dwarf binaries. We confirmed the radial velocities reported by West et al. (2011) by manually examining the remaining stars, specifically the locations of the sodium absorption lines (two at 5891/5897 Å, and two at 8185/8197 Å). We present the final catalog of high velocity candidates and a preliminary analysis of their spectroscopically derived properties, including 3D kinematics, magnetic activity and metallicity distributions.

Author(s): ***Andrej Favia (University of Maine)***, Andrew West (Boston University)

322.15 – A New Sample of Cool Subdwarfs from SDSS: Properties and Kinematics

We present a new sample of M subdwarfs compiled from the 7th data re- lease of the Sloan Digital Sky Survey. With 3517 new subdwarfs, this new sample significantly increases the number the existing sample of low-mass subdwarfs. This catalog includes unprecedentedly large numbers of extreme and ultra sudwarfs. Here, we present the catalog and the statistical analysis we perform. Subdwarf template spectra are derived. We show color-color and reduced proper motion diagrams of the three metallicity classes, which are shown to separate from the disk dwarf population. The extreme and ultra subdwarfs are seen at larger values of reduced proper motion as expected for more dynamically heated populations. We determine 3D kinematics for all of the stars with proper motions. The color-magnitude diagrams show a clear separation of the three metallicity classes with the ultra and extreme subdwarfs being significantly closer to the main sequence than the ordinary subdwarfs. All subdwarfs lie below and to the blue of the main sequence. Based on the average (U, V, W) velocities and their dispersions, the extreme and ultra subdwarfs likely belong to the Galactic halo, while the ordinary subdwarfs are likely part of the old Galactic (or thick) disk. An extensive activity analy- sis of subdwarfs is performed using chromospheric H? emission and 208 active subdwarfs are found. We show that while the activity fraction of subdwarfs rises with spectral class and levels off at the latest spectral classes, consistent with the behavior of M dwarfs, the extreme and ultra subdwarfs are basically flat.

Author(s): ***Antonia Savcheva (Harvard-Smithsonian Center for Astrophysics)***, Andrew West (Boston University), John Bochanski (Haverford college)

322.16 – Period04 FCAPT uvby Photometric Studies of Eight Magnetic CP Stars

We present Four College Automated Photometric Telescope (FCAPT) differential Stromgren uvby photometry of 8 magnetic CP (mCP) stars: HD 5797 (V551 Cas), HD 26792 (DH Cam), HD 27309 (56 Tau, V724 Tau), HD 49713 (V740 Mon), HD 74521 (49 Cnc, BI Cnc), HD 120198 (84 UMa, CR UMa), HD 171263 (QU Ser), and HD 215441 (GL Lac, Babcock's star). Our data sets are larger than those of most mCP stars in the literature. These are the first FCAPT observations of HD 5797, HD 26792, HD 49713, and HD 171263. Those for the remaining four stars substantially extend published FCAPT data. The FCAPT observed some stars for a longer time range and with greater accuracy than other optical region automated photometric telescopes. Our goals were to determine very accurate periods, the u, v, b, and y amplitudes, and if there were any long period periods. In addition we wanted to compare our results with those of magnetic field measurements to help interpret the light curves. We used the Period04 computer program to analyze the light curves. This program provides errors for the derived quantities as it fits the light curve. Our derived periods of 68.046 +/- 0.008 days for HD 5797, 3.80205 +/- 0.00006 days for HD 26792, 1.56889 +/- 0.000002 days for HD 27309, 2.13536 +/- 0.00002 days for HD 49713, 7.0505 +/- 0.0001 days for HD 74521, 1.38577 +/- 0.000004 days for HD 120198, 3.9974 +/- 0.0001days for HD 171263, and 9.487792 +/- 0.00005 days for HD 215441 are refinements of the best determinations in the literature.

Author(s): ***Saul Adelman (The Citadel)***, Robert Dukes (College of Charleston)

322.17 – Clues to the Evolution of the R Coronae Borealis Stars from their Unique 16O/18O ratios

We report new spectroscopic observations of the CO bands near 2.3 micron in order to measure the 16O/18O isotopic ratio in the R Coronae Borealis (RCB) stars using IRTF/SpeX. These observations of ten additional stars confirm the remarkable discovery made a few years ago that the hydrogen-deficient carbon (HdC) and RCB stars have 16O/18O ratios that are close to and in some cases less than unity, values that are orders of magnitude smaller than measured in other stars (the Solar value is 500). The RCB stars are a small group of carbon-rich supergiants. Only about 100 RCB stars are known in the Galaxy. Their defining characteristics are hydrogen deficiency and unusual variability - RCB stars undergo massive declines of up to 8 mag due to the formation of carbon dust at irregular intervals. The six known HdC stars are very similar to the RCB stars spectroscopically, but do not show declines or IR excesses. Two scenarios have been proposed for the origin of an RCB star: the double degenerate and the final helium-shell flash models. The former involves the merger of a CO- and a He-white dwarf. In the latter, a star evolving into a planetary nebula central star expands to supergiant size by a final, helium-shell flash. Greatly enhanced 18O is evident in every HdC and RCB we have measured that is cool enough to have detectable CO bands. This discovery is important evidence to help distinguish between the proposed evolutionary pathways of HdC and RCB stars. No overproduction of 18O is expected in a final flash, so we are investigating the merger scenario. We are working to reproduce the observed 16O/18O ratios by performing hydrodynamical simulations of the merger of CO- and He-WDs to investigate the formation of RCB stars. We are also using the MESA stellar evolution and NuGrid nucleosynthesis codes to construct post-merger 1D spherical models and follow their evolution into the region of the HR diagram where RCB stars are located.

Author(s): ***Geoffrey Clayton (Louisiana State University)***, Edward Montiel (Louisiana State University), Thomas Geballe (Gemini Observatory), Douglas Welch (McMaster University), Patrick Tisserand (Institut d'Astrophysique de Paris)

322.18 – Monitoring H-alpha Emission in Be Stars of NGC 659 and NGC 663

Over the past nine years we have developed a calibrated H-alpha index based on spectrophotometric data from the Dominion Astrophysical Observatory 1.2-m telescope. We have also manufactured a set of filters to photometrically match our spectrophotometric band-passes. This filter set is employed at the BYU West Mountain Observatory 0.9-m telescope. As one of our first applications of these new filters we examined stars in the young open clusters NGC 659 and NGC 663. We were primarily interested in the Be stars and High Mass X-ray binaries in the field. From July 2013 to January 2104 we observed both fields on 17 nights. We will present our preliminary results from this data set.

Author(s): ***Eric Hintz (Brigham Young Univ.)***, Michael Joner (Brigham Young Univ.)

322.19 – Sizing Up Red Giants Using Bayes' Rule

Using the general-purpose stellar atmosphere code PHOENIX, we have constructed a grid of spherical stellar atmosphere models for comparison to cool giant star spectral energy distributions(SEDs). The models are not only parametrized by effective temperature (3500 K to 3700 K) and surface gravity (log(g) = -0.5 to 1.0), but also by mass (7 Msun to 21 Msun), a required parameter for spherical model atmospheres. The shapes of the synthetic spectral energy distributions are sensitive to a change in mass at fixed values for the effective temperature and surface gravity. At our lowest surface gravity, differences in mass of a factor of two can yield up to 20% flux differences in the shape of the SED between 400 nm and 900 nm.Also, for a fixed mass, differences in the surface gravity of a factor of 10 can yield up to 100% flux differences in the shape of the SED below 450 nm. We are investigating whether the mass-dependence of the model SED shape may be used to constrain single star masses. One of our target stars is the supergiant Betelgeuse which has a poorly constrained mass: published estimates differ by a factor of two. To aid in our analysis, we have developed a method to extract Bayesian posterior distributions for four model parameters (effective temperature, surface gravity, mass, and angular size) from the comparison of the synthetic SED grid to individual observed SEDs of red giants.

Author(s): ***Jason Aufdenberg (Embry-Riddle Aeronautical Univ.)***, Tyler Parsotan (Embry-Riddle Aeronautical Univ.)

322.20 – The Complex Velocity Structure of the Chromosphere of VV Cephei

The eclipsing binary system VV Cephei consists of an M2 Iab supergiant primary and a hotter, probably B-type main-sequence companion. The last eclipse was observed with the HST-STIS spectrograph at 21 epochs ranging from mid-totality through first quadrature. These observations sampled seven lines of sight through the entire, extended chromosphere of the M supergiant star, beginning shortly after the hot companion emerged from total eclipse. At all seven of these egress epochs, the observed chromospheric absorption line profiles had a typical FWHM of 25-30 km/s. These profiles contained multiple (usually two) components that persisted throughout the chromosphere. The relative strengths of the two components were observed to depend on the ionization level and excitation potential, with the longer-wavelength (red) component tending to be stronger than the shorter-wavelength (blue) component in the higher-ionization and higher-excitation lines, while the strengths of the two components were more similar in lower-excitation features. This behavior suggests the red components form in hotter gas than the blue components. The great width of these chromospheric lines has been attributed both to intrinsic chromospheric turbulence and absorption due to the accelerating stellar wind. Here we present evidence that the complex absorption line profiles observed in the extended chromosphere of VV Cep reflect an intrinsic, coherent, multi-temperature component, azimuthal velocity structure present over the entire height of the M supergiant chromosphere, which is about a stellar radius in extent. This velocity model is inferred from the behavior of weak ultraviolet lines of species including Al I, Ti I, Fe I, Co I, Ni I, and Zr II. We present observations, analysis of the line profile velocity structure, and discuss the implications for driving the stellar wind and associated mass loss.

Author(s): ***Wendy Bauer (Wellesley College)***, Philip Bennett (Saint Mary's University)

322.21 – A New Millimeter Look at the HD 15115 Debris Disk

We have used the Submillimeter Array (SMA) to make 1.3 millimeter observations of the debris disk surrounding HD 15115, an F-type star located in the 12 Myr-old beta Pictoris moving group. This nearly edge-on debris disk (the "Blue Needle") has been previously well-resolved in optical scattered light and displays an extreme asymmetry. Unlike scattered light that reflects tiny grains that are blown out by stellar radiation and swept by the interstellar medium, the thermal emission from large grains that dominate at millimeter wavelengths closely traces the locations of the dust-producing parent planetesimals. The SMA observations reveal a circumstellar belt of dust emission. We characterize the millimeter emission using Markov Chain Monte Carlo methods to fit parametric models directly to the visibilities and place limits on departures from axisymmetry.

Author(s): ***Meredith MacGregor (Harvard-Smithsonian Center for Astrophysics)***, David Wilner (Harvard-Smithsonian Center for Astrophysics), Sean Andrews (Harvard-Smithsonian Center for Astrophysics), A. Hughes (Wesleyan University)

322.22 – Resolved Multifrequency Radio Observations of GG Tau

We present sub-arcsecond resolution observations of continuum emission associated with the GG Tau quadruple star system at wavelengths of 1.3, 2.8, 7.3, and 50 mm. These data confirm that the GG Tau A binary is encircled by a narrow (FWHM of 60 AU) circumbinary ring centered at a radius of 235 AU. We find no evidence for a radial gradient in the ring spectrum, suggesting that the particle size distribution is spatially homogeneous. A central point source, likely associated with the primary component (GG Tau Aa), exhibits a composite spectrum from dust and free-free emission. Faint emission at 7.3 mm is observed toward the low-mass star GG Tau Ba, although its origin remains uncertain. Using these measurements of the resolved, multifrequency emission structure of the GG Tau A system, models of the far-infrared to radio spectrum are developed to place constraints on the grain size distribution and dust mass in the circumbinary ring. The non-negligible curvature present in the ring spectrum implies a maximum particle size of 1-10 mm, although we are unable to place strong constraints on the distribution shape. The corresponding dust mass is 30-300 earth masses, at a temperature of 20--30 K. We show how this significant concentration of relatively large particles in a narrow ring at a large radius might be produced in a local region of higher gas pressures (i.e., a particle "trap") located near the inner edge of the circumbinary disk.

Author(s): ***Sean Andrews (Harvard-Smithsonian Center for Astrophysics)***, Claire Chandler (National Radio Astronomy Observatory), Andrea Isella (California Institute of Technology), Tilman Birnstiel (Harvard-Smithsonian Center for Astrophysics), Katharine Rosenfeld (Harvard-Smithsonian Center for Astrophysics), David Wilner (Harvard-Smithsonian Center for Astrophysics), Laura Perez (National Radio Astronomy Observatory), Luca Ricci (California Institute of Technology), John Carpenter (California Institute of Technology)

Contributing teams: Disks@EVLA

322.23 – Growth and Transport of Dust: Constraints from Circumstellar Disks and the Solar System

I present how dust grains in protoplanetary disks form larger bodies and how the combined effects of dust growth, shattering, and global transport of dust aggregates shape the observational signatures of protoplanetary disks. I will show how observations of protoplanetary disks are able to constrain these early stages of planet formation and how our results can be linked to properties of our own solar system.

Author(s): ***Tilman Birnstiel (Harvard-Smithsonian Center for Astrophysics)***

323 – SPD Posters 3

Poster Session – Essex Ballroom and America Foyer – 04 Jun 2014 09:00 AM to 06:30 PM

323.01 – High Resolution Observations of Chromospheric Jets in Sunspot Umbra

Recent observations of sunspot's umbra suggested that it may be finely structured at a sub-arcsecond scale representing a mix of hot and cool plasma elements. In this study we report the first detailed observations of the umbral spikes, which are cool jet-like structures seen in the chromosphere of an umbra. The spikes are cone-shaped features with a typical height of 0.5-1.0~Mm and a width of about 0.1~Mm. Their life time ranges from 2 to 3 ~min and they tend to re-appear at the same location. The preliminary analysis indicates that the spikes are not associated with photospheric umbral dots and they rather tend to occur above darkest parts of the umbra, where magnetic fields are strongest. The spikes exhibit up and down oscillatory motions and their spectral evolution suggests that they might be driven by upward propagating shocks generated by photospheric oscillations. It is worth noting that triggering of the running penumbral waves seems to occur during the interval when the spikes reach their maximum height.

Author(s): ***Vasyl Yurchyshyn (Big Bear Solar Obs.)***, Valentyna Abramenko (Big Bear Solar Obs.), Alexander Kosovichev (Big Bear Solar Obs.), Philip Goode (Big Bear Solar Obs.)

323.02 – Realistic Modeling of Spontaneous Flow Eruptions in the Quiet Sun

Ground and space observations reveal that the solar surface is covered by high-speed jets transporting mass and energy into the solar corona and feeding the solar wind. The origin and driving forces of the observed eruptions are still unknown. Using realistic numerical simulations we find that small-scale plasma eruptions can be produced by ubiquitous magnetized vortex tubes generated in the Sun's turbulent convection. The vortex tubes (resembling tornadoes) penetrate into the solar atmosphere, capture and strengthen the background magnetic field, and push surrounding material up, generating impulses of Alfven waves and shocks. Our simulations reveal complicated high-speed flows, thermodynamic, and magnetic structures in the erupting vortex tubes. We find that the eruptions are initiated in the subsurface layers, and initially are driven by high-pressure gradients in the subphotosphere and photosphere, and are accelerated by the Lorentz force in the higher atmospheric layers. The eruptions are often quasi-periodic with a characteristic period of 2-5 min. These vortex eruptions have a complicated flow helical pattern, with predominantly downward flows in the vortex tube cores and upward flows in their surroundings. For comparison with observations we calculate full Stokes profiles in different wavelength for different space and ground instruments, such as HMI/SDO, Hinode, NST/BBSO, IMaX/Sunrise. In particular, we find that the observed eruption events are not always associated with strong magnetic field concentrations, and that strong field patches can be a source of several simultaneous eruptions.

Author(s): ***Irina Kitiashvili (Stanford University)***, Seokkwan Yoon (NASA Ames Research Center)

323.03 – Theory of Collisional Two-Stream Plasma Instabilities in the Solar Chromosphere

The solar chromosphere experiences intense heating just above its temperature minimum. The heating increases the electron temperature in this region by over 2000 K. Furthermore, it exhibits little time variation and appears widespread across the solar disk. Although semi-empirical models, UV continuum observations, and line emission measurements confirm the existence of the heating, its source remains unexplained. Potential heating sources such as acoustic shocks, resistive dissipation, and magnetic reconnection via nanoflares fail to account for the intensity, persistence, and ubiquity of the heating. Fontenla (2005) suggested turbulence from a collisional two-stream plasma instability known as the Farley-Buneman instability (FBI) could contribute significantly to the heating. This instability is known to heat the plasma of the E-region ionosphere which bears many similarities to the chromospheric plasma. However, the ionospheric theory of the FBI does not account for the diverse ion species found in the solar chromosphere. This work develops a new collisional, two-stream instability theory appropriate for the chromospheric plasma environment using a linear fluid analysis to derive a new dispersion relationship and critical E x B drift velocity required to trigger the instability. Using a 1D, non-local thermodynamic equilibrium, radiative transfer model and careful estimates of collision rates and magnetic field strengths, we calculate the trigger velocities necessary to induce the instability throughout the chromosphere. Trigger velocities as low as 4 km s^-1 are found near the temperature minimum, well below the local neutral acoustic speed in that region. From this, we expect the instability to occur frequently, converting kinetic energy contained in neutral convective flows from the photosphere into thermal energy via turbulence. This could contribute significantly to chromospheric heating and explain its persistent and ubiquitous nature.

Author(s): ***Chad Madsen (Boston University)***, Yakov Dimant (Boston University), Meers Oppenheim (Boston University), Juan Fontenla (NorthWest Research Associates)

323.04 – Chromospheric umbral dynamics

The chromosphere above sunspots is seen to undergo dynamical driving from perturbations from lower layers of the atmosphere. Umbral flashes have long been understood to be the result of acoustic shocks due to the drop in density in the sunspot chromosphere. Detailed observations of the umbral waves and flashes may help reveal the nature of the sunspot structure in the upper atmosphere. We report on high-resolution observations of umbral dynamics observed in the Ca II 8542 line by IBIS at the Dunn Solar Telescope. We use a principal component decomposition technique (POD) to isolate different components of the observed oscillations. We are able to explore temporal and spatial evolution of the umbral flashes. We find significant variation in the nature of the flashes over the sunspot, indicating that the chromospheric magnetic topology can strongly modify the nature of the umbral intensity and velocity oscillations.

Author(s): ***Kevin Reardon (INAF)***, Antonio Vecchio (Calabria University), Gianna Cauzzi (INAF), Alexandra Tritschler (National Solar Observatory)

323.05 – On the Signatures of Waves and Oscillations in IRIS Observations

The objective of this study is to explore the signatures of acoustic waves and oscillations in a variety of magnetic field configurations in the Sun’s atmosphere using high-resolution spectroscopic “sit-an-stare” time series obtained with the Interface Region Imaging Spectrogragh (IRIS) in lines formed in the chromosphere and lower transition region (C II 1335 & 1336, C I 1352, O I 1356, Si IV 1394 & 1403 and Mg h and k). The occurrence of oscillations in the transition region is found to strongly depend on the magnetic field topology. The Mg h and k lines reveal a particularly complex spatio-temporal behavior. In an effort to better understand what physical parameters can be extracted from these lines, we extend our analysis to synthetic spectra obtained from numerical simulations and compare the results to observations.

Author(s): ***Bernard Fleck (ESA Science Operations Department)***, Thomas Straus (INAF/OAC), Bart De Pontieu (LMSAL), Jorrit Leenaarts (Stockholm University), Tiago M.D. Pereira (Universtiy of Oslo)

323.06 – Investigating Molecular Hydrogen in Active Regions with IRIS

Molecular hydrogen should be the most abundant molecular species in sunspots, but recent observations with IRIS show that its florescent signature is absent from above the sunspot umbra, but appears brightly during flares. In this poster we continue the analysis of FUV observations of H2 in active regions, examining the correlation between the intensity of the H2 lines and the lines of C II and Si IV which are responsible for their excitation. We particularly focus on differentiating places where H2 is abundant, holes in the chromospheric opacity where FUV photons can enter more deeply into the solar atmosphere, and places where the FUV radiation field is intense, as in flares.

Author(s): ***Sarah Jaeggli (Montana State University)***, Steven Saar (Harvard-Smithsonian Center for Astrophysics), Adrian Daw (NASA Goddard Space Flight Center), Davina Innes (Max Planck Institute for Solar System Research)

Contributing teams: The IRIS Team

323.07 – Asymmetric Magnetic Reconnection in Partially Ionized Chromospheric Plasmas

Magnetic reconnection is a ubiquitous process in the solar chromosphere. Realistic models of chromospheric reconnection must take into account that the plasma is partially ionized. Asymmetric reconnection in the chromosphere may occur when newly emerged flux interacts with pre-existing, overlying flux. We present simulations of asymmetric reconnection in weakly ionized, reacting plasmas where the magnetic field strengths, densities, and temperatures are different in each upstream region. The simulations show considerable thinning of the current sheet, asymmetric decoupling of ions and neutrals in the inflow regions, and plasmoid formation late in time. We will discuss these simulations in the context of newly available observations from the Interface Region Imaging Spectrograph (IRIS).

Author(s): ***Nicholas Murphy (Harvard-Smithsonian Center for Astrophysics)***, Vyacheslav Lukin (Naval Research Laboratory), John Raymond (Harvard-Smithsonian Center for Astrophysics)

323.09 – Jets and Bombs: Characterizing IRIS Spectra

For almost two decades, SUMER has provided an unique perspective on explosive events in the lower solar atmosphere. One of the hallmark observations during this tenure is the identification of quiet sun bi-directional jets in the lower transition region. We investigate these events through two distinct avenues of study: a MHD model for reconnection and the new datasets of the Interface Region Imaging Spectrograph (IRIS). Based on forward modeling optically thin spectral profiles, we find the spectral signatures of reconnection can vary dramatically based on viewing angle and altitude. We look to the IRIS data to provide a more complete context of the chromospheric and coronal environment during these dynamic events. During a joint IRIS-SUMER observing campaign, we observed spectra of multiple jets, a small C flare, and an Ellerman bomb event. We discuss the questions that arise from the inspection of these new data.

Author(s): ***Donald Schmit (Max Planck Institute for Solar System Research)***, Davina Innes (Max Planck Institute for Solar System Research)

323.10 – Analyzing an IRIS Blowout jet via Magnetofrictional Simulation

The imaging spectrograph, IRIS, offers unprecedented spatial and temporal resolution of small-scale phenomena, which allows the study of their spectral properties in the chromosphere and transition region. This study present IRIS observations of a blowout coronal jet, demonstrating the ability of IRIS to detect reconnection effects in the low atmosphere in the available suite of spectral lines. We present Doppler velocity and non-thermal width (NTW) maps of the jet and their evolution in time. We interpret the results using MHD simulations of jets. In addition, we present a data-driven magnetofrictional simulation of the same jet and match the magnetic and current structure of the jet to the observed NTW maps. We infer the height of the null point and the extent of the region showing reconnection effects. We discuss the implications of understanding reconnection effects in conjunction with NTW maps.

Author(s): ***Antonia Savcheva (Harvard-Smithsonian Center for Astrophysics)***, Hui Tian (Harvard-Smithsonian Center for Astrophysics), Karen Meyer (Harvard-Smithsonian Center for Astrophysics)

323.11 – Obtaining Stokes Parameters From The SUMI Experiment

A sounding rocket experiment designed at the Marshall Space Flight Center, named the Solar Ultraviolet Magnetograph Investigation, had its second launch in July of 2012 to test the feasibility of measuring polarization signals of the ionized magnesium resonance doublet near 280 nm, originating from the transition region. The rocket housed a telescope at the front end and an imaging system at the rear end. Placed at the focal point of the self-filtering telescope, a wave plate rotated through 12 predefined angular orientations to restrict the measurements to specific combinations of circular and linear polarization. Coupled with a double Wollaston analyzer, the linearly polarized ordinary and extraordinary beams were measured for the 12 combinations, each containing different fractions of the Stokes parameters (I, Q, U, V). A thorough analysis of the data has allowed us to come to several conclusions regarding the design of the experiment. 1) We are confident that polarization can be measured. A sunspot region was determined to exhibit similar results over multiple pixels. 2) Measurements are limited by resolution, i.e. regions smaller than the angular resolution per pixel cannot be resolved with any certainty. 3) Temporal evolution of magnetic features must be considered in future experimental designs. Measurements need to be taken in repeated cycles as opposed to a single cycle over the duration of the experiment. In our presentation, we will provide a summary of the observations along with the methods of our analysis, including the limitations that we've encountered.

Author(s): ***Brian Fayock (University of Alabama in Huntsville)***, Amy Winebarger (NASA's Marshall Space Flight Center), Jonathan Cirtain (NASA's Marshall Space Flight Center), Ken Kobayashi (NASA's Marshall Space Flight Center), Ed West (NASA's Marshall Space Flight Center)

323.12 – The Stellar-IRIS Connection: Four Years of FUV Measurements of Alpha Centauri by HST/STIS

Since 2010 January, shortly after the miraculous repair of Hubble's Space Telescope Imaging Spectrograph (STIS) by SM4, the two sun-like stars of Alpha Centauri ("A" [G2V] and "B" [K1V]) have been recorded on a semi-annual basis utilizing STIS's far-ultraviolet (115-170 nm) medium resolution mode (about 8 km/s FWHM resolving power), jointly with an X-ray imaging study of AB by the Chandra Observatory. Both efforts are intended to assess the long-term behavior of high-energy (multimillion K) coronal, and subcoronal, processes on the two relatively low-activity solar-age dwarfs. In fact, the near-solar-twin Alpha Cen A has been mired in a coronal lull since 2005, originally recognized by XMM-Newton, and only recently has begun to climb out of the extended X-ray minimum. Meanwhile, the lower mass, lower luminosity, but coronally more active secondary has displayed a clear 8-year X-ray cycle, extending from the mid-1990's ROSAT era. The current study focuses on properties of the "transition zone" lines (T~100,000 K) of the Alpha Centauri stars, namely the bulk redshifts exhibited by the Si IV, C IV, and N V doublets; the multi-component nature of the hot-line profiles; behavior of the Fe XII 124 nm coronal forbidden line; and variability of the FUV fluxes relative to the higher-energy X-ray time series. These stellar measurements, with their high precision in wavelength and flux, complement the detailed high-spatial and high-temporal resolution spectral mapping of the solar corona and lower atmosphere being carried out by NASA's Interface Region Imaging Spectrograph (IRIS). [This work supported by GO grants 12758, 13060, and 13465 from Space Telescope Science Institute.]

Author(s): ***Thomas Ayres (University of Colorado)***

323.13 – Brightenings Caused by Falling Filament Material on 2011 September 7

Solar filaments exhibit a range of eruptive-like dynamic activity from the full, or partial, eruption of the filament mass and surrounding magnetic structure, as a CME, to a fully confined dynamic evolution or 'failed' eruption. On 2011 September 7, a partial eruption of a filament was observed by SDO and STEREO, generating a substantial stream of returning filament material that exhibited a strong interaction with the solar surface. Similarly to the recently studied 2011 June 7 event, the impact sites show clear evidence of brightening in the observed EUV wavelengths due to energy release by the impact. We explore two plausible physical mechanisms that would cause such brightening: heating of the plasma due to the kinetic energy of the impacting material - compression of the plasma, or reconnection between the magnetic field of the low-laying loops with the field carried by the impacting material, or combination thereof. By analyzing the emission of the brightenings in several SDO/AIA wavelengths, and comparing the kinetic energy of the impacting material to the radiative energy we provide clues for the dominant mechanism of energy release involved in the observed brightenings. We compare this event to another in which we performed the same analysis (2011 June 7) where we determined that compression was the dominant mechanism.

Author(s): ***Holly Gilbert (NASA's Goddard Space Flight Center)***, Andrew Inglis (NASA's Goddard Space Flight Center), Leila Mays (NASA's Goddard Space Flight Center), Leon Ofman (NASA's Goddard Space Flight Center), Elena Provornikova (NASA's Goddard Space Flight Center)

323.14 – Characterizing and Modeling Coronal Loop Blobs

The solar corona is dominated by loop-like structures. Most of these loops seem to be quite quiescent with a near uniform emission along their length. However, a small sample of loops show bright, transient blobs flowing across their length. Unlike the falling blobs observed in EIT by De Groof et. al (2003), AIA has recorded blobs that rise from the base of the loop and transverse the entire loop length. A sporadic and short lived heating event is thought to initiate the launch of a blob. However, these heating events are thought by some to be common in the lower solar atmosphere, so it is unclear why only a small subset of loops should show these blobs. In this work we perform a statistical analysis on the physical properties of blobs (size, speed, intensity profile, etc.) that transverse the entire loop length. We then model a series of loops under various heating scenarios and geometrical configurations in order to determine which parameters play a role in blob formation.

Author(s): ***Henry Winter (SAO)***, Mita Tembe (University of Virginia), Kathy Reeves (SAO), Patrick McCauley (SAO)

323.15 – A Survey of Coronal Heating Properties in Solar Active Regions

We investigate the properties of coronal heating in solar active regions (AR) by systematically analyzing coronal light curves observed by the Atmospheric Imaging Assembly onboard the Solar Dynamics Observatory. Our automated technique computes time-lags (cooling times) on a pixel-by-pixel basis, and has the advantage that it allows us to analyze all of the coronal AR emission, including the so-called diffuse emission between coronal loops. We recently presented results using this time-lag analysis on NOAA AR 11082 (Viall & Klimchuk 2012) and found that the majority of the pixels contained cooling plasma along their line of sight. This result is consistent with impulsive coronal nanoflare heating of both coronal loops and the surrounding diffuse emission in the AR. Here we present the results of our time-lag technique applied to a survey of 15 AR of different magnetic complexity, total unsigned magnetic flux, size and age. We show that the post-nanoflare cooling patterns identified in NOAA AR 11082 are identified throughout all of the active regions in this survey, indicating that nanoflare heating is ubiquitous in solar active regions. However, some details of the nanoflare properties, such as the nanoflare energy, are different across these different active regions. We thank the SDO/AIA team for the use of these data, and the Coronal Heating ISSI team for helpful discussion of these topics. This research was supported by a NASA Heliophysics GI.

Author(s): ***Nicholeen Viall (NASA Goddard Space Flight Center)***, James Klimchuk (NASA Goddard Space Flight Center)

323.16 – Imaging and Spectra of the Chromosphere and Corona at the 2013 Total Eclipse in Gabon

We successfully observed the 3 November 2013 eclipse's 59 s of totality in clear sky from the centerline of totality where it exited La Lope National Park in Gabon, close to the maximum totality available on land. Our wide-field imaging showed two CMEs and an erupting prominence. We compare our images with those obtained elsewhere in totality to assess motion and dynamics. Our imaging observations are also compared with near-simultaneous observations from SDO/AIA, SDO/HMI, Hinode/XRT, SOHO/LASCO, SOHO/EIT, PROBA2/SWAP, and STEREO/SECCHI. We also have flash and coronal spectra, which continue to show overall warming of the corona in 2012 and 2013 through studies we have made over the solar cycle that include the ratio of intensities of the coronal red (Fe X 637.4 nm) and green (Fe XIV 530.3 nm) forbidden lines. The Williams College 2013 total-eclipse expedition was supported in part by grant 9327-13 from the Committee for Research and Exploration of the National Geographic Society. Our continued work on the 2012 eclipse results is supported in part by grant AGS-1047726 from Solar Terrestrial Research/NSF AGS.

Author(s): ***Jay Pasachoff (Williams College)***, Allen Davis (Williams College), Marek Demianski (Williams College), Vojtech Rusin (Astronomical Institute), Metod Saniga (Astronomical Institute), Daniel Seaton (Royal Obs.), Pavlos Gaintatzis (Aristotle U.), Aristeidis Voulgaris (Aristotle U.), Robert Lucas (U. Sydney), Zophia Edwards (Boston U.), Michael Zeiler (ESRI), Michael Kentrianakis (CBS News)

323.18 – The Coronal Global Evolutionary Model (CGEM): Highlights of the First Year

The Coronal Global Evolutionary Model (CGEM) is a model for the evolution of the magnetic field in the solar corona, driven by vector and line-of-sight magnetogram data, along with Doppler data, taken from HMI instrument on NASA's SDO Mission. On long time scales, the magnetic field evolution is computed quasi-statically using the magnetofrictional method. For a configuration which becomes unstable and erupts or undergoes rapid evolution, we will use the magnetofrictional configuration as the initial state for an MHD simulation. The model will be run in both global configurations, covering the entire Sun, and local configurations, designed to model the evolution of the corona above active regions. In both cases, the model will use spherical coordinates to enable a more realistic geometry in the outer corona. The CGEM project also includes the dissemination of other information derivable from HMI magnetogram data, such as the vertical and horizontal Lorentz-forces computed over active region domains, to facilitate easier comparisons of flare/CME behavior and observed changes of the photospheric magnetic field. We describe progress we have made both on the development of this new model, and our continued development of our prototype Cartesian model, which was the basis for the CGEM proposal. We will discuss updated simulations that use our prototype model to study the evolution of NOAA AR 11158 over the time period that includes the 2011 February 15 X-class flare.

Author(s): ***George Fisher (UC Berkeley)***

Contributing teams: The CGEM Team (members at UCB/SSL, Stanford University, LMSAL)

323.19 – Active Region Magnetic Field Modeling Guided by Coronal Loops and Surface Fields

Dynamic events such as solar flares, filament eruptions, and mass ejections are powered by the evolving coronal magnetic field. However, the ways in which energy is stored in, and released from, the coronal magnetic field are poorly understood, in large part because the field configuration cannot be determined directly from observations and has eluded the successful application of routine modeling based on surface magnetograms. Recently, we have demonstrated that the Quasi-Grad-Rubin (QGR) method for modeling the current-carrying field associated with active regions shows promise. In Malanushenko et al. (2014, ApJ 783:102) we have used the QGR method to construct the magnetic field at several times during the evolution of AR11158 during February 2011. The QGR method does not require vector magnetograms, and instead uses the trajectories of observed coronal loops to constrain the locations of electric currents within the modeling domain. In this study, we continue to assess the utility of QGR by applying this method to additional active regions from the current activity cycle, making use of SDO/HMI line-of-sight magnetograms and imagery from the extreme ultraviolet channels of SDO/AIA.

Author(s): ***Marc DeRosa (Lockheed Martin Solar and Astrophysics Laboratory)***, Anna Malanushenko (Lockheed Martin Solar and Astrophysics Laboratory), Carolus Schrijver (Lockheed Martin Solar and Astrophysics Laboratory), Michael Wheatland (University of Sydney)

323.20 – The Substructure of the Solar Corona Observed in the Hi-C Telescope

In the summer of 2012, the High-resolution Coronal Imager (Hi-C) flew aboard a NASA sounding rocket and collected the highest spatial resolution images ever obtained of the solar corona. One of the goals of the Hi-C flight was to characterize the substructure of the solar corona. We therefore calculate how the intensity scales from a low-resolution (AIA) pixels to high-resolution (Hi-C) pixels for both the dynamic events and “background” emission (meaning, the steady emission over the 5 minutes of data acquisition time). We find there is no evidence of substructure in the background corona; the intensity scales smoothly from low-resolution to high-resolution Hi-C pixels. In transient events, however, the intensity observed with Hi-C is, on average, 2.6 times larger than observed with AIA. This increase in intensity suggests that AIA is not resolving these events. This result suggests a finely structured dynamic corona embedded in a smoothly varying background.

Author(s): ***Amy Winebarger (NASA MSFC)***, Jonathan Cirtain (NASA MSFC), Leon Golub (Harvard-Smithsonian Center for Astrophysics), Ed DeLuca (Harvard-Smithsonian Center for Astrophysics), Sabrina Savage (NASA MSFC), Caroline Alexander (NASA MSFC), Timothy Schuler (State University of New York College at Buffalo)

323.21 – Power Spectra in AIA 171 and 193 and Their Implications for Coronal Seismology

We examine Fourier power spectra of time-series of AIA 171 and 193 waveband data. We show that these power spectra exhibit a red-noise like power-law behaviour on time-scales of interest to coronal seismology. We show that assuming a white noise background power spectrum when a red-noise power spectrum is present can lead to the mistaken identification of narrow-band oscillatory power when none is present. This implies that a background power-law power spectrum must be taken in to account when determining the presence of narrow-band oscillations that may be due to MHD wave processes in the solar corona. We also show that the red-noise power spectrum is consistent with the expected power spectrum from large number of exponentially decaying emission events with event size taken from a power law distribution.

Author(s): ***Jack Ireland (ADNET Systems, NASA's GSFC)***, Robert Mcateer (New Mexico State University), Andrew Inglis (Catholic University of America / NASA GSFC)

323.22 – Thermal Diagnostics with SDO/AIA: A new method and application to Eruptive Active Regions

We present a new method for the retrieval of the emission measure (EM) distribution of coronal plasma using SDO/AIA EUV images. Unlike some existing EM inversion algorithms, this inversion scheme does not make assumptions about the functional form (e.g. Gaussian, power law etc.) of the solution. The method returns positive definite solutions and runs at a speed ~O(10^4) pixels per second in a Solarsoft implementation. We apply the method to a selection of eruptive active regions (ARs) to study the thermal evolution of AR loops. In terms of both morphology and temporal evolution, synthetic Hinode/XRT images calculated from EM solutions retrieved using only AIA data show good agreement with actual XRT images.

Author(s): ***Mark Cheung (Lockheed Martin Solar and Astrophysics Laboratory)***, Paul Boerner (Lockheed Martin Solar and Astrophysics Laboratory), Paola Testa (Smithsonian Astrophysical Observatory)

323.23 – The Sources of F10.7 Emission

The solar radio flux at a wavelength of 10.7 cm, F10.7, serves as a proxy for the Sun’s ionizing flux striking the Earth and is a heavily used index for space weather studies. In principal both the coronal sources of ionizing flux and strong coronal magnetic fields contribute to F10.7 via different emission mechanisms. Recently the Expanded Very Large Array (EVLA) has added the capability to make high–spatial–resolution images of the Sun at 10.7 cm. In this work we compare a trial F10.7 image from the EVLA with the radio emission predicted to be present from EUV images of the Sun acquired by the AIA telescope on the Solar Dynamics Observatory at 6 wavelengths covering the coronal temperature range. Photospheric magnetograms are used to identify likely regions of strong coronal magnetic field, and the circular polarization measured by the EVLA is used as a tracer of gyroresonance contributions to F10.7. We discuss the conversion of the EUV data to bremsstrahlung radio fluxes via the construction of differential emission measure images, and analyze the relative contributions of the different sources of F10.7 flux.

Author(s): ***Samuel Schonfeld (New Mexico State University)***, Stephen White (Kirtland AFB), Carl Henney (Kirtland AFB), James McAteer (New Mexico State University), Charles Arge (Kirtland AFB)

323.24 – Single-point Inversion of the Coronal Magnetic Field

The Fe XIII 10747 and 10798 \AA\ lines observed in the solar corona are sensitive to the coronal magnetic field in such a way that, in principle, the full vector field at a point on the line of sight can be inferred from their combined polarization signals. This paper presents analytical inversion formulae for the field parameters and analyzes the uncertainty of magnetic field measurements made from such observations, assuming emission dominated by a single region along the line-of-sight. We consider the case of the current CoMP instrument as well as the future COSMO and ATST instruments. Uncertainties are estimated with a direct analytic inverse and with an MCMC algorithm. We find that (in effect) two components of the vector field can be recovered with CoMP, and well-recovered with COSMO or ATST, but that the third component can only be recovered when the solar magnetic field is strong and optimally oriented.

Author(s): ***Joseph Plowman (NCAR)***, Roberto Casini (NCAR), Philip Judge (NCAR), Steven Tomczyk (NCAR)

323.25 – Observational Signatures of Alfven Wave Turbulence in Solar Coronal Loops

The non-thermal width in coronal emission lines could be due to the Alfven wave turbulence. In order to find observational evidence of the Alfven waves that result in coronal heating, we examine and analyze the dynamics of an active region observed on 2012 September 7. We use spectral line profiles of Fe XII, Fe XIII, Fe XV and Fe XVI obtained by Extreme-ultraviolet Imaging Spectrometer (EIS) on Hinode spacecraft. Line profile observations from EIS were generated and compared with our computations of line of sight Alfven wave amplitude. We show non-thermal velocities, Doppler outflows, and intensities for loops in this active region and derive comparisons between our numerical results and observations from EIS. In our modeling we take into account the relationship between the width of the coronal emission lines and the orientation of the coronal loops with respect to the line-of-sight direction. We conclude that the Alfven wave turbulence model is a strong candidate for explaining how the observed loops are heated.

Author(s): ***Mahboubeh Asgari-Targhi (Harvard-Smithsonian)***, Shinsuke Imada (Nagoya University), Edward DeLuca (Harvard-Smithsonian)

323.26 – First use of synoptic vector magnetograms for global nonlinear, force-free coronal magnetic field models

The magnetic field permeating the solar atmosphere is generally thought to provide the energy for much of the activity seen in the solar corona, such as flares, coronal mass ejections (CMEs), etc. To overcome the unavailability of coronal magnetic field measurements, photospheric magnetic field vector data can be used to reconstruct the coronal field. Currently, there are several modelling techniques being used to calculate three dimensional field lines into the solar atmosphere. For the first time, synoptic maps of a photospheric vector magnetic field synthesized from the vector spectromagnetograph (VSM) on Synoptic Optical Long term Investigations of the Sun (SOLIS) are used to model the coronal magnetic field and estimate free magnetic energy in the global scale. The free energy (i.e., the energy in excess of the potential field energy) is one of the main indicators used in space weather forecasts to predict the eruptivity of active regions. We solve the nonlinear force free field equations using an optimization principle in spherical geometry. The resulting three-dimensional magnetic fields are used to estimate the magnetic free energy content, which is the difference of the magnetic energies between the nonpotential field and the potential field in the global solar corona. For comparison, we overlay the extrapolated magnetic field lines with the extreme ultraviolet (EUV) observations by the atmospheric imaging assembly (AIA) on board the Solar Dynamics Observatory (SDO). For a single Carrington rotation 2121, we find that the global nonlinear force free field (NLFFF) magnetic energy density is 10.3% higher than the potential one. Most of this free energy is located in active regions.

Author(s): ***Tilaye Tadesse Asfaw (NASA-Goddard Space Flight Center)***, Alexei Pevtsov (National Solar Observatory), Peter Macneice (NASA-Goddard Space Flight Center)

323.27 – Grand Unified Speculation: Coronal Cooling & Multi-thermal Analysis of AIA Loops

We have tested three controversial properties for a target loop observed with the Atmospheric Imaging Assembly: (1) overdense loops; (2) long-lifetime loops; and (3) multithermal loops. Our loop is overdense by a factor of about 10 compared to results expected from steady uniform heating models. If this were the only inconsistency, our loop could still be modeled as a single strand, but the density mismatch would imply that the heating must be impulsive. Moving on to the second observable, however, we find that the loop lifetime is at least an order of magnitude greater than the predicted cooling time. This implies that the loop cannot be composed of a single flux tube, even if the heating were dynamic, and must be multi-stranded. Finally, differential emission measure analysis shows that the cross-field temperature of the target loop is multithermal in the early and middle phases of its lifetime, but isothermal before it fades from view. If these multithermal cooling results are found to be widespread, our results could resolve the original coronal loop controversy of isothermal versus multithermal cross-field temperatures. That is, the cross-field temperature is not always multithermal nor is it always isothermal, but changes as the loop cools.

Author(s): ***Joan Schmelz (Univ. of Memphis)***

323.28 – Independent CMEs from a Single Solar Active Region – The Case of the Super-Eruptive NOAA AR11429

In this investigation we study AR 11429, the origin of the twin super-fast CME eruptions of 07-Mar-2012. This AR fulfills all the requirements for the 'perfect storm'; namely, Hale's law incompatibility and a delta-magnetic configuration. In fact, during its limb-to-limb transit, AR 11429 spawned several eruptions which caused geomagnetic storms, including the biggest in Cycle 24 so far. Magnetic Flux Ropes (MFRs) are twisted magnetic structures in the corona, best seen in ~10MK hot plasma emission and are often considered as the culprit causing such super-eruptions. However, their 'dormant' existence in the solar atmosphere (i.e. prior to eruptions), is a matter of strong debate. Aided by multi-wavelength and multi-spacecraft observations (SDO/HMI & AIA, HINODE/SOT/SP, STEREO B/EUVI) and by using a Non-Linear Force-Free (NLFFF) model for the coronal magnetic field, our work shows two separate, weakly-twisted magnetic flux systems which suggest the existence of possible pre-eruption MFRs.

Author(s): ***Georgios Chintzoglou (Naval Research Laboratory)***, Spiros Patsourakos (University of Ioannina), Angelos Vourlidas (Naval Research Laboratory)

323.29 – Findings from a Three Year Survey of Coronal Null Points

We report the findings from a comprehensive coronal magnetic null point survey created by Potential Field Source Surface (PFSS) modeling & Solar Dynamic Observatory/Atmospheric Imaging Assembly (SDO/AIA) observations. Locations of magnetic null points in the corona were predicted from the PFSS model from Carrington Rotation 2098 to 2139 and manually compared to contrast enhanced SDO/AIA images in 171 angstroms. Statistical results will be presented that illustrate the characteristics associated with the observed and predicted null points. These characteristics include the radial & latitudinal distribution; eigenvalues associated with null point structure; and the effect spine orientation has on observability.

Author(s): ***Michael Freed (Montana State University)***, Dana Longcope (Montana State University), David McKenzie (Montana State University)

323.30 – Validation of Spherically Symmetric Inversion by Use of a Tomographic Reconstructed Three-Dimensional Electron Density of the Solar Corona

Determination of the coronal electron density by the inversion of white-light polarized brightness (pB) measurements by coronagraphs is a classic problem in solar physics. An inversion technique based on the spherically symmetric geometry (Spherically Symmetric Inversion, SSI) was developed in the 1950s, and has been widely applied to interpret various observations. In this study we present the detailed assessment of this method using a model in terms of three-dimensional (3D) electron density in the corona from 1.5 to 4 solar radii reconstructed by tomography method from STEREO/COR1 observations. We first show in theory and observation that the spherically symmetric polynomial approximation (SSPA) method and the Van de Hulst inversion technique are equivalent. Then we assess the SSPA method using synthesized pB images from the 3D density model, and find that the SSPA density values for edge-on streamers are very close to the model inputs in the plane of sky with differences generally less than a factor of two or so; the SSPA density has the lower peak but more spread in latitudinal direction than in the model. Our results confirm the previous suggestion that the SSI method is very suitable to streamers in the solar minimum. In addition, we demonstrate that the SSPA method can be used to reconstruct the 3D coronal density, roughly in agreement with that by tomography in a period of low solar activity. We suggest that the SSI method is complementary to the 3D tomographic technique in some cases, given that the development of the latter is still an ongoing research effort.

Author(s): ***Tongjiang Wang (Catholic Univ of America / NASA GSFC)***, Maxim Kramar (Catholic Univ of America / NASA GSFC), Joseph Davila (NASA Goddard Space Flight Center)

323.31 – A Comparison Study of Two Neighboring Eruptive and Non-Eruptive Filaments

We perform a comparison study of an eruptive filament in AR 11283 and a nearby quiescent filament. The coronal magnetic field supporting these two filaments is extrapolated using a CESE-MHD-NLFFF code (Jiang et al. 2013, Jiang et al. 2014), which presents two magnetic flux ropes (FRs) in the same extrapolation box. The numerically reproduced magnetic dips of the FRs match observations of the filaments strikingly well, which supports strongly the FR-dip model for filaments. The FR that supports the AR eruptive filament is much smaller (with length of 30~Mm) compared with the large-scale FR holding the quiescent filament (with length of 300~Mm). But the AR eruptive FR contains most of the magnetic free energy in the extrapolation box and holds a much higher magnetic energy density than the quiescent FR, because it resides along the main polarity inversion line (PIL) around sunspots with strong magnetic shear. Both the FRs are weakly twisted and cannot trigger kink instability. The AR eruptive FR is unstable because its axis reaches above a critical height for torus instability (TI), at which the overlying closed arcades can no longer confine the FR stably. On the contrary, the quiescent FR is very firmly held by its overlying field, as its axis apex is far below the TI threshold height. (This work is supported by NSF)

Author(s): ***Chaowei Jiang (The University of Alabama in Huntsville)***, S. Wu (The University of Alabama in Huntsville), Xueshang Feng (Center for Space Science and Applied Research, Chinese Academy of Sciences), Qiang Hu (The University of Alabama in Huntsville)

323.32 – Solar Coronal Temperature During the Rise of Cycle 24

Observations of the solar corona are obtained with the photoelectric coronal photometer fed by the 40-cm coronagraph in the John W. Evans Solar Facility at the National Solar Observatory at Sacramento Peak in Sunspot, NM. The observations consist of daily scans every 3° in latitude at 1.15 solar radii in Fe XIV 530.3 nm and Fe X 637.4 nm. The scans were obtained from 1983 to 2013. The coronal temperature (Tc) may be calculated as a function of the ratio of the intensities of Fe XIV and Fe X, as shown by Guhathakurta, Fisher and Altrock (1993, *Astrophys. J. Lett.*, **414**, L145). In this paper, I use this technique to study the long-term, large-scale variation of Tc over the last 3 solar cycles. The observations are used to determine the variation of Tc at latitudes above 30°. Latitudes below 30° are not studied, because the technique used to determine Tc is not applicable to active regions, where the assumption of a uniform temperature along the line-of-sight is denied by the presence of many active-region loops of varying temperatures. Suitable temporal averages are taken to reduce noise. Prior to the last solar minimum we find that (i) a well-defined solar-cycle variation of Tc at 1.15 Ro was seen, varying by 0.4 MK near the poles, (ii) Tc near solar minimum decreased strongly toward the poles above 60° latitude, and (iii) a variation ~ 0.1 MK was seen in the average Tc above 30° latitude. However, since the last solar maximum, we show that the pattern established during the previous two cycles was broken. The most important new conclusions are **Tc since minimum reached maximum earlier in the North than in the South, and Tc at the maximum of Cycle 24 is significantly lower than in previous cycles.** We also found that (i) the polar Tc only decreased by 0.3 MK from solar maximum to minimum instead of 0.4 MK, (ii) Tc near solar minimum did not decrease strongly toward the poles above 60° latitude, which it did in earlier cycles, (iii) the average Tc above 30° latitude reached a record low value of 1.4 MK, but the minimum polar Tc was 0.13 MK hotter than the previous cycle, and (iv) the latitude-variation of Tc at solar minimum was less than 0.1 MK.

Author(s): ***Richard Altrock (Air Force Research Laboratory)***

323.33 – Photospheric Signatures of Coronal Hole Jets

Coronal jets are transient, collimated ejections of plasma that are a common feature of solar X-ray and EUV image sequences. Of special interest is the contribution that coronal hole jets make to the solar wind outflow. A new class of coronal hole jets, termed "dark jets", has been identified with the EUV Imaging Spectrometer (EIS) on board Hinode. The jets are identified in EUV spectral lines with line-of-sight velocities of 50-100 km/s and enhanced line widths, yet they show little or no intensity signature in image sequences from the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory (SDO) or the X-Ray Telescope on board Hinode. In this contribution we will investigate the photosphere at the footpoint of these jets. White light images from the Helioseismic Magnetic Imager (HMI) on board SDO are used to derive the plane-of-sky flow field using local correlation tracking, and HMI magnetograms show the evolution of the magnetic flux. Both the evolution of the magnetic field and flows allow us to study the photospheric driver of these jets.

Author(s): ***Karin Muglach (Artep, Inc)***, Peter Young (GMU)

323.34 – Simulations on Coronal Jets with Thermal Conduction

Observations by Yohkoh, SOHO, Hinode and STEREO show that X-ray jets in the coronal holes, with an inverse-Y shape, occur at a rate of about 60 jets/day, and have a typical outward velocity of 160km/s, height of 50 Mm and width of 8 Mm, and liftime of 10 min (Savcheva et al., 2007). Numerical simulations suggest that jets are related to the reconnection between the newly emerging and pre-existing magnetic fields. We here study the eruption of coronal jets by MHD simulations of flux emergence into the corona with ambient fields. Reconnection of the emerging and ambient fields converts magnetic energy into thermal and kinetic energy of the plasma, capturing the statistical properties of coronal jets. Interesting features of observed jets, such as the twisting motion sigmoidal current structure are also produced in our simulations. In addition, we implemented heat conduction along the field lines to produce a more realistic structure along the field lines, which allows us to compare the synthetic images with AIA observations.

Author(s): ***Fang Fang (High Altitude Observatory)***, Yuhong Fan (High Altitude Observatory)

323.36 – MHD Modeling of Coronal Hole Evolution

MHD simulations of the solar corona based on maps of the solar magnetic field have been demonstrated to describe many aspects of coronal structure. However, these models are typically integrated to steady state, using synoptic or daily-updated magnetic maps to derive the boundary conditions. The Sun's magnetic flux is always evolving, and these changes in the flux affect the structure and dynamics of the corona and heliosphere. In this presentation, we describe an approach to evolutionary models of the corona and solar wind, using time-dependent boundary conditions. A key aspect of our approach is the use of the Air Force Data Assimilative Photospheric flux Transport (ADAPT) model to develop time-evolving boundary conditions for the magnetic field. In this study, we use a simplified (zero-beta) MHD model to investigate coronal hole evolution during the June-August 2010 time period (Carrington rotations 2098-2099). We compare modeled and observed coronal holes, and discuss implications of coronal hole evolution for the origin of the slow solar wind.

Author(s): ***Jon Linker (Predictive Science Inc)***, Roberto Lionello (Predictive Science Inc), Cooper Downs (Predictive Science Inc), Ron Caplan (Predictive Science Inc), Zoran Mikic (Predictive Science Inc), Pete Riley (Predictive Science Inc), Carl Henney (Air Force Research Laboratory), Charles Arge (Air Force Research Laboratory)

323.37 – Statistical Properties of Jets in the SDO Era

We examine the statistical properties of jets observed in X-ray and EUV since the launch of the Solar Dynamics Observatory (SDO). We identify over 150 jets using data from Hinode X-ray Telescope (XRT) coronal hole observing campaigns and examine their properties using SDO Atmospheric Imaging Array (AIA) . Each event is identified as type 1 (classic jet), type 2 (blowout jet) or type 3 (indeterminable). We calculate their intensity, lifetime, apparent velocity, angle of inclination and note if they are associated with a bright points. This study will be used for the validation of the Automatic Jet Detection Module; part of the SDO Feature Finding Team.

Author(s): ***Samaiyah Farid (University of Alabama Huntsville)***, Antonia Savcheva (Smithsonian Astrophysical Observatory)

323.38 – A Comparison of EUV Coronal Hole Measurements and Modeled Open Magnetic Field

Coronal holes are regions on the Sun's surface that map the footprints of open magnetic field lines. We have developed an automated routine to detect and track boundaries of long-lived coronal holes using full-disk extreme-ultraviolet (EUV) images obtained by SOHO/EIT, SDO/AIA, and STEREO/EUVI. Using these observations in conjunction with the potential field source surface (PFSS) model, we find that from 1996 through 2010, coronal holes extend between 5% and 17% of the solar surface area, with total unsigned open flux varying between (2-5)x10^{22} Mx. AIA/EUVI measurements spanning 2010 through 2013 mark coronal hole coverage areas of 5% to 10% of total solar surface area, with total unsigned open magnetic flux ranging from (2-4)x10^{22} Mx. A detailed comparison indicates that coronal holes in low latitudes significantly contribute to the total open magnetic flux. Previous studies using the He I 10830 line or EIT EUV images do not always accurately measure these low latitude coronal holes. Enhanced observations from AIA/EUVI in conjunction with an observation-driven flux transport model allow a more accurate measure of these low latitude coronal holes and their resulting contribution to solar open magnetic flux.

Author(s): ***Chris Lowder (Montana State University)***, Jiong Qiu (Montana State University), Robert Leamon (Montana State University), Dana Longcope (Montana State University), Yang Liu (Stanford University)

323.39 – Further Analysis of Active Region Thermal Structure from EUNIS-13

The 2013 April 23 flight of the Extreme Ultraviolet Normal Incidence Spectrograph (EUNIS) sounding rocket instrument returned high-quality spectra in two wavelength bands, 30.0-37.0 nm and 52.7-63.5 nm, sampling three active regions (11723, 11724, and 11726). The spectral lines in these bands probe a wide temperature range, 0.03 MK to 8 MK. We have demonstrated that the differential emission measure (DEM) varies significantly between different sub-regions of AR 11726. We extend this analysis to ARs 11723 and 11724 and include a wider selection of spectral lines to delineate better the variations in thermal structure.

Author(s): ***Douglas Rabin (NASA Goddard Space Flight Center)***, Enrico Landi (University of Michigan), Adrian Daw (NASA Goddard Space Flight Center), Jeffrey Brosius (NASA Goddard Space Flight Center)

323.40 – Computing EUV and Soft X-rays Emissions from an Active Region in 3D

EUV and soft X-rays can be a useful tool for plasma diagnostics when applied to an active region. Instead of trying to unfold the plasma properties from the observed emissions, we use a forward modeling method on AR 7986. Namely, we first compute the thermal structure of the active region. The resulting density and temperature profiles are then used to compute the expected emissions, and the synthetic images are compared with observations. Our model reproduces many features of an observed active region, including a dark neutral line, coronal loops, fan loops, etc. The time evolution of the emissions show plasma flows that resemble coronal rains. Quantitatively, the coronal part of the loops compare favorably with observations on all three coronal lines of EIT, although their footpoints are somewhat brighter than observed. The discrepancy may be attributed to the inaccurate abundances used to compared the emissions in the low corona and below. Work supported by the Heliophysics Theory Program of NASA.

Author(s): ***Yung Mok (Univ. of California, Irvine)***, Roberto Lionello (Predictive Science, Inc.), Zoran Mikic (Predictive Science, Inc.), Jon Linker (Predictive Science, Inc.)

323.41 – Thermal Non-equilibrium Consistent with Widespread Cooling

Time correlation analysis has been used to show widespread cooling in the solar corona; this cooling has been interpreted as a result of impulsive (nanoflare) heating. In this work, we investigate wide-spread cooling using a 3D model for a solar active region which has been heated with highly stratified heating. This type of heating drives thermal non-equilibrium solutions, meaning that though the heating is effectively steady, the density and temperature in the solution are not. We simulate the expected observations in narrowband EUV images and apply the time correlation analysis. We find that the results of this analysis are qualitatively similar to the observed data. We discuss additional diagnostics that may be applied to differentiate between these two heating scenarios.

Author(s): ***Amy Winebarger (NASA MSFC)***, Roberto Lionello (Predictive Science, Inc), Zoran Mikic (Predictive Science, Inc), Jon Linker (Predictive Science, Inc), Yung Mok (University of California)

323.42 – The Onset of Magnetic Reconnection in the Solar Atmosphere

A fundamental question concerning magnetic energy release on the Sun is why the release occurs only after substantial stresses have been built up in the field. If reconnection were to occur readily, then the released energy would be much less than the energy required for coronal heating, CMEs, flares, jets, spicules, etc. How can we explain this switch-on property? What is the physical nature of the onset conditions? One idea involves the "secondary instability" of current sheets, which switches on when the rotation of the magnetic field across a current sheet reaches a critical angle. Such conditions would occur at the boundaries of flux tubes that become tangled and twisted by turbulent photopheric convection, for example. Other ideas focus on a critical thickness for the current sheet. We report here on the preliminary results of our investigation of reconnection onset. Unlike our earlier work on the secondary instability (Dahlburg, Klimchuk, and Antiochos 2005), here we treat the coupled chromosphere-corona system. Using the BATS-R-US MHD code (Toth et al. 2012), we simulate a single current sheet in a sheared magnetic field that extends from the chromosphere into the corona. Driver motions are applied at the base of the model. The configuration and chromosphere are both idealized, but capture the essential physics of the problem. The advantage of this unique approach is that it resolves the current sheet to the greatest extent possible while maintaining a realistic solar atmosphere. It thus bridges the gap between "reconnection in a box" studies and studies of large-scale systems such as active regions. One question we will address is whether onset conditions are met first in the chromosphere or corona.

Author(s): ***Rebekah Evans (NASA Goddard Space Flight Center)***, James Klimchuk (NASA Goddard Space Flight Center), Bart Van Der Holst (University of Michigan)

323.43 – Coronal Seismology: Inferring Magnetic Fields and Exploring Damping Mechanisms

Coronal seismology provides a method to both infer coronal plasma parameters and to differentiate between potential damping mechanisms. We study a complex set of flare-induced, off-limb, coronal kink-mode oscillations. There are over 100 loops that display a spread of periods, amplitudes, and damping times. These are used to create a coronal magnetic field map, where the behavior of each loop allows for the magnetic field strength to be determined on a case-by-case basis. We show that both Fourier and Wavelet routines can be used to automatically extract and characterize such oscillations, and therefore can provide such magnetic field maps in a near-realtime setting. We study the damping lengths and times to differentiate between several damping mechanisms. Resonant absorption and phase mixing are both in agreement with the damping parameters in this event, with resonant absorption appearing the simplest explanation. We explore how such studies can now be carried out across all available SDO EUV passbands.

Author(s): ***James McAteer (New Mexico State University)***, Jack Ireland (NASA GSFC), Andrew Inglis (NASA GSFC)

Contributing teams: SDO Feature Finding Team

323.44 – Advection of Magnetic Field Lines in Supra-Arcade Fan Structures

Recent attempts to characterize the apparent motion of supra-arcade fan structures have revealed bulk velocity and displacement spectra that may give insights into the energy distribution in supra-arcade plasma sheets. In order to form a more complete picture of the energy balance in these structures it is important to understand the magnetic field on a similar scale. In this work we used velocity maps found through local correlation tracking (LCT) as source functions for a 2D, time-dependent, ideal induction equation. We began with an assumed initial configuration and then evolved the magnetic field in order to maintain the frozen-in condition. We then characterized the energy deposition into the field as well as the field strength spectrum and several other quantities of interest. It is our hope that this study will serve to improve our understanding of the interplay between the plasma and the magnetic field in the supra-arcade region.

Author(s): ***Roger Scott (Montana State University)***, Michael Freed (Montana State University), David McKenzie (Montana State University), Dana Longcope (Montana State University)

323.45 – Coronal Magnetography of a Simulated Solar Active Region from Microwave Imaging Spectropolarimetry

We have simulated the Expanded Owens Valley Solar Array (EOVSA) radio images generated at multiple frequencies from a model solar active region, embedded in a realistic solar disk model, and evaluated the resulting datacube for different spectral analysis schemes to evaluate the potential for realizing one of EOVSA's most important scientific goals — coronal magnetography. In this paper, we focus on modeling the gyroresonance and free-free emission from an on-disk solar active region model with realistic complexities in electron density, temperature and magnetic field distribution. We compare the magnetic field parameters extrapolated from the image datacube along each line of sight after folding through the EOVSA instrumental profile with the original (unfolded) parameters used in the model. We find that even the most easily automated, image-based analysis approach (Level 0) provides reasonable quantitative results, although they are affected by systematic effects due to finite sampling in the Fourier (uv) plane.

Author(s): ***Zhitao Wang (New Jersey Institute of Technology)***, Dale Gary (New Jersey Institute of Technology), Stephen White (Air Force Research Laboratory)

323.46 – Magnetic reconnection and tearing in a 3D current sheet about a solar coronal null

Three-dimensional magnetic null points are ubiquitous in the solar corona and in any generic mixed-polarity magnetic field. We discuss the nature of flux transfer during reconnection an isolated coronal null point, that occurs across the fan plane when a current sheet forms about the null. We then go on to discuss the breakup of the current sheet via a non-linear tearing-type instability and show that the instability threshold corresponds to a Lundquist number comparable to the 2D case. We also discuss the resulting topology of the magnetic field, which involves a layer in which open and closed magnetic fields are effectively mixed, with implications for particle transport.

Author(s): ***David Pontin (University of Dundee)***, Peter Wyper (University of Dundee)

323.47 – Visibility of Extended Coronal Structures and CMEs in the EUV

Extended coronal structures around active regions and coronal mass ejections (CMEs) have often been seen in the extreme-ultraviolet (EUV) channels to the full extent of the AIA and SWAP field of views (~1.3 and 1.7 Rsun). Using off-pointed comet data in AIA we sum a large number of frames to evaluate the off-limb distance to which streamers can be detected. For CMEs, we compared the events classified as halo CMEs in the white-light LASCO CACTus catalog from July-September 2013 to the AIA and SWAP data collected around those events. We discovered that roughly 80% of events could be seen in the EUV using both regular and running difference movies, with the most effective channels being the 193 and 304Å channels. By projecting out the signal strength of several of these events, we conclude that these EUV events can in many cases be detected to over 2.5 Rsun. A larger field-of-view telescope would make it possible to track the development of these structures and events from the disk out to several solar radii, complementing the traditional white-light methods.

Author(s): ***Nicole Schanche (SAO)***, Leon Golub (SAO)

323.48 – Waves and jets in coronal loops: the effects of radiative cooling

Observations with Hinode/EIS of coronal loops in solar active regions revealed that propagating disturbances of EUV intensity are associated with plasma upflows or jets at loops footpoints. To investigate the excitation and evolution of waves due to plasma jets, we expand recent studies with more realistic 3D MHD model that includes full energy equation with empirical heating and radiative cooling terms. We perform 3D MHD simulations of loops by applying different flow drivers at the loops footpoints, a single upflow pulse and a broadband excitation of small amplitude (subsonic) velocity pulses. Parameters of the pulses are chosen according to the observed properties. We initialize the computations with an equilibrium state of a model active region using potential (dipole) magnetic field, gravitationally stratified density and temperature obtained from polytropic equation of state of the background coronal plasma. We study the initiation and the dynamics of plasma flows, excitation and damping of waves, and flow-wave interactions in the loops for various forms of heating. We investigate the effects of radiation losses on the damping of MHD waves on the jets in coronal loops.

Author(s): ***Elena Provornikova (NASA Goddard Space Flight Center)***, Leon Ofman (NASA Goddard Space Flight Center), Tongjiang Wang (NASA Goddard Space Flight Center)

323.49 – MESSENGER soft X-ray observations of the quiet solar corona

In a remarkable result from their "SphinX" experiment, Sylwester et al. (2012) found a non-varying base level of soft X-ray emission at the quietest times in 2009. We describe comparable data from the soft X-ray monitor on board MESSENGER (en route to Mercury) which had excellent coverage both in 2009 and during the true solar minimum of 2008. These observations overlap SphinX's and also are often exactly at Sun-MESSENGER-Earth conjunctions. During solar minimum the Sun-MESSENGER distance varied substantially, allowing us to use the inverse-square law to help distinguish the aperture flux (ie, solar X-rays) from that due to sources of background in the 2-5 keV range. The MESSENGER data show a non-varying background level for many months in 2008 when no active regions were present. We compare these data in detail with those from SphinX. Both sets of data reveal a different behavior when magnetic active regions are present on the Sun, and when they are not. Reference: Sylwester et al., ApJ 751, 111 (2012)

Author(s): ***Richard Schwartz (NASA's GSFC)***, Hugh Hudson (University of Glasgow), Anne Tolbert (NASA's GSFC), Brian Dennis (NASA's GSFC)

323.50 – A study on the sensitivity of outflow velocity determinations for coronal streamers made within 2.5 solar radii

Outflow velocity determinations in coronal streamers have been traditionally studied using the Doppler dimming techniques (SOHO/UVCS) and correlation tracking of brightness irregularities (blobs) with white light coronagraphs. These velocity measurements are in the plane of sky, approximately transverse to the line of sight. The earlier UVCS outflow measurements are not very sensitive for low outflows (V < 30 km/s) and the white light coronagraphs probably have similar uncertainties. We have started a new streamer study which uses the approach of Noci & Gavryuseva (2007) to determine outflow velocities as low as 20 km/s in the plane of the sky. This study is being used to improve the mapping of solar wind outflow in the transition between open and mainly closed magnetic field regions on the boundaries of coronal streamers. We show initial results using data from SOHO observations and discuss their relevance to mechanisms for generating the slow solar wind.

Author(s): ***Leonard Strachan (Harvard-Smithsonian, CfA)***

323.51 – Solar Polar Jets Driven by Magnetic Reconnection, Gravity, and Wind

Polar jets are dynamic, narrow, radially extended structures observed in solar EUV emission near the limb. They originate within the open field of coronal holes in “anemone” regions, which are intrusions of opposite magnetic polarity. The key topological feature is a magnetic null point atop a dome-shaped fan surface of field lines. Applied stresses readily distort the null into a current patch, eventually inducing interchange reconnection between the closed and open fields inside and outside the fan surface (Antiochos 1996). Previously, we demonstrated that magnetic free energy stored on twisted closed field lines inside the fan surface is released explosively by the onset of fast reconnection across the current patch (Pariat et al. 2009, 2010). A dense jet comprised of a nonlinear, torsional Alfvén wave is ejected into the outer corona along the newly reconnected open field lines. Now we are extending those exploratory simulations by including the effects of solar gravity, solar wind, and expanding spherical geometry. We find that the model remains robust in the resulting more complex setting, with explosive energy release and dense jet formation occurring in the low corona due to the onset of a kink-like instability, as found in the earlier Cartesian, gravity-free, static-atmosphere cases. The spherical-geometry jet including gravity and wind propagates far more rapidly into the outer corona and inner heliosphere than a comparison jet simulation that excludes those effects. We report detailed analyses of our new results, compare them with previous work, and discuss the implications for understanding remote and in-situ observations of solar polar jets. This work was supported by NASA’s LWS TR&T program.

Author(s): ***C. DeVore (NASA GSFC)***, Judith Karpen (NASA GSFC), Spiro Antiochos (NASA GSFC)

323.52 – A Solar Coronal Cavity with a Hot Core Observed by Hinode

Coronal cavities are large low density regions often observed above high latitude filament channels. These cavities will sometimes have areas of bright X-ray emission near their centers. Using Hinode satellite data from the X-ray Telescope (XRT) and the EUV Imaging Spectrometer (EIS) we examine the thermal emission properties and coronal velocity structures of a cavity, containing a central bright X-ray emission, observed on 23 February 2012. We investigate the interaction between the coronal cavity and the prominence material using data from the Atmospheric Imaging Assembly (AIA) aboard the Solar Dynamic Observatory (SDO) and H-? data from the Hinode Solar Optical Telescope (SOT). We use a non-linear force-free field model to understand the magnetic field structure that gives rise to the coronal emission in this cavity. A comparison of AIA and XRT data reveal emission in 171 that outlines the hot core of the cavity; consistent with the modeled magnetic field structure. This work is supported by under contract SP02H1701R from Lockheed-Martin to SAO, contract NNM07AB07C from NASA to SAO and grant number NNX12AI30G from NASA to SAO.

Author(s): ***Patricia Jibben (Harvard-Smithsonian Center for Astrophysics)***, Kathy Reeves (Harvard-Smithsonian Center for Astrophysics), Yingna Su (Harvard-Smithsonian Center for Astrophysics)

323.53 – Hinode/EIS observations signatures of plume and interplume regions.

Alfven waves are a very promising mechanism to explain the process by which energy is transported from the solar surface into the solar corona and then dissipated by various process, thereby heating the solar corona and driving the solar wind. Recent work has shown that Alfven waves both carry and dissipate enough energy to heat coronal holes and accelerate the fast solar wind. Within coronal holes, one finds plumes, relatively bright, narrow structures, coinciding with open magnetic field lines. They expand from the chromosphere far out into the solar corona. Many aspects of these structures remain poorly understood, such as their morphology and their contribution to the fast solar wind. More specifically, it is not known whether the plume or interplume regions are the preferred channel for supplying material into the fast solar wind. In this work, we investigate spectroscopically the properties of both plume and interplume regions, using Hinode/EIS observations during the recent solar minimum. In particular, we focus on determining the wave properties of the gas, through the analysis of EUV line width variations. The presence of such waves broadens spectral lines in proportion to the wave amplitude. By separating both the thermal and non-thermal broadening, we can determine the energy carried by waves within such structures as well as the ion temperatures. Density and additional temperatures diagnostics are also used allowing us to further characterize the coronal plasma.

Author(s): ***Chloe Guennou (Columbia astrophysics Laboratory)***, Daniel Savin (Columbia astrophysics Laboratory), Michael Hahn (Columbia astrophysics Laboratory)

323.54 – SDO/AIA observations and model of standing waves in hot coronal loops excited by a flare

The strongly damped Doppler shift oscillations in hot coronal loops were first observed by SOHO/SUMER in flare lines formed at plasma temperature more than 6 MK. They were mainly interpreted as the standing slow magnetosonic waves excited by impulsive energy release at the loop’s footpoint based on the measured properties and on MHD modeling results. Longitudinal waves with similar properties have been recently observed by SDO/AIA in active region loops. In this study, we report a new event that exhibited the flare-excited intensity disturbances propagating back and forth in a hot coronal loop imaged by AIA in 131 bandpass. We measure the physical parameters of the wave and loop plasma, determine the loop geometry, and explore the triggering mechanism. We identify the wave modes (propagating or standing waves) based on these measurements and on 3D MHD modeling. A loop model is constructed with enhanced density in a hydrostatic equilibrium following potential or force-free magnetic field lines extrapolated from the photospheric magnetic field data observed by SDO/HMI. We also discuss the applications of coronal seismology to this event.

Author(s): ***Tongjiang Wang (Catholic Univ of America / NASA GSFC)***, Leon Ofman (Catholic Univ of America / NASA GSFC), Elena Provornikova (Catholic Univ of America / NASA GSFC), Joseph Davila (NASA's GSFC)

323.55 – Coronal Cavity Catalog from SDO Observations

We present a catalog of coronal cavities and prominences associated with cavities since the launch of Solar Dynamics Observatory (SDO). Coronal cavities are dark, circular regions observed above the solar limb in white light and EUV coronal images. They are believed to be regions of lower density relative to the surrounding corona. We use synoptic maps made from EUV images from the Atmospheric Imager Assembly (AIA) instrument on board SDO to study coronal cavities. The synoptic maps, constructed from annuli above the solar limb, best show cavities in 211 A (Fe XIV, 2.0 MK) and 193 A (Fe XII, 1.6 MK) and 171 A (Fe IX, 0.6 MK) passbands. Moreover, 304 A (He II, 0.05 MK) synoptic maps best show the evolution of any prominences associated with a cavity. The catalog lists the number of cavities seen in each Carrington rotation starting from CR 2097, the cavity’s size, shape, and the heliographic longitudes and latitudes of the appearance and disappearance of the cavity. Our goal is to provide a consistent set of the cavity structures for broad scientific use.

Author(s): ***Nishu Karna (NASA GSFC)***, Jie Zhang (George Mason University), William Pesnell (NASA GSFC), Shea Hess Webber (NASA GSFC)

323.56 – Untangling Coronal Streamers from Pseudostreamers

We study the coronal source regions of the solar wind -- in particular the coronal streamers and pseudostreamers that are believed to be the sources of slow wind streams -- with multi-spacecraft and ground-based observations. Due to the large number of both unipolar pseudostreamers and classical bipolar helmet streamers and their long persistence over multiple solar rotations, their relative contributions to the solar wind are likely to be substantial. We compare the physical properties of selected helmet streamers and pseudostreamers to characterize how the differences in magnetic topology affect the plasma properties of the coronal structures. In order to investigate slow solar wind heating and acceleration, we also compare our measurements with predictions from streamer and pseudostreamer theoretical models. This work is supported by NASA grant NNX10AQ58G to the Smithsonian Astrophysical Observatory.

Author(s): ***Mari Paz Miralles (Harvard-Smithsonian CfA)***, Steven Cranmer (Harvard-Smithsonian CfA), Guillermo Stenborg (George Mason University)

323.58 – Solar Energetic Particle Events in Different Types of Solar Wind

We examine statistically some properties of 96 20 MeV gradual solar energetic proton (SEP) events as a function of three different types of solar winds (SWs) as classified by Richardson and Cane (2012). Gradual SEP (E > 10 MeV) events are produced in shocks driven by fast (V > 900 km/s) and wide (W > 60 deg) coronal mass ejections (CMEs). We find no differences between transient and fast or slow SW streams for SEP 20-MeV event timescales. It has recently been found that the peak intensities Ip of these SEP events scale with the ~ 2 MeV proton background intensities, which may be a proxy for the near-Sun shock seed particles. Both the intensities Ip and their 2 MeV backgrounds are significantly enhanced in transient SW compared to those of fast and slow SW streams, and the values of Ip normalized to the 2 MeV backgrounds only weakly correlate with CME V for all SW types. This result implies that forecasts of SEP events could be improved by monitoring both the Sun and the local SW stream properties and that the well known power-law size distributions of Ip may differ between transient and long-lived SW streams. We interpret an observed correlation between CME V and the 2 MeV background for SEP events in transient SW as a manifestation of enhanced solar activity.

Author(s): ***Stephen Kahler (Air Force Research Laboratory)***, Angelos Vourlidas (Naval Research Laboratory)

323.59 – Taking Extreme Space Weather to the Milky Way

Extreme Space Weather events are large solar flares or geomagnetic storms, which can cause economic damage that cost billions of dollars to recover from. We have few examples of such events; only the Carrington Event (the solar superstorm) has superlatives in three categories: size of solar flare, drop in Dst, and amplitude of aa. Kepler observations show that stars similar to the Sun can have flares releasing thousands of times more energy than an X-class flare. These flares would strongly affect the atmosphere surrounding a planet orbiting such a star. Particle and magnetic field outflows from these stars could also be present. We are investigating the level of solar activity that is necessary to strongly affect the atmosphere of terrestrial planets. We assume that a habitable planet requires an atmosphere with a temperature and composition that is stable in time. Can we then extrapolate results from our solar system to determine a space of stellar parameters in which habitable planets can exist?

Author(s): ***W. Pesnell (NASA GSFC)***

323.60 – Validating solar wind prediction using the Current Sheet Source Surface model

We have carried out a comparative study of the predicted solar wind based on the flux tube expansion factor (FTE) computed using the Current Sheet Source Surface (CSSS) model and the Potential Field Source Surface (PFSS) model, with the aim of determining whether the CSSS model represents the solar wind sources better than the PFSS model. For this, we obtained the root mean square errors (RMSEs) and the correlation coefficients between the observed solar wind speed and that predicted by the models, the ratio of RMSEs between the two models, and a skill score. On average, the CSSS predictions are more accurate than the PFSS predictions by a factor of~1.6, taking RMS error as the metric of accuracy. The RMS errors increased as the solar cycle progressed towards maximum indicating the difficulty in modelling the corona as the global field becomes more complex. We also compared the WSA/ENLIL predictions for a few Carrington rotations; WSA model makes use of the PFSS extrapolations to model the wind source. We found that the average value of RMSE ratio between the CSSS and the WSA/ENLIL predictions was about~1.9, implying that the CSSS predictions are nearly twice better than the WSA/ENLIL predictions, despite the simplicity of the CSSS model compared to ENLIL. We conclude, based on the present analysis, that the CSSS model is a valid proxy for solar wind measurements and that it improves upon existing commonly--used methods of wind prediction or proxy analysis.

Author(s): ***Bala Poduval (Southwest Research Institute)***, Xuepu Zhao (Stanford University)

323.61 – Interpretation of Solar Spectral Irradiance variations from analysis of 3D MHD simulations

Recent measurements by SIM radiometers show that the solar irradiance varies in the Visible and IR bands in counterphase with the magnetic activity cycle. Such variations have been largely debated, as they do not agree with measurements obtained with other radiometers, while the majority of reconstruction techniques employed to reconstruct the total irradiance do not reproduce such signals. It is therefore yet not clear whether the SIM measurements are still not fully compensated for residual instrumental degradation, or if instead new physical phenomena must be invoked to explain such variations. A large part of reconstruction techniques employ semiempirical one-dimensional models. In this contribution I will explain the limitations of such models and why we expect a noticeable improvement of reconstructions obtained by 3-D magnetohydrodynamic simulations. I will also present some preliminary results obtained with the STAGGER simulations which indicate that solar irradiance in the Visible and IR bands might be in counterphase with the magnetic activity, as measured by SIM radiometers.

Author(s): ***Serena Criscuoli (AURA-NSO)***

323.62 – A 3D Radiative Transfer Simulation of Lyma-alpha Backscatter Intensity Reduced From Voyager's Ultraviolet Spectrometer

Models of the heliosphere have evolved for the past few decades to fit observations made by a large number of spacecraft. Voyager missions have provided unique in-situ measurements that have proven to be essential for model testing. Lyman-alpha backscatter intensity has been reduced from measurements taken by the ultraviolet spectrometers on board both Voyager spacecraft. We have developed a 3D Monte Carlo radiative transfer code to simulate this backscatter intensity by generating millions of photons from the sun to scatter within a neutral hydrogen distribution resulting from a state-of-the-art 3D MHD-kinetic neutral heliospheric model, both of which have been developed within the Center for Space Physics and Aeronomic Research at the University of Alabama in Huntsville. While many have attempted to simulate the Voyager observations, we are the first to achieve agreement with our results. In this presentation, we will discuss the core mechanisms driving the radiative transfer code, the statistical quantities collected, and the interpretation of the results relative to the spacecraft data.

Author(s): ***Brian Fayock (University of Alabama in Huntsville)***, Gary Zank (University of Alabama in Huntsville), Jacob Heerikhuisen (University of Alabama in Huntsville)

323.63 – The Turbulent Origin of the Slow Solar Wind

We report on preliminary analyses of early solar wind turbulence via heliospheric imaging: both the brightness structure function in the STEREO-A HI-1 field of view and paths taken by individual boli of comet-tail material in the solar wind. The analyses are complementary and preliminary results indicate that turbulent processing is underway even within the early HI-1 field of view (as low as 20-30 Rs).

Author(s): ***Craig DeForest (Southwest Research Inst.)***, Bill Matthaeus (University of Delaware), Tim Howard (Southwest Research Inst.)

323.64 – Connecting the Dots - Magnetic Field in the Inner Heliosphere

At any given time the Earth is connected by a cluster of magnetic field lines to the solar photosphere. The same holds true for any location in the heliosphere - be it a solar orbiting spacecraft, region of particle acceleration, source of southward IMF, flare site, ICME, co-rotating interaction region, comet, planet, etc. That cluster of field lines may have a common origin that is relatively easy to identify, e.g. in the center of a high speed stream originating in an equatorial coronal hole. More often the geometry is complex - adjacent field lines may come from widely separated places, the coronal topology may be convoluted, and the field will have been distorted during its transit. Furthermore, conditions change and history is important - foot points move or reconnect, the corona is dynamic - sometimes dramatically so, and the prior state of the heliosphere matters. Conversely, a region of interest, e.g. an active region, coronal hole, reconnection site, or shock, may be linked simply or in a more complex way to one or many other locations in the heliosphere. We bring together a variety of coronal and heliospheric modeling tools and new sources of comprehensive solar data to improve the knowledge of how points in the heliosphere are connected to each other and to the photosphere and how those connections evolve in time. Our goal is to determine not only the useful magnetic connections in the corona and inner heliosphere, but the implications of the corona's fundamental skeletal structure for understanding sources of in situ observations.

Author(s): ***Jon Hoeksema (Stanford University)***, Yang Liu (Stanford University), Xudong Sun (Stanford University), Aimee Norton (Stanford University)

323.65 – Case Studies of Interplanetary Coronal Mass Ejections

We contrast the solar wind characteristics and origins for typical and extreme ICME cases using STEREO data. This past solar minimum was characterized by weak transients. In contrast the rise of the cycle included extremely fast interplanetary coronal mass ejections, with one such ICME observed in situ by STEREO A exceeding 1500 km/s at 1 AU. We will compare specific cases of slow and fast ICME solar wind observed in situ by STEREO to general solar wind ion parameters, particularly for proton, helium and iron ions.

Author(s): ***Antoinette Galvin (Univ. of New Hampshire)***, Kristin Simunac (Univ. of New Hampshire), Charles Farrugia (Univ. of New Hampshire)

323.66 – Temporal Evolution of Solar Wind Ion Composition and their Source Coronal Holes During the Declining Phase of Cycle 23

We present our analysis of the temporal trend in the solar wind (SW) ion charge states and the properties in the associated source coronal holes (CHs) during the declining phase of solar cycle 23. We find that the SW ions exhibit a trend of decreasing ionization state with time, consistent with previous studies. However the rate of decrease is different between the slow and fast SW. The photospheric magnetic field strength in both regions is found to exhibit similar trend of decrease with time. On the other hand, the temporal trend is different in the line emissions from different layers of the atmosphere (chromosphere, transit region and corona). Within each CH, the coronal emission generally increases toward the boundary of the CH as the underlying photospheric magnetic field strength increases, the net unbalanced field strength decreases and the magnetic field becomes less unipolar. But the coronal emission averaged over the entire CH area does not have appreciable change with time. We find that ions which freeze-in at lower altitude in the corona, such as C and O ions, have a stronger correlation between their ionization state and the average photospheric magnetic field strength in the slow SW, while Fe ions which freeze-in at higher altitude have a stronger correlation in the fast SW. Our analyses provide important clues for how the SW is formed, heated and accelerated in response to the long-term evolution of the solar magnetic field at its source coronal hole.

Author(s): ***Yuan-Kuen Ko (Naval Research Laboratory)***, Karin Muglach (NASA Goddard Space Flight Center), Yi-Ming Wang (Naval Research Laboratory), Peter Young (George Mason University), Susan Lepri (University of Michigan)

323.67 – A Study of Type II Radio Bursts to Map the Alfvén Speed Profile in the Inner Heliosphere

It is well accepted that interplanetary Type II radio bursts are the manifestations of electron acceleration in shocks driven by propagating of coronal mass ejections (CMEs) traveling faster than the characteristic local fast magnetosonic speed. A prominent feature of type II radio bursts is the intermittency of the observed emission across the metric, decametric and kilometric frequency ranges, as the shock propagates to greater distances. This can be attributed to changes in both the shock driver and to the conditions in the ambient medium. We present results from a survey of coronal and interplanetary type II radio bursts using radio observations from STEREO/WAVES and WIND/WAVES to determine the distance of the observed type II emission and the speed of the associated shock. By establishing regions of the corona and interplanetary medium that are predisposed to shock formation, we map out the profile of the fast magnetosonic speed, and in turn infer the local Alfvén speed.

Author(s): ***Hazel Bain (University of California, Berkeley)***, Juan Carlos Martinez Oliveros (University of California, Berkeley), David Sundkvist (University of California, Berkeley), Stuart Bale (University of California, Berkeley)

323.68 – A Survey of STEREO LET SEP Anisotropies and their Solar and Heliospheric Associations

Studies have shown solar energetic particle (SEP) events display a variety of anisotropy behaviors. The Low-Energy Telescope (LET) of the IMPACT SEP instrument onboard the STEREO spacecraft provides in situ angular distribution measurements of the 4 – 6 MeV SEP proton flux. Using the instruments sunward and antisunward-facing sectored detector, we survey anisotropies present in SEP events covering the LET observing period. The events are categorized into those associated with unidirectional, bidirectional and omnidirectional pitch angle distributions and classified in accordance with their relation to ICME shock and magnetic cloud signatures. Determination of the source origin from the east or west of the Sun adds context for our understanding of these events.

Author(s): ***Hazel Bain (University of California, Berkeley)***, Janet Luhmann (University of California, Berkeley), Yan Li (University of California, Berkeley), Richard Leske (California Institute of Technology), Leila Mays (NASA/GSFC)

323.69 – Role of Heliospheric Magnetic Mirrors in Major SEP Events

One of the challenges in interpreting major solar energetic particle (SEP) events is that they often occur when multiple CMEs occur - making the distinction between what is newly injected at the shock source and what is temporarily trapped in the disturbed heliospheric field difficult to untangle. Recent ENLIL heliospheric modeling of such complex CME periods, including the major events periods of March 2012 and July 2012, provide some first-order indications of possibly existing SEP magnetic traps and their influences. For example, one can examine the magnetic field strength along field lines to find local minima in the field -from which trapping efficiencies can be evaluated from conservation of adiabatic invariants. One can also determine the spatial extent and lifetimes of these traps. The results give an idea of how important the large scale magnetic geometry can be in determining the heliospheric SEP environment- especially at very active times. Models that do not take this into account may incorrectly infer the shock source strength and time evolution. (Model results provided by CCMC/SWRA.)

Author(s): ***Janet Luhmann (UC, Berkeley)***, Leila Mays (CUA), Dusan Odstrcil (George Mason University), Hazel Bain (UC, Berkeley), Yan Li (UC, Berkeley)

323.70 – Laboratory Study of Magnetic Reconnection in Partially Ionized Plasmas Relevant to the Solar Chromosphere

Magnetic reconnection is observed to occur in the solar chromosphere where plasma is only partially ionized. In order to understand the effects of partial ionization on the reconnection process, systematic experiments have been performed in the Magnetic Reconnection Experiment (MRX) where plasma is controlled from nearly full ionization to partial ionization of about 1%. It is shown that, when neutrals are added, the Hall quadrupole field pattern and thus electron flow are unchanged while the ion outflow speed is reduced due to ion-neutral drag. However, in contrast to theoretical predictions, the ion diffusion layer width does not change appreciably. Therefore, the total ion outflow flux and the normalized reconnection rate are reduced*. Both 2-fluid and 3-fluid modeling using the HiFi code is used to interpret the experimental data, and implications to the interpretation of solar observations will be also discussed. Future plans to study effects of neutral particles on further details on magnetic reconnection, such as plasma heating, will be described. * E. Lawrence, H. Ji, M. Yamada, and J. Yoo, "Laboratory Study of Hall Reconnection in Partially Ionized Plasmas", Phys. Rev. Lett. 110, 015001 (2013).

Author(s): ***William Fox (Princeton Plasma Physics Laboratory)***, Bart De Pontieu (Lockheed Martin), Hantao Ji (Princeton Plasma Physics Laboratory), Eric Lawrence (Princeton Plasma Physics Laboratory), Vyacheslav Lukin (Naval Research Laboratory), Nicholas Murphy (Havard-Smithsonian Center for Astrophysics), Masaaki Yamada (Princeton Plasma Physics Laboratory), Jongsoo Yoo (Princeton Plasma Physics Laboratory)

301 – On the Shoulders of Giants: Planets Beyond the Reach of Kepler III: Ground-based Imaging and Spectroscopy

Meeting-in-a-Meeting – America Ballroom North/Central – 04 Jun 2014 10:00 AM to 11:30 AM

What kind of planets lie at orbit radii of 1-2 AU - beyond the reach of Kepler? In the last two decades we have explored a large sample of RV-detected and transit-detected planets, discovered distant planets with microlensing and several hot young planets at large radii using direct imaging, as well as the debris disks that provide clues to formation and evolution. In these 4 sessions, we explore the near future, and how we can expect to learn much more about the demographics and properties of cold outer planets. WFIRST-AFTA will open up this area, with a microlensing survey to probe the population of long-orbit planets, and coronagraphy to take images and spectra of large planets in orbits at a few AU. Session III covers direct observation of exoplanets with imaging and spectroscopy, and what we learn from debris-disks around planet-bearing stars.

Chair(s):
Charles Beichman (JPL)

Organizer(s):
Stephen Unwin (JPL)

301.01 – Detecting and Characterizing Exoplanets with Direct Imaging from the Ground

The last decade has yielded the first images of exoplanets, considerably advancing our understanding of the properties of young giant planets. In this talk I will discuss current results from ongoing direct imaging efforts as well as future prospects for detection and characterization of exoplanets via high contrast imaging. Direct detection, and direct spectroscopy in particular, have great potential for advancing our understanding of extrasolar planets. In combination with other methods of planet detection, direct imaging and spectroscopy will allow us to eventually: 1) study the physical properties of exoplanets (colors, temperatures, etc.) in depth and 2) fully map out the architecture of typical planetary systems. Direct imaging has offered us the first glimpse into the atmospheric properties of young high-mass (3-10 M Jup) exoplanets. Deep direct imaging surveys for exoplanets have also yielded the strongest constraints to date on the statistical properties of wide giant exoplanets.

Author(s): ***Beth Biller (MPIA)***

301.02 – The Gemini Planet Imager

The Gemini Planet Imager (GPI) is a next-generation adaptive optics coronagraph designed for direct imaging and spectroscopy of extrasolar planets and polarimetry of circumstellar disks. It is the first such facility-class instrument deployed on a 8-m telescope, designed to achieve contrast levels of up to 10^7. This allows observations of warm self-luminous planets, with masses greater than a Jupiter mass and ages less than a few hundred megayears. GPI will be used for a large-scale survey of 600 nearby young stars, as well as for guest observer science. I will present first-light science results and discuss the scientific capabilities of GPI.

Author(s): ***Bruce Macintosh (Stanford University)***

301.03 – SEEDS - Direct Imaging of Exoplanets and Their Forming Disks with the Subaru Telescope

SEEDS (Strategic Explorations of Exoplanets and Disks with Subaru) is the first Subaru Strategic Program, whose aim is to conduct a direct imaging survey for giant planets as well as protoplanetary/debris disks at a few to a few tens of AU region around 500 nearby solar-type or more massive young stars devoting 120 Subaru nights for 5 years. The targets are composed of five categories spanning the ages of ~1 Myr to ~1 Gyr. Some RV-planet targets with older ages are also observed. The survey employs the new high-contrast instrument HiCIAO, a successor of the previous NIR coronagraph camera CIAO for the Subaru Telescope. More than 100 nights have already been observed so far without major instrument troubles. We describe the outline of this survey and present its main results. The topic includes (1) detection and characterization of one of the most lowest-mass planet via direct imaging. (2) detection of a super-Jupiter around the most massive star ever imaged, (3) detection of companions around retrograde exoplanet, which supports the Kozai mechanism for the origin of retrograde orbit. We also report (4) the discovery of unprecedentedly detailed structures of more than a dozen of protoplanetary disks and some debris disks. The detected structures such as wide gaps and spirals arms of a Solar-system scale could be signpost of planet.

Author(s): ***Motohide Tamura (National Astronomical Obs.)***

Contributing teams: SEEDS team

301.04 – Tracing Planetary System Architecture with Debris Disk Imaging

Planetary systems can be imaged indirectly via their debris disks - the remnants left over after planets form. Ongoing destruction of asteroids and comets in these disks creates a continual supply of orbiting dust around most Sun-like stars, including our own. In the Solar System such dust is bright enough to be seen with the naked eye - the Zodiacal light. Far-infrared observations by the Spitzer Space Telescope and the Herschel Space Observatory have identified many nearby stars with even brighter orbiting debris, orders of magnitude more than in the Solar System. Because they are so bright, optical imaging of debris disks is much easier than detecting their embedded planets. Such planets can be inferred from disk structure - the inner warp of beta Pic and the sharply defined eccentric rings of Fomalhaut and HD 202628, for example. Resolving individual belts of debris, meanwhile, infers the location of intermediate planets (as in the HR 8799 planetary system) and allows for comparison with the 2-belt architecture of Solar System. Debris disk imaging is particularly well suited toward exploring the outer regions of planetary systems (>10 AU), where mature (cold) planets cannot otherwise be detected. Overall, images of debris disks probe their underlying planetary systems both generally, by mapping the system architecture, and specifically, by determining the location of individual planets.

Author(s): ***Geoffrey Bryden (JPL)***

301.05 – Overview of future ground and space imaging capabilities

This talk serves as an introduction to the session and context of future exoplanet direct imaging capabilities on the ground and in space. The emphasis of the presentation is on short-medium term. On the ground a new generation of instrument (Gemini Planet Imager, VLT-SPHERE, Magellan AO) are beginning their operations with considerable improvement over the previous capabilities. In space, while HST continues operations and provides high-contrast capabilities, JWST will offer several coronagraphs both on the NIRCam and MIRI instrument as well as an aperture masking mode on NIRISS. The possibility of a coronagraphy on WFIRST/AFTA also opens new possibilities for space-based coronagraphy in the medium term.

Author(s): ***Remi Soummer (Space Telescope Science Institute)***

301.06 – Pushing the radial velocity accuracy of HARPS and HARPS-N.

HARPS and HARPS-N are reaching an incredible radial velocity precision of one meter per second on bright stars. This precision is made possible by the stability of the instrument, and the cross correlation technique that averages out the different sources of noise by stacking together the information of all the observed spectral lines. All possible lines in the spectrum are used, except a few lines sensitive to activity like for example the Ca II H and K lines, and lines close to telluric features. However, the spectra are recorded on a CCD that is not perfect. With the Earth rotating around the Sun, the spectra are shifted back and forth on the CCD and spectral lines are recorded on different sets of pixels as a function of time. I will show some strange behavior of spectral lines that crosses known features on the CCD. Some specific lines show hundreds of meters per second variation on stars that we know are quiet at the meter per second level. By studying the RV variation of each line as a function of time and not considering the ones that exhibit strong variations, it is possible to improve the accuracy of the measurements taken by HARPS and HARPS-N. I will show that this reduces the noise in the RV measurements, which allows us to confirm or reject some planetary detections that are at the limit of the noise.

Author(s): ***Xavier Dumusque (Harvard Smithsonian CfA)***

301.07 – First science results from the K2 mission

The K2 mission expands upon Kepler's groundbreaking discoveries in the fields of exoplanets and astrophysics through new and exciting observations. K2 will use an innovative way of operating the spacecraft to observe target fields along the ecliptic for the next 2-3 years. Early science commissioning observations have shown an estimated photometric precision near 400 ppm in a single 30 minute observation, and a 6-hour photometric precision of 80 ppm (both at V=12). Here we present the first science data from the spacecraft. These include observations of transiting planets, eclipsing binaries and pulsating stars.

Author(s): ***Thomas Barclay (NASA Ames Research Center)***

Contributing teams: The K2 Mission team

302 – Chromosphere and Transition Region I

Meeting-in-a-Meeting – America Ballroom South – 04 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Holly Gilbert (NASA's Goddard Space Flight Center)

302.01 – Chromospheric Diagnostics from IRIS and DST

Using data obtained during a coordinated observing campaign in September 2013, we compare the spectral and imaging diagnostics from IRIS and the instruments at the Dunn Solar Telescope (DST). We focus on a small active region observed for approximately one hour with IRIS (NUV, FUV, and SJI) in conjunction with IBIS, FIRS, and ROSA from the DST. In particular, we examine the line widths and intensities in the different chromospheric lines (H-alpha, Ca II 8542, Mg II) and the temporal evolution of these different diagnostics. This allows us to better relate the views from new window provided by IRIS to previous studies of the chromosphere.

Author(s): ***Gianna Cauzzi (National Solar Observatory)***, Kevin Reardon (INAF), Sarah Jaeggli (Montana State University), Aaron Reid (Queen's University Belfast)

302.02 – Intense active region brightenings observed by IRIS

Active region raster scans obtained with the Interface Region Imaging Spectrometer (IRIS) typically reveal a few extremely intense brightenings in the Si IV emission lines (formed around 80,000 K) that are not related to flares. The brightenings are around 0.5-1.0 arcsec (0.4-0.8 Mm) in size, and the line profiles can be very broad (up to 300 km/s), showing multiple emission components. Similar brightenings were reported from the Coronal Diagnostic Spectrometer (CDS) on board the Solar and Heliospheric Observatory (SOHO) and were termed active region blinkers. The much higher spatial and spectral resolution of IRIS together with high cadence coronal and photospheric imaging from the Solar Dynamics Observatory allows the brightenings to be identified with magnetic field and coronal signatures. Example events will be shown and statistics given.

Author(s): ***Peter Young (George Mason University)***

302.03 – The role of the chromosphere in the energization of the corona.

We present results on the effect of the partially ionized chromosphere on the transfer of magnetic field and energy into the corona during the birth and evolution of solar active regions. Using numerical MHD simulations which include the effects of partial ionization, namely ion-neutral collisions and Pedersen dissipation, we investigate how the magnetic flux and energy emerges from beneath ths surface to energize the corona, and how these chromospheric partial ionization effects modulate these processes. Of particular interest is the nature of the electric currents and the force-free nature of the magnetic field.

Author(s): ***James Leake (George Mason University)***, Mark Linton (Naval Research Laboratory)

302.04 – From static to dynamic mapping of chromospheric magnetism - FIRS and SPIES

Advancements in theoretical forward modeling and observational techniques now allow the mapping of the chromospheric magnetic field vector in some regions. We report on full maps of the chromospheric magnetic field vector across a sunspot and its superpenumbra within NOAA AR 11408. These maps are derived from full Stokes observations of the He I triplet at 1083 nm, which show both Zeeman and atomic-level polarization signatures. Yet, due to the long time to acquire these observations with the slit-based Facility Infrared Spectropolarimeter (FIRS), our measurements primarily probe long-lived chromospheric structures, albeit at very high polarization sensitivity. The fast temporal scales remain difficult to probe with conventional slit-based spectropolarimeters. Alternatively, SPIES is an instrument based on a birefringent fiber optic IFU, designed to multiplex a two-dimensional spatial field with high spectral resolution spectropolarimetry, and is an ideal tool for probing small-scale, dynamic magnetic features. We will present movies of the dynamic chromosphere acquired from SPIES across a sunspot and its fine-scaled superpenumbra.

Author(s): ***Thomas Schad (University of Hawaii)***, Haosheng Lin (University of Hawaii)

302.05 – First Simulations of a Collisional Two-Stream Instability in the Chromosphere

Observations and modeling shows that immediately above the temperature minimum in the solar atmosphere, a steep rise from below 4,000 K to over 6,000K occurs. Recent papers show that a collisional two-stream plasma instability called the Farley-Buneman Instability can develop at the altitudes where this increase occurs. This instability may play an important role in transferring energy from turbulent neutral flows originating in the photosphere to the mid-chromosphere in the form of heat. Plasma turbulence resulting from this instability could account for some or most of this intense chromospheric heating. This paper presents a set of simulations showing the development and evolution of the Farley-Buneman Instability (FBI) applicable to the chromosphere. It compares these results with the better-understood ionospheric FBI. It examines the linear behavior and the dependence of growth rates for a range of altitudes and driving flows. It also presents the first study of FBI driven plasma nonlinearities and turbulence in the chromosphere. This research should help us evaluate the FBI as a mechanism to convert neutral flow and turbulence energy into electron thermal energy in the quiet Sun.

Author(s): ***Meers Oppenheim (Boston University)***, Yakov Dimant (Boston University), Chad Madsen (Boston University), Juan Fontenla (Northwest Research Institute)

302.06 – Chromospheric Nanoflares

The traditional view is that coronal plasma results from energy release (reconnection, waves, etc.) that takes place above the chromosphere, in the corona itself. However, this need not be the case. Cool chromospheric plasma could be directly heated to high temperatures and rise upward to fill the corona. We here investigate this scenario in the context of impulsive nanoflares that occur in the upper chromosphere. Such events could represent the sudden heating of the tips of type II spicules, or they could take place in the ordinary chromosphere, completely unrelated to spicules. The results are general. We generate synthetic line profiles of Fe XIV (274) and Fe XII (195) based on a series of simulations performed with the HYDRAD 1D hydro code, which includes non-equilibrium ionization. We find that the profiles are strongly blue-shifted and/or have large asymmetries that are grossly inconsistent with actual observations. The results are in agreement with our previous analytical predictions (Klimchuk 2012). We conclude that most coronal plasma is a result of coronal energy release, not chromospheric nanoflares or type II spicules.

Author(s): ***James Klimchuk (NASA GSFC)***, Stephen Bradshaw (Rice University)

303 – CME II

Meeting-in-a-Meeting – Staffordshire – 04 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Thomas Berger (Lockheed Martin Adv. Tech. Ctr.)

303.01 – A Topological View at Observed Flare Features: An Extension of the Standard Flare Model to 3D

We conduct topology analysis of erupting non-linear force-free field (NLFFF) configurations of eight sigmoidal active regions observed with Hinode/XRT and SDO/AIA. The NLFFF models are computed using the flux rope insertion method and unstable models are utilized to represent the erupting configurations. Topology analysis shows that the quasi-separatrix layers (QSLs) in the chromosphere match well the flare ribbons observed in these regions. In addition, we show that low-lying QSLs associated with the rising flux rope change shape and extent to match the separating flare ribbons as observed by AIA. Post-flare loops are fit well by field lines lying under the generalized X-line at the bottom of the flux rope. We show a correspondence in the evolution of the post-flare loops from a strong-to-weak sheared state and the behavior of the field lines as the flux rope expands in the corona. We show that transient corona holes are associated with the footprints of the flux rope in the low atmosphere. In addition, we compute the reconnected flux in one of the regions and using information from the models constrain how much energy has been released during the event. We use this kind of topology analysis to extend the standard CME/flare model to full 3D and find implications to reconnection in 3D.

Author(s): ***Antonia Savcheva (Harvard-Smithsonian Center for Astrophysics)***, Etienne Pariat (Paris Observatory, Meudon), Sean McKillop (Harvard-Smithsonian Center for Astrophysics), Elizabeth Hanson (Univ. of California, Berkley), Yingna Su (Harvard-Smithsonian Center for Astrophysics), Edward DeLuca (Harvard-Smithsonian Center for Astrophysics)

303.02 – Kelvin-Helmholtz instability driven by CMEs expanding in a turbulent medium

Recent high resolution AIA/SDO images show clear evidence of the development of the Rayleigh-Taylor instability, as coronal mass ejections (CMEs) expand in the ambient corona. A large-scale magnetic field mostly tangential to the interface is observed, both on the CME and on the background sides. However, this magnetic field is not intense enough to quench the instability. The ambient corona is expected to be in a turbulent regime, and therefore the development of the Raleigh-Taylor instability can significantly differ from the one corresponding to a laminar medium. To study the evolution of the Rayleigh-Taylor instability in a turbulent background, we perform three-dimensional simulations of the magnetohydrodynamic equations. The instability is driven by a velocity profile tangential to the CME-corona interface, which we simulate through a hyperbolic tangent profile. The turbulent background is obtained by the application of a stationary stirring force. One of the outcomes of these simulations is the computation of the instability growth-rate for different values of the correlation length of the turbulence.

Author(s): ***Daniel Gomez (IAFE)***, Edward DeLuca (Harvard-Smithsonian Center for Astrophysics), Pablo Mininni (University of Buenos Aires)

303.03 – A SOLAR ERUPTION DRIVEN BY RAPID SUNSPOT ROTATION

We present the observation of a major solar eruption that is associated with fast sunspot rotation. The event includes a sigmoidal filament eruption, a coronal mass ejection, and a GOES X2.1 flare from NOAA active region 11283. The filament and some overlying arcades were partially rooted in a sunspot. The sunspot rotated at $\sim$10° per hour rate during a period of 6 hours prior to the eruption. In this period, the filament was found to rise gradually along with the sunspot rotation. Based on the HMI observation, for an area along the polarity inversion line underneath the filament, we found gradual pre-eruption decreases of both the mean strength of the photospheric horizontal field (B_h) and the mean inclination angle between the vector magnetic field and the local radial (or vertical) direction. These observations are consistent with the pre-eruption gradual rising of the filament-associated magnetic structure. In addition, according to the Non-Linear Force-Free-Field reconstruction of the coronal magnetic field, a pre-eruption magnetic flux rope structure is found to be in alignment with the filament, and a considerable amount of magnetic energy was transported to the corona during the period of sunspot rotation. Our study provides evidences that in this event sunspot rotation plays an important role in twisting, energizing, and destabilizing the coronal filament-flux rope system, and led to the eruption. We also propose that the pre-event evolution of B_h may be used to discern the driving mechanism of eruptions.

Author(s): ***Yao Chen (Institute of Space Sciences)***, Guiping Ruan (Institute of Space Sciences)

303.04 – The Relation between Type II Radio Bursts and Large-scale Coronal Propagating Fronts

Both type II radio bursts and chromospheric Moreton-Ramsey waves are believed to signify shock waves that propagate in the solar corona. Large-scale coronal propagating fronts (LCPFs), which are also called EIT waves, EUV waves or coronal bright fronts in the literature, were initially thought to be coronal counterparts of Moreton-Ramsey waves, and thus they were expected to be correlated with type II bursts. At present, the prevailing view seems to be that both type II bursts and LCPFs are more closely linked with CMEs than with flares. Here we revisit the relation between type II bursts and LCPFs, by examining radio dynamic spectra (180-25 MHz) as obtained by USAF/RSTN and analyzing EUV and white-light data from SDO and STEREO. In the sample of about 140 type II bursts and LCPFs between April 2010 and January 2013, we find the correlation of 50-60 %. Type II bursts could be associated with eruptions without significant lateral expansion, and fast LCPFs could show no presence in the metric radio spectral range. Using data from STEREO COR-1 that observed the CME as a limb event, in 42 cases we directly measure the height of the CME at the onset of the type II burst. As expected, the height tends to be lower when the type II burst starts at a higher frequency. It is found that those type II bursts that start at higher altitudes and lower frequencies tend to have weaker EUV fronts. This may indicate multiple ways of how LCPFs and type II bursts are related with CMEs.

Author(s): ***Nariaki Nitta (Lockheed Martin, ATC)***

303.05 – Do all CMEs deflect to the background magnetic minimum by 4Rs?

Accurate space weather forecasting requires knowledge of the trajectory of coronal mass ejections (CMEs), including any CME deflection close to the Sun or through interplanetary space. Kay et al. (2013) introduced ForeCAT, a model of CME deflection resulting from the background solar magnetic field. For a magnetic background corresponding to Carrington Rotation (CR) 2029 (declining phase, April-May 2005), the majority of the CMEs deflected to the streamer belt, the minimum in magnetic pressure. Most of the deflection occurred below 4 Rs. Here we explore the questions: a) Do all CMEs deflect to the magnetic minimum? and b) Does most deflection occur within 4 Rs? We have eliminated many of the underlying simplifications of ForeCAT presented in Kay et al. (2013) with a more detailed three dimensional description of the deflecting flux rope. The locations of coronal magnetic structures that determine the background magnetic minima vary throughout the solar cycle. We show that these variations reproduce observed trends in the direction of CME deflections throughout the solar cycle.

Author(s): ***Christina Kay (Boston Univ.)***, Merav Opher (Boston Univ.)

303.06 – Are Polar-crown Coronal Mass Ejections Similar to the Low-latitude Counterparts?

Coronal mass ejections (CMEs) from the polar-crown filament region originate above 60-degree latitude during solar activity maxima. Polar-crown CMEs originate from bipolar magnetic regions, whereas both bipolar and multipolar regions produce CMEs at low latitudes. If polar CMEs are similar to the low-latitude ones, then a single eruption mechanism can apply to all CMEs, the common element being the magnetic free energy. We examine several polar-crown CMEs to determine their three-part morphology, acceleration profile including the height of peak acceleration, CME-flare relationship, and energetics. We found that these properties are similar to those of low-latitude CMEs. We use illustrative examples from the Solar Dynamics Observatory images to show quantitatively that the polar-crown CMEs are very similar to their low-latitude counterparts. Even though the post eruption arcades are weak, we show that the peak thermal energy of these arcades is a few percent of the CME kinetic energy, similar to what is observed in large eruptive events. These observations suggest that a bipolar configuration is sufficient for the production of CMEs.

Author(s): ***N. Gopalswamy (NASA GSFC)***, Seiji Yashiro (NASA GSFC), Sachiko Akiyama (NASA GSFC)

304 – Observation and Theory for Multiverse

Special Session – St. George AB – 04 Jun 2014 10:00 AM to 11:30 AM

The multiverse is a hypothetical set of finite or infinite possible universes existing in the entire space. The highly precise map of cosmic microwave background (CMB) radiation from the data recently measured by the Planck satellite has shown some anomalies that give a hard evidence for the multiverse. The standard big bang universe model predicts that the cosmic microwave background radiation of the universe should be evenly distributed, but the map shows a stronger concentration or hotter in the south half of the sky and a large colder spot that is also not understandable under conventional physics. In addition, the observation of quantum nonlocality and the theory of natural unnaturalness have also provided support or evidence for the multiverse. There are various multiverse models developed so far such as the bubble universe model. Max Tegmark categorized the various multiverse models as four levels, while Brian Greene divided them into nine typ es. Recently, Tianxi Zhang slightly modified the standard big bang theory and developed a new multiverse model called black hole universe, which is consistent with Mach's principle, governed by Einstein's genera relativity, and be able to explain all observations of the universe. It has only one postulate but can self-consistently interpret the origin, structure, evolution, and expansion as well as quantitatively explain the measurements for the redshift and luminosity distance of type-Ia supernovae, the cosmic microwave background radiation, and the emissions of quasars and gamma-ray bursts. This session is proposed to the 224th AAS meeting in order for cosmologists to discuss and share their recent investigations on the multiverse theories and observations.

Chair(s):

Tianxi Zhang (Alabama A&M University)

304.01 – Experimentally Testing the Mulitverse/Many-Worlds Theory

Many-Worlds quantum mechanics is NOT experimentally equivalent to standard quantum mechanics. I shall demonstrate this fact and investigate its consequences. I first show the Schrödinger equation is a special case of the classical Hamilton-Jacobi equation, with $|?|^2$ being most naturally interpreted as a quantity proportional to the density of universes in the multiverse. I then show that with this interpretation for $|?|^2$, we can test the multiverse theory, because in the multiverse theory, the Born Interpretation is derived from this assumption, not merely assumed as in standard quantum theory, and the derivation gives us a means of computing how fast $|?|^2$ will build up from individual particles in an experiment, a computation I shall show cannot be done in standard quantum mechanics. In some types of experiments, the observed pattern will approach the final Born pattern as $1/N^{1/2}$, and in other types of experiments, the approach will be as 1/N, where N is the number of observed "particles." The multiverse meaning of has other advantages over the standard probability amplitude meaning, because if is a universe density amplitude, need not be restricted to being a Hilbert space function. In particular, delta functions and plane waves are NOT functions in any Hilbert space, but they are both used extensively in quantum mechanics, though disallowed by the axioms of standard quantum mechanics. Finally, I shall show that multiverse experiments have important implications for cosmology. The Wheeler-DeWitt equation for quantum gravity, applied to a spatially closed Friedman radiation universe in conformal time, is mathematically the Schrödinger equation for a simple harmonic oscillator. I show that if the wave function of the universe were a delta function at the initial singularity — I show that the universes being exactly classical now implies such a universal wave function — then we are overwhelmingly likely to find ourselves in a closed universe that is very large, hence nearly flat. Thus the existence of the multiverse solves the Flatness Problem. No inflation force is needed. I show ALL major problems of cosmology can be similarly solved.

Author(s): ***Frank Tipler (Tulane University)***

304.02 – Testing Quantum Mechanics and Bell's Inequality with Cosmological Observations of Quasars

We discuss a proposed experiment which would leverage cosmology to test quantum mechanics using astronomical observations. Specifically, we aim to close the "setting independence" or so-called "free will" loophole in experimental tests of Bell's inequality by choosing the detector settings (e.g. polarizer orientations) using real-time observations of causally disconnected cosmic sources, for example sufficiently distant quasar pairs, all while the entangled particles are still in flight. This would help close one of the most important remaining Bell test loopholes whereby an alternative theory could mimic the quantum predictions if the experimental settings choices shared even a small correlation with some local "hidden variables" due to unknown causal influences a mere few milliseconds prior to the experiment. Our "Cosmic Bell" experiment would push any such hidden variable conspiracy all the way back to the hot big bang 13.8 Gyr ago, an improvement of 20 orders of magnitude. The talk will demonstrate the real world feasibility of our experimental setup, with emphasis on the theoretical cosmology constraints needed to choose optimal sources. We thus describe general conditions for pairs of cosmological events with arbitrary redshifts and angular separations to have no shared causal pasts since the hot big bang in flat, dark energy dominated, accelerating Friedman-Lemaitre-Robertson-Walker universes like our own. While causally disjoint patches of the cosmic microwave background radiation at redshift $z \sim 1090$ could be used to set the detectors, $z > 3.65$ quasars observed at optical wavelengths are arguably the optimal candidate source pairs using present technology that meet the condition of having no shared causal past since the end of any period of inflation, 13.8 Gyr ago. Results are illustrated for our universe with causal structure animations to help visualize the intersections of past light cones for arbitrary event pairs.

Author(s): ***Andrew Friedman (Harvard-Smithsonian Center for Astrophysics)***, Jason Gallicchio (University of Chicago, Kavli Institute for Cosmological Physics), David Kaiser (Massachussetts Institute of Technology, Center for Theoretical Physics), Alan Guth (Massachussetts Institute of Technology, Center for Theoretical Physics)

304.03 – The Black Hole Universe Model

The black hole universe model is a multiverse model of cosmology recently developed by the speaker. According to this new model, our universe is a fully grown extremely supermassive black hole, which originated from a hot star-like black hole with several solar masses, and gradually grew up from a supermassive black hole with million to billion solar masses to the present state with trillion-trillion solar masses by accreting ambient matter or merging with other black holes. The entire space is structured with infinite layers or universes hierarchically. The innermost three layers include the universe that we live, the inside star-like and supermassive black holes called child universes, and the outside space called mother universe. The outermost layer is infinite in mass, radius, and entropy without an edge and limits to zero for both the matter density and absolute temperature. All layers are governed by the same physics and tend to expand physically in one direction (outward or the direction of increasing entropy). The expansion of a black hole universe decreases its density and temperature but does not alter the laws of physics. The black hole universe evolves iteratively and endlessly without a beginning. When one universe expands out, a new similar one is formed from inside star-like and supermassive black holes. In each of iterations, elements are resynthesized, matter is reconfigurated, and the universe is renewed rather than a simple repeat. The black hole universe is consistent with the Mach principle, observations, and Einsteinian general relativity. It has only one postulate but is able to explain all phenomena occurred in the universe with well-developed physics. The black hole universe does not need dark energy for acceleration and an inflation epoch for flatness, and thus has a devastating impact on the big bang model. In this talk, I will present how this new cosmological model explains the various aspects of the universe, including the origin, structure, evolution, expansion, background radiation, acceleration, anisotropy, quasars, gamma-ray bursts, nucleosynthesis, etc., and compares to the big bang model.

Author(s): ***Tianxi Zhang (Alabama A&M University)***

304.04 – Are Parallel Universes Unscientific Nonsense or Should BICEP2 Make Us Take Them Seriously?

Parallel universes are not theories, but predictions of certain theories, such as eternal inflation and no-collapse quantum mechanics. I explore the logical links between recent experimental progress in cosmology and other areas and various types of parallel universes.

Author(s): ***Max Tegmark (MIT)***

305 – Bridging Laboratory & Astrophysics: Plasmas

Meeting-in-a-Meeting – St. George CD – 04 Jun 2014 10:00 AM to 11:30 AM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This session will focus on the interplay between astrophysics with theoretical and experimental studies into the underlying plasma processes, which drive our Universe.

Chair(s):
R. Paul Drake (Univ. of Michigan)
Organizer(s):
Farid Salama (NASA Ames Research Center)

305.01 – Using Laser-produced Plasmas to Study Magnetized Collisionless Shocks

A new laser experiment to study the interaction of an energetic laser plasma with a large magnetized ambient plasma is now operational at the Large Plasma Device (LAPD) at UCLA. A rapidly exploding, and super-Alfvénic (M_A>2) plasma-plume is created by irradiating a solid target within the preformed magnetized plasma with an energetic laser pulse (200 J in 20 ns). The ambient plasma (10^{13} cm^{-3}, 5 eV) is current free, stationary, quiescent, and large enough (17x0.5 m) to support Alfvén waves. The dynamics of the laser-plasma piston and formation and structure of the shock is measured with magnetic flux-probes, spectroscopy, and Thomson scattering. We observe how the initial magnetic pulse steepens into a collisionless shock and separates from the piston by several ion Larmor radii. Hybrid simulations indicate that these features can be directly related to the degree of collisionless plasma coupling. The results will be discussed in the context of debris-ambient coupling in space and astrophysical explosions and other laboratory experiments.

Author(s): ***Christoph Niemann (UCLA)***, Derek Schaeffer (UCLA), Erik Everson (UCLA), E. Clark (UCLA), Anton Bondarenko (UCLA), Carmen Constantin (UCLA), Walter Gekelman (UCLA), Dan Winske (Los Alamos National Laboratory)

305.02 – Progress In Iron Transmission Measurements Relevant to the Solar Convection/Radiation Boundary

Iron plasma opacity influences the internal structure of the sun. However, opacity models have never been experimentally tested at stellar interior conditions. Recent iron opacity experiments at the Sandia Z facility reached 195 eV temperatures, nearly the same as the solar convection/radiation zone boundary (CZB), at electron densities that are roughly ½ the solar CZB value. Progress to solidify these results and use them to examine the physical underpinnings of opacity models will be described. We will also discuss impact of the results on the Rosseland mean opacities important for stellar physics.++Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Author(s): ***Jim Bailey (Sandia National Laboratories)***, T. Nagayama (Sandia National Laboratories), G. Loisel (Sandia National Laboratories), G. Rochau (Sandia National Laboratories), C. Blancard (CEA, DAM, DIF, F-91297), J. Colgan (Los Alamos National Laboratory), Ph Cosse (CEA, DAM, DIF, F-91297), G. Faussurier (CEA, DAM, DIF, F-91297), Christopher Fontes (Los Alamos National Laboratory), I. Golovkin (Prism Computational Sciences), S. Hansen (Sandia National Laboratories), C. Iglesias (LLNL), D. Kilcrease (Los Alamos National Laboratory), Joseph MacFarlane (Prism Computational Sciences), Roberto Mancini (Univeristy of Nevada), S. Nahar (Ohio State University), T. Nash (Sandia National Laboratories), Chris Orban (Ohio State University), Marc Pinsonneault (Ohio State University), Anil Pradhan (Ohio State University), M. Sherrill (Los Alamos National Laboratory), B. Wilson (LLNL)

305.03 – Astrophysical Weibel instability in counterstreaming laser-produced plasmas

Astrophysical shock waves play diverse roles, including energizing cosmic rays in the blast waves of astrophysical explosions, and generating primordial magnetic fields during the formation of galaxies and clusters. These shocks are typically collisionless and require collective electromagnetic fields to couple the upstream and downstream plasmas. The Weibel instability has been proposed to provide the requisite interaction mechanism for shock formation in weakly-magnetized shocks by generating turbulent electric and magnetic fields in the shock front. This work presents the first laboratory identification of this Weibel instability between counterstreaming supersonic plasma flows and confirms its basic features, a significant step towards understanding these shocks. In the experiments, conducted on the OMEGA EP laser facility at the University of Rochester, a pair of plasmas plumes are generated by irradiating of a pair of opposing parallel plastic (CH) targets. The ion-ion interaction between the two plumes is collisionless, so as the plumes interpenetrate, supersonic, counterstreaming ion flow conditions are obtained. Electromagnetic fields formed in the interaction of the two plumes were probed with an ultrafast laser-driven proton beam, and we observed the growth of a highly striated, transverse instability with extended filaments parallel to the flows. The instability is identified as an ion-driven Weibel instability through agreement with analytic theory and particle-in-cell simulations, paving the way for further detailed laboratory study of this instability and its consequences for particle energization and shock formation. [1] W. Fox, G. Fiksel, A. Bhattacharjee, P. Y. Chang, K. Germaschewski, S. X. Hu, and P. M. Nilson, “Filamentation instability of counterstreaming laser-driven plasmas,” Phys. Rev. Lett. 111, 225002 (2013).

Author(s): ***William Fox (University of New Hampshire)***, Gennady Fiksel (University of Rochester), Amitava Bhattacharjee (Princeton University), Po-Yu Change (University of Rochester), Kai Germaschewski (University of New Hampshire), Suxing Hu (University of Rochester), Philip Nilson (University of Rochester)

305.04 – Investigation of Interacting Fast and Slow Winds in Multi-ring Nebulae

Ring nebulae are often observed in the final stages of blue supergiant stars. The generally accepted formation paradigm for these systems typically consists of a sparse, fast wind interacting with a previously ejected denser, slow wind. Various numerical codes have demonstrated that such an interaction may explain observed ring nebulae. We propose a novel set of laboratory-astrophysics experiments to investigate the interaction of these two fluids and provide a controllable system to benchmark numerical simulations. The experimental platform and nominal parameters will be discussed. Support for this work was provided by NASA through Einstein Postdoctoral Fellowship grant number PF3-140111 awarded by the Chandra X-ray Center, which is operated by the Astrophysical Observatory for NASA under contract NAS8-03060. This work is funded by the NNSA-DS and SC-OFES Joint Program in High-Energy-Density Laboratory Plasmas, grant number DE-NA0001840 and by the Predictive Sciences Academic Alliances Program in NNSA-ASC via grant DEFC52- 08NA28616. Work by LLNL was performed under the auspices of U.S. DOE under contract DE-AC52-07NA27344.

Author(s): ***Mario Manuel (Smithsonian Astrophysical Observatory)***, R. Paul Drake (University of Michigan)

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306 – Education and History

Oral Session – Gloucester, 2nd Floor – 04 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Jay Pasachoff (Williams College)

306.01 – Higher Education Resources from the NASA SMD Astrophysics Forum

The NASA Astrophysics Science Education and Public Outreach Forum (SEPOF) coordinates the work of individual NASA Science Mission Directorate (SMD) Astrophysics EPO projects and their teams into a coherent, effective, efficient, and sustainable effort. The Astrophysics Forum assists scientists and educators with becoming involved in SMD E/PO and makes SMD E/PO resources and expertise accessible to the science and education communities. Here we describe how the Astrophysics Forum and the Astrophysics E/PO community have focused efforts to support and engage the higher education community on enhancing awareness of the resources available to them. To ensure Astrophysics higher education efforts are grounded in audience needs, we held informal conversations with instructors of introductory astronomy courses, convened sessions with higher education faculty and E/PO professionals at conferences, and examined existing literature and findings of the SMD Higher Education Working Group. To address the expressed needs, the Astrophysics Forum collaborated with the Astrophysics E/PO community, researchers, and Astronomy 101 instructors to place individual science discoveries and learning resources into context for higher education audiences. Among these resources are two Resource Guides on the topics of cosmology and exoplanets. These fields are ripe with scientific developments that college instructors have told us they find challenging to stay current. Each guide includes a wide variety of sources and is available through the ASP website: http://www.astrosociety.org/education/astronomy-resource-guides/ To complement the resource guides, we are developing a series of slide sets to help Astronomy 101 instructors incorporate new discoveries from individual SMD Astrophysics missions in their classrooms. The “Astro 101 slide sets” are 5-7 slide presentations on a new development or discovery from a NASA SMD Astrophysics mission relevant to an Astronomy 101 topic. We intend for these slide sets to help Astronomy 101 instructors include new, unfamiliar developments (discoveries not yet in their textbooks) into the “big-picture” context of the course.

Author(s): ***Bonnie Meinke (STScI)***, Gregory Schultz (Astronomical Society of the Pacific), James Manning (NASA Astrophysics SEPOF), Denise Smith (STScI), Luciana Bianchi (Johns Hopkins University), William Blair (Johns Hopkins University), Andrew Fraknoi (Foothill College)

Contributing teams: the Astrophysics E/PO community

306.02 – Leveraging Cognitive Science Underpinnings to Enhance NGSS Astronomy Concepts

National-scale science education reform efforts have been hampered by highly fragmented frameworks and standards that vary considerably from one state to the next. In an effort to improve the quality of science education across the nation’s K-12 schools, the 2013 Next Generation Science Standards (NGSS) have been designed to guide states in specifying the learning targets and performance expectations of all K-12 students. The NGSS is designed to reflect the 2011 Framework for K-12 Science Education developed by the National Research Council of the National Academy of Sciences. As teachers, curriculum developers, and assessment experts begin to implement the NGSS in specific geographical and socio-economic contexts, moving beyond an examination of common student misconceptions and reasoning difficulties to delineate the specific cognitive sources of those difficulties, and the specific interventions that can serve as countermeasures, should be a fruitful next step. While astronomy education researchers have already documented challenges in teaching system processes that operate with the space system, solar system, and interconnected Earth science systems, we are far from a thorough understanding of student thinking in astronomy. Many of these ideas can be better taught-and tested-by carefully examining the underlying cognitive science including learners’ difficulties with spatial thinking and the prescribed astronomy and space science concepts. The NGSS may prove to be useful as a framework for next steps in the cognitive science within astronomy, and this work may benefit from deliberate collaborations between education researchers, curriculum developers, and those who engage in teacher professional development.

Author(s): ***Stephanie Slater (CAPER Center for Astronomy & Physics Education Research)***, Timothy Slater (University of Wyoming)

306.03 – The Pulsar Quartet: Listening to a Galactic Symphony

Pulsars are exotic dead stars that emit very regular radio pulses. These pulses are attributed to their regular rotation. Some pulsars are spinning fast enough that the audio equivalent waveform of their pulses fall within our hearing range. If human ears were tuned to radio waves it would have been possible to ‘hear’ these very compact stars. We produced the audio waveform of these pulsar signals and mapped them onto a frequency chart to find the corresponding musical notes. We use these ‘audible' pulsars like musical instruments in a symphony orchestra to play a full quartet. At the same time, an accompanying visual interface shows the realistic distribution of all pulsars in our own Galaxy. Pulsars shine as they play each note in the quartet with realistic brightening and subsequent dimming proportional to their rotational energies. This can serve as an educational tool at all levels to demonstrate many interesting aspects of stellar evolution and articulate an aesthetic connection of us with the cosmos. Interested in watching the light show while the Milky Way Pulsar Orchestra plays a quartet?

Author(s): ***Bülent Kiziltan (Harvard-Smithsonian Center for Astrophysics)***

306.04 – Nova Discovery Efficiency 1890-2014; Only 43%±6% of the Brightest Nova Are Discovered

Galactic nova discovery has always been the domain of the best amateur astronomers, with the only substantial exception being the use of the Harvard plates from 1890-1947. (Modern CCD surveys have not produced any significant nova discoveries.) From 1890-1946, novae were discovered by gentlemen who deeply knew the stars in the sky and who checked for new stars on every clear night. This all changed when war surplus binoculars became commonly available, so the various organizations (e.g., AAVSO, BAA) instructed their hunters to use binoculars to regularly search small areas of the Milky Way. In the 1970s the hunters largely switched to blinking photographs, while they switched to CCD images in the 1990s, all exclusively in Milky Way regions. Currently, most hunters use 'go-to' scopes to look deeply only in the Milky Way, use weekly or monthly cadences, never go outside to look up at the light-polluted skies, and do not have the stars memorized at all. This situation is good for catching many faint novae, but is inefficient for catching the more isotropic and systematically-fast bright novae. I have made an exhaustive analysis of all known novae to isolate the effects on the relative discovery efficiency as a function of decade, the elongation from the Sun, the Moon's phase, the declination, the peak magnitude, and the duration of the peak. For example, the relative efficiency for novae south of declination -33° is 0.5 before 1953, 0.2 from 1953-1990, and 0.8 after 1990. My analysis gives the overall discovery efficiency to be 43%±6%, 30%, 22%, 12%, and 6% for novae peaking brighter than 2, 4, 6, 8, and 10 mag. Thus, the majority of first magnitude novae are being missed. The bright novae are lost because they are too close to the Sun, in the far south, and/or very fast. This is illustrated by the discovery rate for Vpeak<2 novae being once every five years before 1946, yet only one such nova (V1500 Cyg) has been seen in the last 68 years. A critical consequence of this result is that the nova rate for our Milky Way has doubled.

Author(s): ***Bradley Schaefer (Louisiana State Univ.)***

306.05 – The first published chart of the Andromeda Nebula, 1667

The Parisian astronomer Ismaél Bullialdus (1605–1694) is known for his planetary tables (Astronomia philolaica, 1645) based on a geometrical approximation to the Keplerian ellipse, and for his long correspondence with the Danzig astronomer Johannes Hevelius and with Christiaan Huygens. Bullialdus became interested in the nascent study of variable stars, and in 1667 published a small pamphlet with two contributions, one on Mira Ceti and the other on the nebula in Andromeda. He found a manuscript portraying the nebula with the date 1428, and because Tycho Brahe never mentioned a nebula in Andromeda, Bullialdus conjectured that this object was a variable that had disappeared in the intervening era. “We conclude this since this conglomeration was observed neither by Hipparchus nor anyone else in antiquity, nor in the previous age by Tycho, nor in the age of our forefathers like Bayer.” His publication included a handsome engraving of the image of Andromeda and the position of the nebula, its first printed chart. I recently acquired a copy of this rare pamphlet, Ad astronomos monita duo, and realized that the image matched a manuscript now in the Gotha Research Library, a 15th-century Latin version based on the work of the tenth-century Islamic astronomer, al-Sufi. The manuscript does not carry the name of al-Sufi, and hence Bullialdus had no real clue about its origin or its date of composition. Paul Kunitzsch (The Arabs and the Stars, 1989, Article XI, “The Astronomer Abu ’l-Husayn al-Sufi”) has identified a group of eight “Latin al-Sufi” manuscripts from this period, scattered in European libraries, but only the one now in Gotha is an exact match to Bullialdus’ engraving. The al-Sufi manuscript was given to the Gotha Library in 1798 by Duke Ernst II of Saxonia-Gotha-Altenburg, who must have acquired it from France sometime in the 18th century.

Author(s): ***Owen Gingerich (Harvard-Smithsonian, CfA)***

306.06 – The Portrayal of the Medicean Moons in Early Astronomical Charts and Books

Galileo’s talents in perspective and chiaroscuro drawing led to his images of the Moon being accepted as the portrayal of a truly natural physical place. The Moon was seen as a world—real but separate from Earth. In contrast to his resolved views of the Moon, Galileo saw the moons of Jupiter as only points of light, and thus in Sidereus Nuncius they appear as star-symbols. Within 50 years, in Cellarius’ Atlas Coelestis seu Harmonia Macrocosmica (1660), the Medicean moons continue to appear in multiple charts as star-shaped symbols—in most cases equidistant from Jupiter. They appear in the Cellarius charts as updates to the cosmological systems of Copernicus and Tycho Brahe, but not in the charts devoted to the Ptolemaic system. A quarter century later, Mallet did not include the moons of Jupiter in his Copernican chart in Description de l’Universe (1683). Around 1690, in Jaillot’s Four Systems of Cosmology, the Medicean moons appear as circular symbols in four distinct concentric orbits around Jupiter. Additional examples appear in a later edition of Mallet ((1690s), and in De Fer (1705), Dopplemayer (1720), and still later in Buy de Mornas (1761). As objects discussed in scientific book, symbolic representations of the Medicean moons appear in Marius (1614), Descartes (1644), Fontana (1646) and Hevelius (1647). A pictorial survey of antiquarian charts and books depicting the Medicean moons will be the focus of this presentation. As telescope sizes increased, the Galilean moons could be seen as extended objects, and thus the transition occurred from portraying the moons as points of light to disks with physically-meaningful details. Initially, these were done via drawings of glimpses of the disks of the four moons during moments of extremely good seeing (termed “lucky images” in the pre-adaptive optics period). This era of portraying surface characteristics of Io, Europa, Ganymede and Callisto by hand-drawn images from naked-eye observations ended in the 1970s when spaceflight missions to the outer planets returned photographic images.

Author(s): ***Michael Mendillo (Boston University)***

307 – Sebastian Heinz: Jets On All Scales: A Phenomenological View of Collimated Outflows and Their Importance for Cosmic Structure

Plenary Session – America Ballroom North/Central – 04 Jun 2014 11:40 AM to 12:30 PM

Chair(s):
Chryssa Kouveliotou (NASA/MSFC)

307.01 – Jets on all scales: a phenomenological view of collimated outflows and their importance for cosmic structure

The concept of a relativistic jet is simple: A bundled flow of momentum and energy, launched by an accretion flow onto a massive compact object - most commonly a black hole. Phenomenologically, jets do indeed show a range of simple properties that connect them across a wide range of scales: similar radiative processes and observational signatures, similar efficiencies in converting accreted mass to outflow energy, similar morphologies. This common, apparent simplicity in observable properties hides the complex plasma astrophysics at work in the creation of the often ultra-relativistic flows we observe in extragalactic jets. It indicates that the underlying processes, if not simple, are at least similar in a wide range of objects and suggests that we may learn a lot about the properties of jets and the central engines that create them even in the absence of a complete understanding of jet acceleration and collimation. The scientific benefit of such an approach can be significant: For example, we now know that jets are energetically important in the context of cosmic structure formation and galaxy evolution, and phenomenological scaling models can provide well calibrated models for how jets impact their environments. I will present an overview of jet phenomenology and how an integrated view of the problem for a wide range of black hole properties can inform models of jet creation as well as global models of feedback on interstellar and intergalactic scales.

Author(s): ***Sebastian Heinz (Univ. Of Wisconsin, Madison)***

311 – On the Shoulders of Giants: Planets Beyond the Reach of Kepler IV: The Near Future

Meeting-in-a-Meeting – America Ballroom North/Central – 04 Jun 2014 02:00 PM to 03:30 PM

What kind of planets lie at orbit radii of 1-2 AU - beyond the reach of Kepler? In the last two decades we have explored a large sample of RV-detected and transit-detected planets, discovered distant planets with microlensing and several hot young planets at large radii using direct imaging, as well as the debris disks that provide clues to formation and evolution. In these 4 sessions, we explore the near future, and how we can expect to learn much more about the demographics and properties of cold outer planets. WFIRST-AFTA will open up this area, with a microlensing survey to probe the population of long-orbit planets, and coronagraphy to take images and spectra of large planets in orbits at a few AU. Session IV covers what we can expect to learn about this planet population in the near future. In addition to TESS and JWST under development, we also discuss the contributions of AFTA-WFIRST through microlensing and spectroscopy.

Chair(s):
Thomas Greene (NASA Ames Research Center)

Organizer(s):
Stephen Unwin (JPL)

311.01 – Overview of WFIRST-AFTA Mission Capabilities

Wide-Field Infrared Survey Telescope (WFIRST), the top-priority mission in the 2010 Astronomy & Astrophysics Decadal Survey, is now planned to use an already-built 2.4m telescope obtained from the National Reconnaissance Organization. This telescope provides image clarity similar to HST, but with an optical design and array of new-generation H4RG infrared detectors that enables imaging of 100 times the area of HST in a single exposure. This wide-field IR instrument will provide galaxy surveys and supernova monitoring for dark energy studies that are significantly deeper than those planned by other observatories. A microlensing survey of the galactic bulge will give a census of exoplanets that is at larger distance to the Kepler sample. A coronagraph instrument will directly image ice and gas giant planets, and circumstellar disks. There will be significant opportunities for guest observer science. The talk will summarize capabilities and current status.

Author(s): ***Neil Gehrels (NASA's GSFC)***

311.02 – Mass Measurements for Microlens Planets with WFIRST/AFTA

Unlike ground-based surveys, WFIRST/AFTA will be able to systematically measure masses of the lens stars (and hence their planets) for a large number of microlensing events. I will review the methods WFIRST/AFTA will use to measure masses (detection of lens light, microlens parallax, and astrometric microlensing) and present a few examples of how these techniques have been applied to date. These mass measurements are important for understanding the planet population and characterizing structures in the planet mass function beyond the snow line. In addition, they can be used to measure the stellar mass function from black holes to brown dwarfs and unambiguously identifying free-floating planets.

Author(s): ***Jennifer Yee (Harvard Smithsonian CfA)***

311.03 – WFIRST-AFTA: What Can We Learn by Detecting Thousands of Cold Exoplanets via Microlensing?

The WFIRST-AFTA microlensing survey will monitor a few hundred million stars in the Galactic bulge every ~15 minutes to measure the microlensing signatures of thousands of both bound and free-floating planets with masses ranging from super-Jupiters down to that of Ganymede. This huge sample of cold planets will perfectly compliment the sample of warm and hot planets that have been found by Kepler and will be further expanded by TESS and PLATO. I will review the measurements that WFIRST-AFTA will make for each of the planets it finds, and attempt to predict the impact that these will have on our understanding of exoplanet demographics and the planet formation process.

Author(s): ***Matthew Penny (Ohio State University)***

311.04 – Capabilities of WFIRST-AFTA for coronagraphic imaging of exoplanets

The coronagraph on WFIRST-AFTA will be capable of detecting all known radial velocity planets within its range of angular sensitivity, and of characterizing them with photometry and spectroscopy. The coronagraph will also be capable of detecting as-yet unknown exoplanets, from gas giants down to super-Earths around nearby stars, and zodiacal dust disks down to the level of a few times the solar system zodi.

Author(s): ***Wesley Traub (Jet Propulsion Laboratory)***

311.05 – Observing Other Worlds With JWST

Exoplanet science is one of the four highest level science themes identified by the JWST project. And indeed, JWST offers dramatic capabilities for characterizing exoplanets with all four of its science instruments. The major observing modes will be coronagraphic imaging, transit photometry, and transit spectroscopy. Both the near-IR camera, NIRCam, and the mid-IR instrument, MIRI, have coronagraphs which will be able to image directly young planets orbiting nearby stars. While 8-10 m ground-based telescopes equipped with Extreme AO can work at smaller inner working angles, JWST will offer unprecedented sensitivity at 3-20 um outside of ~1" (~4 lam/D at 5 um). At these angular separations JWST will push the detection limit for young planets orbiting at ~10-200 AU down to roughly the mass of Saturn from present-day limits of a few times the mass of Jupiter. This imaging will be carried out using a variety of narrow-, medium- and broad filters to characterize exoplanet orbits and atmospheres. NIRCam and MIRI coronagraphs will also make detailed maps of bright debris disks to investigate their shapes and composition. All four instruments have photometric and spectroscopic capabilities for transit observations. NIRCam and MIRI will study primary and secondary transits and obtain full orbital light curves in a variety of photometric filters with precision much better than 100 ppm. NIRCam and the Canadian instrument, NIRISS, have grism spectrometers which together span the 1-5 um region at resolutions of a R~300-2,000. NIRSpec has prism and spectrometer modes with spectral resolutions ranging from R=30- 3,000 across the 1-5 um region. MIRI has spectrometer and grism capabilities extending out to 30 um. These spectra and light curves will be used to investigate atmosphere composition, surface gravity, vertical structure, and horizontal flows. With exoplanet research identified as one of JWST's four highest level science themes, the exoplanet community should be planning a wide variety of programs that will be strong enough to capture 25% of JWST's observing time.

Author(s): ***Charles Beichman (JPL)***

311.06 – Exo-S: A Probe-scale Space Mission to Directly Image and Spectroscopically Characterize Exoplanetary Systems Using a Starshade and Telescope System

"Exo-S" is NASA's first directed community study of a starshade and telescope system for space-based discovery and characterization of exoplanets by direct imaging. Under a cost cap of $1B, Exo-S will use a modestly sized starshade (also known as an "external occulter") and a modest aperture space telescope for high contrast observations of exoplanetary systems. The Exo-S will obtain spectra of a subset of its newly discovered exoplanets as well as already known Jupiter-mass exoplanets. Exo-S will be capable of reaching down to the discovery of Earth-size planets in the habitable zones of twenty sun-like stars, with a favorable few accessible for spectral characterization. We present highlights of the science goals, the mission design, and technology milestones already reached. At the study conclusion in 2015, NASA will evaluate the Exo-S concept for potential development at the end of this decade.

Author(s): ***Sara Seager (Massachusetts Institute of Technology)***, Webster Cash (University of Colorado), N. Kasdin (Princeton University), William Sparks (STScI), Margaret Turnbull (Global Science Institute), Marc Kuchner (NASA GSFC), Aki Roberge (NASA GSFC), Shawn Domagal-Goldman (NASA GSFC), Stuart Shaklan (NASA-JPL/Caltech), Mark Thomson (NASA-JPL/Caltech), Doug Lisman (NASA-JPL/Caltech), Suzanne Martin (NASA-JPL/Caltech), Eric Cady (NASA-JPL/Caltech), David Webb (NASA-JPL/Caltech)

311.07 – Exo-C: A probe-scale space mission to directly image and spectroscopically characterize exoplanetary systems using an internal coronagraph

"Exo-C" is NASA's first community study of a modest aperture space telescope designed for high contrast observations of exoplanetary systems. The mission will be capable of taking optical spectra of nearby exoplanets in reflected light, searching for previously undetected planets, and imaging structure in a large sample of circumstellar disks. We present the mission/payload design and highlight steps to reduce mission cost/risk relative to previous mission concepts. At the study conclusion in 2015, NASA will evaluate it for potential development at the end of this decade.

Author(s): ***Karl Stapelfeldt (NASA Goddard Space Flight Center)***, Michael Brenner (Jet Propulsion Laboratory, California Institute of Technology), Keith Warfield (Jet Propulsion Laboratory, California Institute of Technology), Ruslan Belikov (NASA Ames Research Center), Paul Brugarolas (Jet Propulsion Laboratory, California Institute of Technology), Geoffrey Bryden (Jet Propulsion Laboratory, California Institute of Technology), Kerri Cahoy (Massachusetts Institute of Technology), Supriya Chakrabarti (University of Massachusetts), Frank Dekens (Jet Propulsion Laboratory, California Institute of Technology), Robert Effinger (Jet Propulsion Laboratory, California Institute of Technology), Brian Hirsch (Jet Propulsion Laboratory, California Institute of Technology), Andrew Kissil (Jet Propulsion Laboratory, California Institute of Technology), John Krist (Jet Propulsion Laboratory, California Institute of Technology), Jared Lang (Jet Propulsion Laboratory, California Institute of Technology), Mark Marley (NASA Ames Research Center), Michael McElwain (NASA Goddard Space Flight Center), Victoria Meadows (University of Washington), Joel Nissen (Jet Propulsion Laboratory, California Institute of Technology), Jeffrey Oseas (Jet Propulsion Laboratory, California Institute of Technology), Gene Serabyn (Jet Propulsion Laboratory, California Institute of Technology), Eric Sunada (Jet Propulsion Laboratory, California Institute of Technology), Wesley Traub (Jet Propulsion Laboratory, California Institute of Technology), John Trauger (Jet Propulsion Laboratory, California Institute of Technology), Stephen Unwin (Jet Propulsion Laboratory, California Institute of Technology)

312 – Corona I

Meeting-in-a-Meeting – America Ballroom South – 04 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Nicholeen Viall (NASA Goddard Space Flight Center)

312.01D – The Heating of Active Regions Using Active Region Transient Brightenings Observed with XRT and Hi-C

Active region transient brightentings (ARTBs) are among the smallest and most fundamental of energetic transient events in the corona; as such, they provide a testbed for models of heating and active region dynamics. We have modeled a large collection of ARTBs observed with Hinode/XRT and with Hi-C as both (a) multi-stranded loops and (b) monolithic loops which experience multiple heating events, to explore the energetic ramifications and characteristics in active region dynamics. Even for these small, short-lived transients, our modeling indicates that multiple heating events are required for each ARTB. We compare the quality of model fits for two different temporal envelopes of the heating function, and discuss whether the results more strongly favor nanoflare or wave-absorption heating.

Author(s): ***Adam Kobelski (Montana State University)***, David McKenzie (Montana State University)

312.02 – Distribution of electric currents in source regions of solar eruptions

There has been a long-lasting debate on the question of whether or not electric currents in the source regions of solar eruptions are neutralized. That is, whether or not the direct coronal currents connecting the photospheric polarities in such regions are surrounded by return currents of equal amount and opposite direction. In order to address this question, we consider several mechanisms of source region formation (flux emergence, photospheric shearing/twisting flows, and flux cancellation) and quantify the evolution of the electric currents, using 3D MHD simulations. For the experiments conducted so far, we find a clear dominance of the direct currents over the return currents in all cases in which the models produce significant magnetic shear along the source region's polarity inversion line. This suggests that pre-eruptive magnetic configurations in strongly sheared active regions and filament channels carry substantial net currents. We discuss the implications of this result for the modeling of solar eruptions.

Author(s): ***Tibor Torok (Predictive Science, Inc.)***, James Leake (George Mason University), Viacheslav Titov (Predictive Science, Inc.), Vasilis Archontis (University of St. Andrews), Zoran Mikic (Predictive Science, Inc.), Mark Linton (U.S. Naval Research Lab), Kevin Dalmasse (Observatoire de Paris), Guillaume Aulanier (Observatoire de Paris), Bernhard Kliem (Universität Potsdam)

312.03 – Verification of Loop Diagnostics

Many different techniques have been used to characterize the plasma in the solar corona: density-sensitive spectral line ratios are used to infer the density, the evolution of coronal structures in different passbands is used to infer the temperature evolution, and the simultaneous intensities measured in multiple passbands are used to determine the emission measure. All these analysis techniques assume that the intensity of the structures can be isolated through background subtraction. In this paper, we use simulated observations from a 3D hydrodynamic simulation of a coronal active region to verify these diagnostics. The density and temperature from the simulation are used to generate images in several passbands and spectral lines. We identify loop structures in the simulated images and calculate the loop background. We then determine the density, temperature and emission measure distribution as a function of time from the observations and compare with the true temperature and density of the loop. We find that the overall characteristics of the temperature, density, and emission measure are recovered by the analysis methods, but the details of the true temperature and density are not. For instance, the emission measure curves calculated from the simulated observations are much broader than the true emission measure distribution, though the average temperature evolution is similar. These differences are due, in part, to inadequate background subtraction, but also indicate a limitation of the analysis methods.

Author(s): ***Amy Winebarger (NASA MSFC)***, Roberto Lionello (Predictive Science, Inc), Yung Mok (University of California), Jon Linker (Predictive Science, Inc), Zoran Mikic (Predictive Science, Inc)

312.04 – Evidence for Impulsive Coronal Heating from EUNIS 2013

Pervasive, faint Fe XIX 592 Å line emission was observed in active regions by the Extreme Ultraviolet Normal Incidence Spectrograph (EUNIS) sounding rocket instrument on 23 April 2013. The broad spectral coverage (303-370 Å, 527-635 Å) and unprecedented dynamic range of the EUNIS observations includes emission lines of ionization stages from He I to Fe XX, and thus a wide temperature range of 0.03 to 10 MK. Comparison of observed line intensities with calculations demonstrates that the Fe XIX emission, formed at temperatures around 8 MK, is evidence of the faint hot emission predicted by impulsive heating models of the solar corona (such as nanoflares).

Author(s): ***Adrian Daw (NASA Goddard Space Flight Center)***, Jeffrey Brosius (NASA Goddard Space Flight Center), Douglas Rabin (NASA Goddard Space Flight Center), Enrico Landi (University of Michigan), James Klimchuk (NASA Goddard Space Flight Center)

312.05 – The Hydrodynamics of High Temperature Plasma: Reproducing the Properties of High Temperature Emission in Solar Active Regions

The launch of Hinode and SDO have revolutionized our ability to measure the plasma properties of the solar corona. Many studies have documented both the temperature structure of the corona as well as its temporal variability. Of particular interest is the behavior of high temperature loops that are typically found in the core of an active region. Temperature distributions in these regions are often sharply peaked near 4 MK but rapidly evolving loops are also observed. In this talk we will present results from our effort to perform hydrodynamic simulations of 15 solar active regions that cover a wide range of solar conditions and to reconcile these simulations with observations. In this work we have coupled non-linear force free extrapolations with solutions to the hydrodynamic loop equations approximated by EBTEL. Using relatively simple heating scenarios we are able to reproduce three important properties of the observations: the dependance of the observed intensity on magnetic flux, the sharply peaked emission measure distributions for large regions, and the general frequency distribution of the observed events. Our current simulations, however, suggest much stronger 1MK emission near the neutral line than is observed, indicating the heating of small loops is not well understood. We also do not properly reproduce the relative distribution of large and small events in these active regions.

Author(s): ***Ignacio Ugarte-Urra (George Mason University)***, Harry Warren (Naval Research Laboratory)

312.06 – Dynamic moss observed with Hi-C

The High-resolution Coronal Imager (Hi-C), flown on 11 July 2012, has revealed an unprecedented level of detail and substructure within the solar corona. Hi-C imaged a large active region (AR11520) with 0.2-0.3’’ spatial resolution and 5.5s cadence over a 5 minute period. An additional dataset with a smaller FOV, the same resolution, but with a higher temporal cadence (1s) was also taken during the rocket flight. This dataset was centered on a large patch of ‘moss’ emission that initially seemed to show very little variability. Image processing revealed this region to be much more dynamic than first thought with numerous bright and dark features observed to appear, move and disappear over the 5 minute observation. Moss is thought to be emission from the upper transition region component of hot loops so studying its dynamics and the relation between the bright/dark features and underlying magnetic features is important to tie the interaction of the different atmospheric layers together. Hi-C allows us to study the coronal emission of the moss at the smallest scales while data from SDO/AIA and HMI is used to give information on these structures at different heights/temperatures. Using the high temporal and spatial resolution of Hi-C the observed moss features were tracked and the distribution of displacements, speeds, and sizes were measured. This allows us to comment on both the physical processes occurring within the dynamic moss and the scales at which these changes are occurring.

Author(s): ***Caroline Alexander (NASA/MSFC)***, Amy Winebarger (NASA/MSFC), Richard Morton (Northumbria University), Sabrina Savage (NASA/MSFC)

313 – Chromosphere and Transition Region (IRIS)

Meeting-in-a-Meeting – Staffordshire – 04 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Bart De Pontieu (Lockheed Martin Solar and Astrophysics Lab)

313.01 – Coordinated IRIS science using the Heliophysics Event Knowledgebase

We have recently enhanced the capabilities of the Heliophysics Event Knowledgebase (HEK) to support the complex datasets being produced by the Interface Region Imaging Spectrograph (IRIS). This includes tools to incorporate observations from the Solar Dynamics Observatory and ground-based facilities to generate composite data products. We will discuss the system and its recent evolution and demonstrate its ability to support coordinated science investigations.

Author(s): ***Neal Hurlburt (Lockheed Martin Corp.)***, Sam Freeland (Lockheed Martin Corp.), Ryan Timmons (Lockheed Martin Corp.), Bart De Pontieu (Lockheed Martin Corp.)

313.02 – IRIS Observations of Twist in the Low Solar Atmosphere

The Interface Region Imaging Spectrograph (IRIS) small explorer was launched in June 2013. IRIS's high-resolution (0.33 arcsec), high-cadence (2s) images and spectra reveal a solar chromosphere and transition region that is riddled with twist. This is evidenced by the presence of ubiquitous torsional motions on very small (subarcsec) spatial scales. These motions occur in active regions, quiet Sun and coronal holes on a variety of structures such as spicules at the limb, rapid-blue/red-shifted events (RBEs and RREs) as well as low-lying loops. We use IRIS data and observations from the Swedish Solar Telescope (SST) in La Palma, Spain to describe these motions quantitatively, study their propagation, and illustrate how such strong twisting motions are often associated with significant and rapid heating to at least transition region temperatures.

Author(s): ***Bart De Pontieu (University of Oslo)***, Luc Rouppe van der Voort (University of Oslo), Tiago M.D. Pereira (University of Oslo), Haakon Skogsrud (University of Oslo), Scott McIntosh (High Altitude Observatory), Mats Carlsson (University of Oslo), Viggo Hansteen (University of Oslo)

Contributing teams: IRIS team

313.03 – IRIS Observations of Coronal Rain and Prominences: Return Flows of the Chromosphere-Corona Mass Cycle

It has recently been recognized that a mass cycle (e.g., Berger et al. 2011; McIntosh et al. 2012) between the hot, tenuous solar corona and the cool, dense chromosphere underneath it plays an important role in the mass budget and dynamic evolution of the solar atmosphere. Although the corona ultimately loses mass through the solar wind and coronal mass ejections, a fraction of its mass returns to the chromosphere in coronal rain, downflows of prominences, and other as-yet unidentified processes. We present here analysis of joint observations of IRIS, SDO/AIA, and Hinode/SOT of such phenomena. By utilizing the wide temperature coverage (logT: 4 - 7) provided by these instruments combined, we track the coronal cooling sequence (e.g., Schrijver 2001; Liu et al. 2012; Berger et al. 2012) leading to the formation of such material at transition region or chromospheric temperatures (logT: 4 - 5) in the million-degree corona. We compare the cooling times with those expected from the radiative cooling instability. We also measure the kinematics and densities of such downflows and infer their mass fluxes, which are compared to the upward mass fluxes into the corona, e.g., those associated with spicules and flux emergence. Special attention is paid to coronal rain formed near cusp-shaped portions of coronal loops, funnel-shaped prominences at dips of coronal loops, and their respective magnetic environments. With the information about where and when such catastrophic cooling events take place, we discuss the implications for the enigmatic coronal heating mechanisms (e.g., Antolin et al. 2010).

Author(s): ***Wei Liu (Lockheed Martin Solar and Astrophysics Laboratory)***, Thomas Berger (National Solar Observatory), Patrick Antolin (National Astronomical Observatory of Japan), Karel Schrijver (Lockheed Martin Solar and Astrophysics Laboratory)

313.04 – Exploring the Components of IRIS Spectra: More Shift, Twist, and Sway Than Shake, Rattle, and Roll

The beautifully rich spectra of the IRIS spacecraft offer an unparalleled avenue to explore the mass and energy transport processes which sustain the Sun's outer atmosphere. In this presentation we will look in detail at the various components of the spectrographic data and place them in context with Slit-Jaw imaging and EUV imaging from SDO/AIA. We will show that the line profiles display many intriguing features including the clear signatures of strong line-of-sight flows (in all magnetized regions) that are almost always accompanied by transverse and torsional motions at the finest resolvable scales. We will demonstrate that many interesting relationships develop when studying the spectra statistically. These relationships indicate IRIS's ability to spectrally and temporally resolve the energetic processes affecting the outer solar atmosphere.

Author(s): ***Scott McIntosh (National Center for Atmospheric Research)***, Bart De Pontieu (LMSAL), Hardi Peter (MPS - Gottingen)

Contributing teams: The IRIS Team

313.05 – Diagnostics of coronal heating and mechanisms of energy transport from IRIS and AIA observations of active region moss

The variability of emission of the "moss", i.e., the upper transition region (TR) layer of high pressure loops in active regions provides stringent constraints on the characteristics of heating events. The Interface Region Imaging Spectrograph (IRIS), launched in June 2013, provides imaging and spectral observations at high spatial (0.166 arcsec/pix), and temporal (down to ~1s) resolution at FUV and NUV wavelengths, and together with the high spatial and temporal resolution observations of SDO/AIA, can provide important insights into the coronal heating mechanisms. We present here an analysis of the temporal variability properties of moss regions at the footpoints of hot active region core loops undergoing heating, as observed by IRIS and AIA, covering emission from the corona to the transition region and the chromosphere. We model the observations using dynamic loop models (the Palermo-Harvard code, and RADYN, which also includes the effects of non-thermal particles) and discuss the implications on energy transport mechanisms (thermal conduction vs beams of non-thermal particles).

Author(s): ***Paola Testa (Smithsonian Astrophysical Observatory)***, Bart De Pontieu (Lockheed Martin Solar and Astrophysics Laboratory), Joel Allred (NASA GSFC), Mats Carlsson (University of Oslo), Fabio Reale (INAF/ University of Palermo), Adrian Daw (NASA GSFC), Viggo Hansteen (University of Oslo)

Contributing teams: IRIS Team

313.06 – IRIS observations of the transition region above sunspots: oscillations and moving penumbral dots

NASA's IRIS mission is providing high-cadence and high-resolution observations of the solar transition region and chromosphere. We present results from IRIS observation of the transition region above sunspots. The major findings can be summarized as following: (1) The C II and Mg II line profiles are almost Gaussian in the sunspot umbra and clearly exhibit a deep reversal at the line center in the plage region, suggesting a greatly reduced opacity in the sunspot atmosphere. (2) Strongly nonlinear sunspot oscillations can be clearly identified in not only the slit jaw images of 2796Å, 1400Å and 1330Å, but also in spectra of the bright Mg II, C II and Si IV lines. The Si iv oscillation lags those of C ii and Mg ii by 6 and 25 seconds, respectively. The temporal evolution of the line core is dominated by the following behavior: a rapid excursion to the blue side, accompanied by an intensity increase, followed by a linear decrease of the velocity to the red side. The maximum intensity slightly lags the maximum blue shift in Si iv , whereas the intensity enhancement slightly precedes the maximum blue shift in Mg ii . We find a positive correlation between the maximum velocity and deceleration. These results are consistent with numerical simulations of upward propagating magneto-acoustic shock waves. We also demonstrate that the strongly nonlinear line width oscillation, reported both previously and here, is spurious. (3) Many small-scale bright dots are present in the penumbral filaments and light bridges in SJI 1330Å and 1400Å images obtained in high-cadence observations. They are usually smaller than 1" and often just a couple of pixels wide. Some bright dots show apparent movement with a speed of 20-60 km/s(either outward or inward). The lifetime of these penumbral dots is mostly less than 1 min. The most obvious feature of the Si IV profiles in the bright dots is the enhanced line width. Besides that, the profile looks normal and no obvious fast flows are detected. The bright dots in the light bridges even show oscillation patterns. It's not clear whether these oscillations are triggered by the umbral oscillations or not.

Author(s): ***Hui Tian (Harvard-Smithsonian Center for Astrophysics)***, Ed DeLuca (Harvard-Smithsonian Center for Astrophysics), Mark Weber (Harvard-Smithsonian Center for Astrophysics), Sean McKillop (Harvard-Smithsonian Center for Astrophysics), Kathy Reeves (Harvard-Smithsonian Center for Astrophysics), Lucia Kleint (Lockheed Martin Solar and Astrophysics Laboratory), Juan Martinez-Sykora (Lockheed Martin Solar and Astrophysics Laboratory), Bart De Pontieu (Lockheed Martin Solar and Astrophysics Laboratory), Mats Carlsson (University of Oslo)

Contributing teams: the IRIS team

314 – Star Clusters, Binaries, Multiples, and Planetary Companions

Oral Session – St. George AB – 04 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Edward Guinan (Villanova Univ.)

314.01 – Introducing A.S.A.D: Analyzer of integrated Spectra for Age Determination

A.S.A.D (Analyzer of integrated Spectra for Age Determination) is a new program that can automatically determine the age and reddening of stellar clusters from their optical integrated spectra. We will show the results we obtained with A.S.A.D for 20 LMC clusters, and present further applications for which A.S.A.D can be used when studying distant unresolved stellar clusters.

Author(s): ***Randa Asa'd (American University of Sharjah)***, Margaret Hanson (University of Cincinnati)

314.02 – The Black Hole X-ray Binary Population of M51 as seen by Chandra

We present an analysis of the black hole X-ray binary population of the interacting galaxy system M51 from new and archival observations by the Chandra X-ray Observatory with total exposure time of nearly 1 Ms. This dataset allows us to probe spectral and temporal variability of the X-ray source population on timescales ranging from tens of seconds to years. We examine both the ultraluminous X-ray source (ULX) population, which likely consists of black hole binaries based solely on luminosity, and the less luminous binaries that show evidence for harboring black holes. We further examine the environments of these sources within the host galaxy using new and archival Hubble Space Telescope observations to determine the probable mass donor stars in the system. We also present initial results from an effort to study the interaction of the luminous X-ray binaries with the interstellar medium of M51. This sample includes all of the historical ULXs as well as a new transient ULX which is a probable black hole low mass X-ray binary.

Author(s): ***Roy Kilgard (Wesleyan Univ.)***, Trevor Dorn-Wallenstein (Wesleyan Univ.), K. Kuntz (Johns Hopkins University), Tyler Desjardins (University of Western Ontario)

314.03 – The Cepheid in the eclipsing binary system OGLE-LMC-CEP1812 is a stellar merger

Classical Cepheids and eclipsing binary systems are powerful probes for measuring stellar fundamental parameters and constraining stellar astrophysics. A Cepheid in an eclipsing binary system is even more powerful, constraining stellar physics, the distance scale and the Cepheid mass discrepancy. However, these systems are rare, only three have been discovered. One of these, OGLE-LMC-CEP1812, presents a new mystery: where the Cepheid component appears to be younger than its red giant companion. In this work, we present stellar evolution models and show that the Cepheid is actually product of a stellar merger during main sequence evolution that causes the Cepheid to be a rejuvenated star. This result raises new questions into the evolution of Cepheids and their connections to smaller-mass anomalous Cepheids.

Author(s): ***Hilding Neilson (East Tennessee State University)***, Richard Ignace (East Tennessee State University)

314.04 – Transit Timing Observations of a Hierarchical Triple M Dwarf System

I will report observations of an eclipsing binary star system in the Kepler field. Transit timing variations in the Kepler data suggest this system may have a third, stellar-mass companion. By obtaining several stellar spectra, we were able to confirm the triple-star hypothesis. Transit timing observations allow us to fully characterize the system, with analytic approximations to the equations of motion providing results consistent with direct 3-body numerical integration. I will detail the system architecture, including the physical parameters of each object, and discuss we can learn about the physics of M dwarfs from studying this system in detail.

Author(s): ***Benjamin Montet (Harvard University)***, Jonathan Swift (California Institute of Technology), John Johnson (Harvard University)

314.05 – Multiplicity of Planets Among the Kepler M Dwarfs

The Kepler data set has furnished more than 130 exoplanetary candidates orbiting M dwarf hosts, nearly half of which reside in multiply transiting systems. I investigate the proposition of self-similarity in this sample, first posited by Swift et al. (2013) for the analysis of the five-planet system Kepler-32. If we compare the predictions of a single mode of planet multiplicity and coplanarity to the Kepler sample, we find that the population of systems with two planets or more is well-replicated. However, the number of singly-transiting systems remains too high to be consistent with this proposition, even accounting for a higher false positive rate among systems exhibiting only one periodic transit. I investigate astrophysical explanations for this feature of Kepler's multiple planet population orbiting small stars, and explore whether the data set supports two distinct modes of planet formation around M dwarfs. I discuss the relative unlikelihood of selection bias or unusually high false positive rates as an explanation, in contrast.

Author(s): ***Sarah Ballard (NASA Carl Sagan Fellow)***

314.06 – The Pan-STARRS-1 Outer Solar System Key Project: A Status Report

The Pan-STARRS-1 (PS1) survey is capable of detecting slow-moving objects in the outer solar system. Among these are Trojans, Centaurs, long-period comets, short-period comets, and trans-neptunian objects brighter than magnitude R~22. We have developed a software pipeline to search for these objects. I will present a status report for this pipeline, as well highlights from the PS1 Outer Solar System Key Project.

Author(s): ***Matthew Holman (Harvard-Smithsonian, CfA)***

Contributing teams: Pan-STARRS-1 Outer Solar System team

315 – Bridging Laboratory & Astrophysics: Nuclear and Particles

Meeting-in-a-Meeting – St. George CD – 04 Jun 2014 02:00 PM to 03:30 PM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This session will focus on the interplay between astrophysics with theoretical and experimental studies into the underlying nuclear processes, which drive our Universe.

Chair(s):
Farid Salama (NASA Ames Research Center)

315.01 – Nuclear Astrophysics in the Laboratory and In the Universe

Nuclear processes drive stellar evolution and so nuclear physics, stellar models and observations together allow us to describe the inner workings of stars and their life stories. This information on nuclear reaction rates and nuclear properties are critical ingredients in addressing most questions in astrophysics and often the nuclear database is incomplete or lacking the needed precision. Direct measurements of astrophysically interesting reactions are necessary and the experimental focus is on improving both sensitivity and precision. In this talk, I will review recent results and approaches taken at the Laboratory for Experimental Nuclear Astrophysics (LENA, http://research.physics.unc.edu/project/nuclearastro/Welcome.html). [Supported in part by the U.S. Department of Energy and by the National Science Foundation.]

Author(s): ***Arthur Champagne (Triangle Universities Nuclear Laboratory)***

315.02 – High Energy Density Plasmas (HEDP) for studies of basic nuclear science relevant to Stellar and Big Bang Nucleosynthesis

Thermonuclear reaction rates and nuclear processes have been explored traditionally by means of conventional accelerator experiments, which are difficult to execute at conditions relevant to stellar nucleosynthesis. Thus, nuclear reactions at stellar energies are often studied through extrapolations from higher-energy data or in low-background underground experiments. Even when measurements are possible using accelerators at relevant energies, thermonuclear reaction rates in stars are inherently different from those in accelerator experiments. The fusing nuclei are surrounded by bound electrons in accelerator experiments, whereas electrons occupy mainly continuum states in a stellar environment. Nuclear astrophysics research will therefore benefit from an enlarged toolkit for studies of nuclear reactions. In this presentation, we report on the first use of High Energy Density Plasmas for studies of nuclear reactions relevant to basic nuclear science, stellar and Big Bang nucleosynthesis. These experiments were carried out at the OMEGA laser facility at University of Rochester and the National Ignition Facility (NIF) at Lawrence Livermore National Laboratory, in which spherical capsules were irradiated with powerful lasers to compress and heat the fuel to high enough temperatures and densities for nuclear reactions to occur. Four experiments will be highlighted in this presentation. In the first experiment, the differential cross section for the elastic neutron-triton (n-T) scattering at 14.1 MeV was measured with significantly higher accuracy than achieved in accelerator experiments. In the second experiment, the T(t,2n)4He reaction, a mirror reaction to the 3He(3He,2p)4He reaction that plays an important role in the proton-proton chain that transforms hydrogen into ordinary 4He in stars like our Sun, was studied at energies in the range 15-40 keV. In the third experiment, the 3He+3He solar fusion reaction was studied directly, and in the fourth experiment, we probed the T+3He reaction, possibly relevant to Big Bang nucleosynthesis.

Author(s): ***Johan Frenje (Massachusetts Institute of Technology)***

316 – Education and Public Outreach

Oral Session – Gloucester, 2nd Floor – 04 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Dawn Gelino (Caltech)

316.01 – NASA SMD Science Education and Public Outreach Forums: A Five-Year Retrospective

NASA's Science Mission Directorate (SMD) created four competitively awarded Science Education and Public Outreach Forums (Astrophysics, Heliophysics, Planetary Science, Earth Science) in 2009. The objective is to enhance the overall coherence of SMD education and public outreach (E/PO), leading to more effective, efficient, and sustainable use of SMD science discoveries and learning experiences. We summarize progress and next steps towards achieving this goal with examples drawn from Astrophysics and cross-Forum efforts. Over the past five years, the Forums have enabled leaders of individual SMD mission and grant-funded E/PO programs to work together to place individual science discoveries and learning resources into context for audiences, conveying the big picture of scientific discovery based on audience needs. Forum-organized collaborations and partnerships extend the impact of individual programs to new audiences and provide resources and opportunities for educators to engage their audiences in NASA science. Similarly, Forum resources support scientists and faculty in utilizing SMD E/PO resources. Through Forum activities, mission E/PO teams and grantees have worked together to define common goals and provide unified professional development for educators (NASA's Multiwavelength Universe); build partnerships with libraries to engage underserved/underrepresented audiences (NASA Science4Girls and Their Families); strengthen use of best practices; provide thematic, audience-based entry points to SMD learning experiences; support scientists in participating in E/PO; and, convey the impact of the SMD E/PO program. The Forums have created a single online digital library (NASA Wavelength, http://nasawavelength.org) that hosts all peer-reviewed SMD-funded education materials and worked with the SMD E/PO community to compile E/PO program metrics (http://nasamissionepometrics.org/). External evaluation shows the Forums are meeting their objectives. Specific examples of Forum-organized resources for use by scientists, faculty, and informal educators are discussed in related presentations (Meinke et al.; Manning et al.).

Author(s): ***Denise Smith (STScI)***, Laura Peticolas (UC-Berkeley), Theresa Schwerin (IGES), Stephanie Shipp (LPI)

Contributing teams: Astrophysics Forum Team, Astrophysics EPO Community

316.02 – The Universe Discovery Guides: A Collaborative Approach to Educating with NASA Science

For the 2009 International Year of Astronomy, the then-existing NASA Origins Forum collaborated with the Astronomical Society of the Pacific (ASP) to create a series of monthly "Discovery Guides" for informal educator and amateur astronomer use in educating the public about featured sky objects and associated NASA science themes. Today's NASA Astrophysics Science Education and Public Outreach Forum (SEPOF), one of a new generation of forums coordinating the work of NASA Science Mission Directorate (SMD) EPO efforts—in collaboration with the ASP and NASA SMD missions and programs--has adapted the Discovery Guides into "evergreen" educational resources suitable for a variety of audiences. The Guides focus on "deep sky" objects and astrophysics themes (stars and stellar evolution, galaxies and the universe, and exoplanets), showcasing EPO resources from more than 30 NASA astrophysics missions and programs in a coordinated and cohesive "big picture" approach across the electromagnetic spectrum, grounded in best practices to best serve the needs of the target audiences. Each monthly guide features a theme and a representative object well-placed for viewing, with an accompanying interpretive story, finding charts, strategies for conveying the topics, and complementary supporting NASA-approved education activities and background information from a spectrum of NASA missions and programs. The Universe Discovery Guides are downloadable from the NASA Night Sky Network web site at nightsky.jpl.nasa.gov. The presenter will share the Forum-led Collaborative's experience in developing the guides, how they place individual science discoveries and learning resources into context for audiences, and how the Guides can be readily used in scientist public outreach efforts, in college and university introductory astronomy classes, and in other engagements between scientists, students and the public.

Author(s): ***Jim Manning (NASA Astrophysics SEPOF)***, Brandon Lawton (STScI), Marni Berendsen (Astronomical Society of the Pacific), Suzanne Gurton (Astronomical Society of the Pacific), Denise Smith (STScI), The NASA SMD Astrophysics E/PO Community (NASA EPO Missions/Programs)

316.03 – Sustaining NASA’S Astrophysics Education And Public Outreach Projects

Sustaining NASA’s Education and Public Outreach (E/PO) projects has been a critical element of the Science Mission Directorate. Astrophysics E/PO programs have built robust partnerships and publicly accessible repositories of their products, which should enable them to form the bases of new initiatives. The recently released digital library, NASAWavelength, has a wealth of information which educators can use to design their own lessons, and students can use as a learning tool. Partnerships with libraries, science museums and amateur astronomers has led to targeted programs such as Astro4Girls and Night Sky Network. Teachers trained as Educator Ambassadors spread the knowledge gained through participating in NASA programs to other educators and students. These and other projects will be presented in this paper as examples of self -sustaining activities, which have a multiplier effect with high impact. While conveying the excitement of scientific discoveries from NASAs Astrophysics missions, these projects provide a powerful means of engaging students towards science and technology careers.

Author(s): ***Hashima Hasan (NASA Headquarters)***, Denise Smith (Space Telescope Science Institute)

316.04 – HERE, THERE, AND EVERYWHERE Public Science Through Analogy

Here, There, and Everywhere (HTE) is a program that consists of a series of exhibitions, posters, and supporting hands-on activities that utilize analogies in the teaching of science, engineering, and technology to provide multi-generational and family-friendly content in English and Spanish to small community centers, libraries, under-resourced small science centers. The purpose of the program is to connect crosscutting science content (in Earth, atmospheric and planetary sciences and astrophysics) with everyday phenomena. By using different modes of content delivery, from physical exhibits and handouts,to interpretive stations, facilitated activities for educators, and online resources, HTE helps to demonstrate the universality of physical laws and the connection between our everyday world and the universe as a whole to members of the public who may not identify strongly with science. HTE is part of a series of public science projects created and developed by the Education and Public Outreach group at the Chandra X-ray Center. The authors discuss how HTE fits into the lineage of public science outreach that aims to engage the greater public in non-traditional venues for science learning and appreciation, as well as what might be learned about the participants of such projects.

Author(s): ***Kimberly Arcand (Smithsonian Astrophysical Observatory)***

Contributing teams: Megan Watzke, Kathleen Lestition, Susan Sunbury

316.05 – Astronomy in the International Year of Light 2015

In December 2013 the United Nations General Assembly proclaimed 2015 as the International Year of Light and Light-based Technologies (IYL 2015), recognizing “the importance of raising global awareness of how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture, and health.” John Dudley, president of the European Physical Society and chair of the IYL 2015 Steering Committee, explains: “An International Year of Light is a tremendous opportunity to ensure that policymakers are made aware of the problem-solving potential of light technology. Photonics provides cost-effective solutions to challenges in so many different areas: energy, sustainable development, climate change, health, communications, and agriculture. For example, innovative lighting solutions reduce energy consumption and environmental impact, while minimizing light pollution so that we can all appreciate the beauty of the universe in a dark sky.” IYL 2015 is bringing together many different stakeholders, including scientific societies and unions, educational and research institutions, technology platforms, non-profit organizations, and private-sector partners to promote and celebrate the significance of light and its applications during 2015. The AAS and the International Astronomical Union (IAU), which were heavily involved in the International Year of Astronomy in 2009, will play a role in IYL 2015 — especially since the AAS will host the 29th General Assembly of the IAU in August 2015. Other US-based organizations, such as NOAO, are organizing efforts jointly with IAU and AAS members to form a cornerstone. Discussion for this presentation will center on the IYL cornerstone project in astronomy, dark-skies awareness, and optics and the related projects and events being formed, as well as the regional, national, and international committees and contact points being established to ensure that all nations of the world can participate. Note: This abstract is adapted, in part, from press releases by the European Physical Society and the AAS.

Author(s): ***Constance Walker (IAU Commission 50)***, Stephen Pompea (NOAO), Richard Green (IAU Commission 50), Richard Fienberg (AAS), Patrick Seitzer (AAS)

317 – Neal Evans: Star Formation in the Gould Belt: Star Formation Rates, Evolutionary Timescales, and Implications for Star Formation Theories

Plenary Session – America Ballroom North/Central – 04 Jun 2014 03:40 PM to 04:30 PM

Chair(s):

Edward Churchwell (Univ. of Wisconsin)

317.01 – Star Formation in the Gould Belt: Star Formation Rates, Evolutionary Timescales, and Implications for Star Formation Theories

Results from the c2d and Gould Belt Spitzer Legacy and Herschel Key Programs provide the most complete and accurate information on star formation in nearby molecular clouds. Complementary and follow-up studies add crucial information on the nature of star forming gas and the evolution of matter as it moves from core to disk to planets. The star formation rates and gas properties provide tests of star formation laws used by extragalactic researchers and of theories of large scale star formation. The durations in the stages of star formation (envelope infall, exposed star and disk, etc.) have been refined. The data are consistent with models in which accretion onto the forming star is episodic, with possible consequences for the initial conditions in planet-forming disks. The evolution of these disks, including dust settling, volatile evolution, and gap-clearing, has been clarified.

Author(s): ***Neal Evans (University of Texas at Austin)***

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400 – Newton Lacy Pierce Prize Lecture, Nadia Zakamska: Quasars and Their Effect on Galaxy Formation

Plenary Session – America Ballroom North/Central – 05 Jun 2014 08:30 AM to 09:20 AM

Chair(s):

David Helfand (Quest University Canada)

400.01 – Quasars and their effect on galaxy formation

At the center of almost every massive galaxy is a supermassive black hole. This realization and the acceptance of the widespread existence of black holes have been major themes in extragalactic astronomy in recent decades. Far from being mere passive sources of gravity, supermassive black holes may have vitally influenced the formation of their host galaxies, most likely during the active "quasar" phase of black hole growth. In this talk, I will outline the historic observations that have led to the current understanding of quasars, including our work on obscured quasars that has helped reveal their ubiquitousness. Furthermore, I will describe how new observations of quasar winds are beginning to tie together the theoretical threads linking quasar and galaxy formation and providing direct insight into the details of the long-sought phenomenon of quasar feedback.

Author(s): ***Nadia Zakamska (Johns Hopkins University)***

– LAD Posters Thursday

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 06:00 PM

413 – LAD Late Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

413.01 – Development of a supersonic, single-mode, shockwave-driven Kelvin-Helmholtz instability experiment

Hydrodynamic instabilities are ubiquitous in high-energy-density systems, including core collapse supernovae and protoplanetary disks. The Kelvin-Helmholtz instability evolves from shear flow at an interface and results in mixing between the two layers. This poster will cover two recent experiments studying the evolution of a single-mode, supersonic case of the Kelvin-Helmholtz instability with well-characterized initial conditions. Classically, the growth rate of the Kelvin-Helmholtz instability increases as the relative shear velocity of the system increases. When the relative velocity becomes very large, compressibility effects begin to inhibit Kelvin-Helmholtz growth. In our experiment we create a steady, high Mach number flow by driving our instability with a shockwave generated by a 20 to 30 ns laser pulse. We seed perturbation growth with a precisely machined, well-characterized, single-mode sinusoidal interface. The system is diagnosed using Spherical Crystal Imaging, a form of x-ray radiography. This work is funded by the U.S. Department of Energy, through the NNSA-DS and SC-OFES Joint Program in High-Energy-Density Laboratory Plasmas, grant number DE-NA0001840, the National Laser User Facility Program, grant number DE-NA0000850, and the Laboratory for Laser Energetics, University of Rochester by the NNSA/OICF under Cooperative Agreement No. DE-FC52-08NA28302.

Author(s): ***Wesley Wan (University of Michigan)***, Guy Malamud (Nuclear Research Center), Carlos Di Stefano (University of Michigan), Matt Trantham (University of Michigan), Sallee Klein (University of Michigan), Assaf Shimony (Nuclear Research Center), Dov Shvarts (Nuclear Research Center), Carolyn Kuranz (University of Michigan), R. Paul Drake (University of Michigan)

413.02 – Modeling the Infrared Emission of High-Latitude Molecular Cirrus Clouds

The exact amount and nature of interstellar matter at high Galactic latitudes is a subject of ongoing scrutiny. The IRAS observations at 60 and 100 micrometer first revealed the prevalence of large-scale, extended filamentary emission (known as ``infrared cirrus'', see Low et al. 1984) at high Galactic latitudes. The presence of significant quantities of CO gas at high Galactic latitudes (|b|>25 degree) was first reported by Blitz et al. (1984) and Magnani et al. (1985). These high latitude molecular clouds can be identified with the cores of the IRAS infrared cirrus (Weiland et al. 1986). Little is known about the dust properties of these high latitude molecular cirrus clouds. We model the infrared emission of nine representative clouds (Verter et al. 2000) for which the visual extinction (A_V) was known from star counts (Magnani & de Vries 1986). All the selected clouds, with A_V <1 mag, are "translucent" to the interstellar radiation. They represent a class of objects intermediate between the properties of diffuse clouds and dark molecular clouds (van Dishoeck & Black 1988). They exhibit notable cloud-to-cloud variations in the mid-infrared, with the ratio of the IRAS 12 micrometer intensity to the IRAS 25 micrometer intensity varying by up to one order of magnitude. The silicate-graphite-PAH model successfully reproduces the infrared emission of all the selected clouds observed by IRAS. We find that all clouds are rich in PAHs as traced by the IRAS 12 micrometer data. They are heated by the local interstellar radiation field, but with the radiation intensity reduced by a factor of about 2 to 3.

Author(s): ***Ajay Mishra (University of MIssouri-Columbia)***, Aigen Li (University of MIssouri-Columbia)

413.03 – Irradiation of oxygen and water ices at by 4 keV singly and doubly charged ions; sputtering and molecular synthesis

The icy surfaces of dust grains in the Interstellar Medium and those of comets, satellites and Kuiper Belt Objects are continuously exposed to photon and charged particle irradiation. These energetic particles may sputter and induce chemical changes in the ices and the underlying surfaces. In the present work 258 nm thick O2 and H2O ices were deposited at 10 K with the thickness measured by a laser interferometer method. A simple model fit to the reflected laser intensity as measured by a photodiode detector enabled the refractive index of the ices to be determined. The ices were then irradiated with various singly and doubly charged ions such as He+, 13C+, N+, O+ , Ar+, 13C2+, N2+ and O2+ at 4 keV. The decrease in ice thickness as a function of ion dose was monitored by a laser interferometer and the model used to determine the sputtering yield as shown in Figure 1. In the case of O2 ice the sputtering yields increased with increasing ion mass in good agreement with a model calculation [Fama, J, Shi, R.A Baragiola, Surface Sci., 602, 156 (2007)]. In the case of O2 ice, O2+ has a significant lower sputtering yield when compared to O+. The sputtering yields for O2 ice were found to be at least 9 times larger compared to those for H2O ice. For H2O ice the sputter yields for C, N and O ions were found to decrease with increasing mass. Doubly charged C, N and O ions which were found to have the same sputtering yield as the singly charged ions within the experimental errors. A preliminary TPD study was carried out using a QMS to detect the desorbed species from water ice after irradiation by 6 × 10^15 ions of 13C+ and 13C2+. The formation of 13CO and 13CO2 was observed with the yield of 13CO almost of a factor of 100 larger than of 13CO2. This is in contrast to our earlier work where only CO¬2 was observed. [A. Dawes et al., Phys. Chem. Chem. Phys., 9, 2886 (2007)].

Author(s): ***Elena Andra Muntean (Queen`s University Belfast)***, Tom Field (Queen`s University Belfast), Alan Fitzsimmons (Queen`s University Belfast), Adam Hunniford (Queen`s University Belfast), Pedro Lacerda (Max Planck Institute for Solar System Research), Bob McCullough (Queen`s University Belfast)

413.04 – Rotational Deexcitation of CO in Inelastic Collisions with H

Carbon monoxide, the second most abundant molecule in the universe after molecular hydrogen, is found in a variety of astrophysical environments and is typically observed in absorption in the UV and near-IR and emission in the FIR/submm. The chemical and physical conditions where CO resides are deduced from spectral lines, but it is often not appropriate to assume local thermodynamic equilibrium (LTE) in these regions. Therefore, collisional rate coefficients with the dominant collision partners H, H_2, and He are necessary to accurately predict spectral line intensities and extract astrophysical parameters. We report new quantum scattering calculations for rotational deexcitation transitions of CO induced by H using the new potential energy surface(PES) of Song et al. (2013, *J. Phys. Chem. A*, 117, 7571). This highly sophisticated three-dimensional *ab initio* PES uses the spin-unrestricted open-shell single and double excitation coupled-cluster method with perturbative triples [UCCSD(T)], with molecular orbitals from restricted Hartree-Fock(RHF) calculations. State-to-state cross sections for collision energies from 10^{-5} to 10^4 cm^{-1} and rate coefficients for temperatures ranging from 1 to 3000 K are computed for CO(v=0, j) deexcitation from j=1-70 to all lower j' levels, where j is the rotational quantum number. The current rate coefficients are compared with previous scattering results using earlier PESs and the differences are discussed.

Author(s): ***Kyle Walker (University of Georgia)***, Lei Song (Radboud University Nijmegen), Benhui Yang (University of Georgia), Gerrit Groenenboom (Radboud University Nijmegen), Ad van der Avoird (Radboud University Nijmegen), Balakrishnan Naduvalath (UNLV), Robert Forrey (Penn State Berks), Phillip Stancil (University of Georgia)

414 – SPD Late Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

414.01 – Confined Eruption of a Multi-thread Filament

Eruptive filaments are believed to be a major component, namely the core, of coronal mass ejections (CMEs). In `confined eruptions', the erupting materials eventually come back to the solar surface instead of escaping away. We study a multi-thread filament, within Active Region NOAA 11861, that splits into two parts. The upper component erupts and comes down while the lower component remains almost in the same location. The data set analyzed includes Hα observation from the 1-meter New Vacuum Solar Telescope (NVST) at Yunnan Astronomical Observatory (YNAO) and the EUV observations taken by the Atmospheric Imaging Assembly (AIA) onboard the Solar Dynamics Observatory (SDO). Both Hα and EUV observations show the erupting phase clearly. Fine details of the eruption are revealed by the high resolution and high cadence Hα observations. The gradual expansion of the filament is followed by twisting of threads that leads to a sudden eruption. The intuition of this process suggests a helical kink instability. By extrapolating the vector magnetograms obtained by Helioseismic and Magnetic Imager (HMI) on SDO, we calculate the magnetic twist and discuss if the kink instability plays a major role of initializing this eruption. In addition, we investigate the overlying fields, also known as strapping fields, that confine against the eruptions. The decay index, a quantitative measurement of the strapping fields, is estimated to be 0.86. This value is smaller than the critical value of 1.5 indicating a strong strapping field preventing the materials from escaping.

Author(s): *Yan Xu (New Jersey Institute of Tech.)*, Zhi Xu (Yunnan Astronomical Observatory), Zhong Liu (Yunnan Astronomical Observatory), Rui Liu (University of Science and Technology of China), Chang Liu (New Jersey Institute of Tech.), Ju Jing (New Jersey Institute of Tech.), Haimin Wang (New Jersey Institute of Tech.)

414.02 – Quick Time-dependent Ionization Calculations Depending on MHD Simulations

Time-dependent ionization is important in astrophysical environments where the thermodynamic time scale is shorter than ionization time scale. In this work, we report a FORTRAN program that performs fast non-equilibrium ionization calculations based on parallel computing. Using MHD simulation results, we trace the movements of plasma in a Lagrangian framework, and obtain evolutionary history of temperature and electron density. Then the time-dependent ionization equations are solved using the eigenvalue method. For any complex temperature and density histories, we introduce a advanced time-step strategy to improve the computational efficiency. Our tests show that this program has advantages of high numerical stability and high accuracy. In addition, it is also easy to integrate this solver with the other MHD routines.

Author(s): *Chengcai Shen (Harvard-Smithsonian Center for Astrophysics)*, John Raymond (Harvard-Smithsonian Center for Astrophysics), Nicholas Murphy (Harvard-Smithsonian Center for Astrophysics)

414.03 – Two Categories of Apparent Tornado-like Prominences

Two categories of solar prominences have been described in the literature as having a pattern of mass motions and/or a shape similar to terrestrial tornados. We first identify the two categories associated with prominences in the historic literature and then show that counterparts do exist for both in recent literature but one has not been called a tornado prominence. One category described as being similar to tornados is associated with the barbs of quiescent filaments but barbs appear to have rotational motion only under special conditions. H alpha Doppler observations from Helio Research confirm that this category is an illusion in our mind’s eye resulting from counterstreaming in the large barbs of quiescent filaments. The second category is a special case of rotational motion occurring during the early stages of some erupting prominences, in recent years called the roll effect in erupting prominences. In these cases, the eruption begins with the sideways rolling of the top of a prominence. As the eruption proceeds the rolling motion propagates down one leg or both legs of an erupting prominence depending on whether the eruption is asymmetric or symmetric respectively. As an asymmetric eruption proceeds, the longer lasting leg becomes nearly vertical and has true rotational motion. If only this phase of the eruption was observed, as in the historic cases, it was called a tornado prominence and spectra recorded in these cases provide proof of the rotational motion. When one observes an entire eruption which exhibits the rolling motion, as accomplished at Helio Research, the similarity to a tornado is lost because the event as a whole has quite a different nature and the analogy to a terrestrial tornado not longer appears suitable or helpful in understanding the observed and deduced physical processes. Our conclusion is that there are no solar prominences with motions that are usefully described as tornado or tornado-like events aside from the fun of observing some prominence barbs whose mass motions yield a fascinating illusion of rotational motion under special conditions.

Author(s): *Sara Martin (Helio Research)*, Aparna Venkataramanasastry (University of North Dakota)

414.04 – Fermi Detection of Gamma-ray Emission from a Behind-the-limb M1.5 Flare on 2013 October 11

On 2013 October 11 an M1.5 class solar flare erupted from the NOAA active region 11868, which was then behind the solar limb. RHESSI images reveal hard X-ray emission well above the limb, most likely from the top of the flare loop whose footpoints were occulted. Surprisingly the Fermi Large Area Telescope (LAT) detected gamma-rays up to 3 GeV for ~30 minutes from this flare, making it the first behind-the-limb flare observed by Fermi. The LAT gamma-ray emission centroid is consistent with the vicinity of the RHESSI hard X-ray source. The gamma-ray spectra can be adequately described by a power law with a high-energy exponential cutoff, or as a result of the decay of pions produced by accelerated protons and ions with an isotropic pitch angle distribution and a power-law energy spectrum. The required proton spectrum would have a number index of ~3.8. We present the Fermi and RHESSI observations together with STEREO and SDO data to explore the various emission scenarios of this behind-the-limb flare.

Author(s): ***Melissa Pesce-Rollins (INFN)***, Nicola Omodei (KIPAC), Vahe Petrosian (KIPAC), Wei Liu (Lockheed Martin Solar and Astrophysics Laboratory), Qingrong Chen (KIPAC), Fatima Rubio Da Costa (KIPAC)

Contributing teams: Fermi LAT Collaboration

414.05 – SWARM: A Compact High Resolution Correlator and Wideband VLBI Phased Array Upgrade for SMA

A new digital back end (DBE) is being commissioned on Mauna Kea. The “SMA Wideband Astronomical ROACH2 Machine”, or SWARM, processes a 4 GHz usable band in single polarization mode and is flexibly reconfigurable for 2 GHz full Stokes dual polarization. The hardware is based on the open source Reconfigurable Open Architecture Computing Hardware 2 (ROACH2) platform from the Collaboration for Astronomy Signal Processing and Electronics Research (CASPER). A 5 GSps quad-core analog-to-digital converter board uses a commercial chip from e2v installed on a CASPER-standard printed circuit board designed by Homin Jiang’s group at ASIAA. Two ADC channels are provided per ROACH2, each sampling a 2.3 GHz Nyquist band generated by a custom wideband block downconverter (BDC). The ROACH2 logic includes 16k-channel Polyphase Filterbank (F-engine) per input followed by a 10 GbE switch based corner-turn which feeds into correlator-accumulator logic (X-engines) co-located with the F-engines. This arrangement makes very effective use of a small amount of digital hardware (just 8 ROACH2s in 1U rack mount enclosures). The primary challenge now is to meet timing at full speed for a large and very complex FPGA bit code. Design of the VLBI phased sum and recorder interface logic is also in process. Our poster will describe the instrument design, with the focus on the particular challenges of ultra wideband signal processing. Early connected commissioning and science verification data will be presented.

Author(s): ***Jonathan Weintroub (Harvard-Smithsonian Center for Astrophysics)***

Contributing teams: The SWARM Development Team

414.06 – MOSES Inversions using Multiresolution SMART

We present improvements to the SMART inversion algorithm for the MOSES imaging spectrograph. MOSES, the Multi-Order Solar EUV Spectrograph, is a slitless extreme ultraviolet spectrograph designed to measure cotemporal narrowband spectra over a wide field of view via tomographic inversion of images taken at three orders of a concave diffraction grating. SMART, the Smooth Multiplicative Algebraic Reconstruction Technique, relies on a global chi squared goodness of fit criterion, which enables overfit and underfit regions to "balance out" when judging fit quality. "Good" reconstructions show poor fits at some positions and length scales. Here we take a multiresolution approach to SMART, applying corrections to the reconstruction at positions and scales where correction is warranted based on the noise. The result is improved fit residuals that more closely resemble the expected noise in the images. Within the multiresolution framework it is also easy to include a regularized deconvolution of the instrument point spread functions, which we do. Different point spread functions among MOSES spectral orders results in spurious doppler shifts in the reconstructions, most notable near bright compact emission. We estimate the point spread funtions from the data. Deconvolution is done using the Richardson-Lucy method, which is algorithmically similar to SMART. Regularization results from only correcting the reconstruction at positions and scales where correction is warranted based on the noise. We expect the point spread function deconvolution to increase signal to noise and reduce systematic error in MOSES reconstructions.

Author(s): ***Thomas Rust (Montana State University)***, Lewis Fox (National Solar Observatory), Charles Kankelborg (Montana State University), Hans Courrier (Montana State University), Jacob Plovanic (Montana State University)

415 – Education and Public Outreach Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

415.01 – A Low-cost 21 cm Horn-antenna Radio Telescope for Education and Outreach

Small radio telescopes (1-3m) for observations of the 21 cm hydrogen line are widely used for education and outreach. A pyramidal horn was used by Ewen & Purcell (1951) to first detect the 21cm line at Harvard. Such a horn is simple to design and build, compared to a parabolic antenna which is usually purchased ready-made. Here we present a design of a horn antenna radio telescope that can be built entirely by students, using simple components costing less than $300. The horn has an aperture of 75 cm along the H-plane, 59 cm along the E-plane, and gain of about 20 dB. The receiver system consists of low noise amplifiers, band-pass filters and a software-defined-radio USB receiver that provides digitized samples for spectral processing in a computer. Starting from construction of the horn antenna, and ending with the measurement of the Galactic rotation curve, took about 6 weeks, as part of an undergraduate course at Harvard University. The project can also grow towards building a two-element interferometer for follow-up studies.

Author(s): ***Nimesh Patel (Harvard-Smithsonian Center for Astrophysics)***, Rishi Patel (Massachusetts Institute of Technology), Robert Kimberk (Harvard-Smithsonian Center for Astrophysics), John Test (Harvard-Smithsonian Center for Astrophysics), Alex Krolewski (Harvard University), James Ryan (Harvard University), Kirit Karkare (Harvard-Smithsonian Center for Astrophysics), John Kovac (Harvard University), Thomas Dame (Harvard-Smithsonian Center for Astrophysics)

415.02 – Measuring the CMB temperature in the classroom with a low-cost antenna and radiometer

Estimation of the cosmic microwave background (CMB) temperature through a skydip is an ambitious undergraduate laboratory exercise in which care must be taken to understand and account for systematic errors. It is an ideal environment for learning about careful experimental design. We present two versions of a low-cost antenna and radiometer system replicating the CMB discovery measurement (Penzias and Wilson, 1965), operating at 11 and 19 GHz. We describe two small-aperture (8") antenna designs: an HDPE lens-coupled corrugated horn, and a single-groove Potter horn, both of which are simple and inexpensive to fabricate. They have been designed to minimize far sidelobe pickup from the ground in conjunction with a straight-walled or Winston cone. The radiometers are based on low-cost commercial satellite TV receivers, read out with standard laboratory equipment. We describe the design of aperture-filling calibration loads necessary to characterize the radiometer performance. Several iterations of this experiment have been run in the advanced undergraduate astrophysics laboratory course (Ay 191) at Harvard University, with the students building the apparatus starting from scratch and finishing in about 6 weeks. Positive detections of background radiation have been achieved with typical uncertainties of 0.3 K.

Author(s): ***Kirit Karkare (Harvard-Smithsonian Center for Astrophysics)***, Rachel Bowens-Rubin (Harvard-Smithsonian Center for Astrophysics), Jake Connors (Harvard-Smithsonian Center for Astrophysics), Thomas Dame (Harvard-Smithsonian Center for Astrophysics), Ryan Gao (Harvard-Smithsonian Center for Astrophysics), Samuel Harrison (Harvard-Smithsonian Center for Astrophysics), Robert Kimberk (Harvard-Smithsonian Center for Astrophysics), John Kovac (Harvard-Smithsonian Center for Astrophysics), Jamie Law-Smith (Harvard-Smithsonian Center for Astrophysics), Derek Robins (Harvard-Smithsonian Center for Astrophysics), Steve Sansone (Harvard-Smithsonian Center for Astrophysics), Robert Wilson (Harvard-Smithsonian Center for Astrophysics), Anya Yermakova (Harvard-Smithsonian Center for Astrophysics), Lingzhen Zeng (Harvard-Smithsonian Center for Astrophysics)

415.03 – Students' Attitudes and Understandings about Science in their Field Trip to Laser Interferometer Gravitational-wave Observatory (LIGO)

The LIGO Science Education Center in Livingston, LA, provides K-12 students with 3.5-hour field trip programs that consist of watching a documentary, touring the LIGO facilities, exploring interactive science exhibits, and hands-on classroom activities with the Center's staff. In our study we administered a pre/post-survey, which consisted of Likert-type and open-ended questions, to approximately 1,000 secondary students who visited LIGO in Spring 2013. In this paper we report on our current findings from a half-way analysis about 1) the students' attitudes and interests about science; 2) their understanding about basic scientific concepts relevant to LIGO science, gravity, light, and sound; and 3) their understanding about the LIGO project. In comparison between pre and post-responses using a paired-samples t-test, the results showed that the field trip to LIGO had significant ($p<0.05$) positive impact on increasing the number of students who think that "science is fun" and that they "would want to be a scientist." In addition, they had significant ($p<0.05$) knowledge gain in understanding that there are frequencies of light that are not visible, and they were able to correctly name the different kinds of electromagnetic waves after the visit. In pre-test 51.5% responded that they did not even hear about LIGO and 17.8% could not explain what it was although they heard about it (as they were from the local schools). On the other hand, 86.6% students were able to explain about LIGO project in post-test. Among them, more than half of the students (59.3%) correctly described the purpose of the LIGO project. Another 9.3% recognized it as a science research center without further information about what specifying the purpose of LIGO. About 8% held misconceptions, and 7% recognized LIGO as a science learning center. The students' learning in this field trip happened mainly by: encountering the new concept; recalling their prior knowledge and reinforcing it; and being able to connect the scientific concept to how it is applied in a professional science research.

Author(s): ***Hyunju Lee (University of South Florida)***, Allan Feldman (University of South Florida)

Contributing teams: LIGO Livingston Science Education Center

416 – Extrasolar Planets Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

416.01 – Tidal Alignment of Exoplanets Around Low Mass Stars

Using the Rossiter-McLaughlin effect, the projected spin–orbit angle for many exoplanetary systems has now been measured. Thanks to this rapidly increasing sample it is becoming clear that stars with surface convective zones appear to be well aligned while those without span a wide range of inclinations. The explanation proposed (Winn et al 2010) is that perhaps only the convective zones align with the planet, while the cores remain misaligned. This explanation suffers from two problems however: the core-envelope coupling in low mass stars appears to be strong enough to prevent long-lived differential rotation and even if only the convective zone is aligned, the planet generally does not survive for long after that. Since tides due to a planet on a misaligned orbit have a component at the rotational frequency of the star, and for an aligned planet the only frequency is the difference between the generally fast planet and the slowly rotating star, it is conceivable that misaligned systems are subject to much enhanced dissipation, acting for example on resonantly excited inertial waves in the star. However, Rogers & Lin (2013) point out that under inertial mode dissipation, in addition to aligned orbits one would expect a pile-up on polar and/or exactly counter-rotating orbits. We propose that the extra equilibrium solutions disappear if one includes in the evolution the fact that stars evolve and shed angular momentum throughout their lifetime. We have built a model including all those effects and will show results exploring this explanation.

Author(s): ***Kaloyan Penev (Princeton University)***, Brian Jackson (Carnegie Dept. of Terrestrial Magnetism)

416.02 – Colour Magnitude Diagrams of Transiting Exoplanets

Colour-Magnitude diagrams form a traditional way of representing luminous objects in the Universe and compare them to each others. Here, the photometric distances of 44 transiting exoplanetary systems were estimated. For seven of those, parallaxes confirm the methodology. From the combination of those measurements with fluxes obtained while planets were occulted by their host stars, colour-magnitude diagrams are composed in the near and mid IR. When possible, planets are plotted with field brown dwarfs who often have similar sizes and equilibrium temperatures, thus offering a natural empirical comparison sample. Exoplanets are also compared to the expected loci of pure blackbodies. In general planets do not agree with the brown dwarfs sequences, and neither do they match blackbodies. It is however possible to affirm that they are not featureless and that they display an increasing diversity in colour with decreasing intrinsic luminosity. A missing source of absorption within the [4.5 ?m] band, for some planets, would generally reconcile hot Jupiters with brown dwarfs' cool atmospheres. Alternatively, measuring the emission of gas giants cooler than 1 000 K would disentangle whether planets' atmospheres behave like brown dwarfs' atmospheres, like blackbodies, or whether they form their own sequence.

Author(s): ***Amaury Triaud (Massachusetts Institute of Technology)***

417 – Galaxies Near and Far Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

417.01 – The Galactic Center Radio Arc: A Multi-Frequency Spectro-Polarimetric Study

Despite the Radio Arc non-thermal filaments (NTFs) being discovered 30 years ago, their origin remain poorly understood. The Radio Arc NTFs have an unusually flat spectrum in the centimeter to millimeter spectrum with a predicted, though poorly constrained, turn-over between 30- 200 GHz. With the recently upgraded wide-band capabilities of the VLA, we conducted a multi-frequency spectro-polarimetric study of the Radio Arc region. With observations at a set of low radio frequencies (continuous coverage over 2-6 GHz & 10-12 GHz), we imaged both the total and polarized intensity distributions at high angular resolution (? 1”). Presented here are the preliminary results from four observations spanning May 2013 to February 2014 using the DnC, CnB, B & BnA array configurations. This study has produced the deepest continuum intensity images of the Radio Arc region to date, with a sensitivity an order of magnitude greater than previous surveys, and resulted in the detection of new structure and compact emission sources. These observations will serve as a pilot polarization study for larger, more complete polarimetric surveys of the Galactic center region.

Author(s): ***James Toomey (University of Iowa)***, Cornelia Lang (University of Iowa), Dominic Ludovici (University of Iowa)

417.02 – Are The Known Milky Way Satellites Enough?

We study the past orbital history of the classical Milky Way satellites, by integrating backwards from their observed positions and proper motions. Starting from the initial conditions derived from the proper motions, we examine the tidal effect of all the known classical Milky Way satellites on the galactic disk. We sample the large parameter space of the measured proper motions and associated uncertainties by modeling the galactic disk as composed of test particles. This approach allows us to quantify the effect of the orbital distribution on the galactic disk, and provide realistic initial conditions for the classical Milky Way satellites. We show that the main tidal players of the Milky Way are the Sagittarius (Sgr) dwarf galaxy, the Large Magellanic Cloud (LMC), and the Small Magellanic Cloud (SMC). We examine both the vertical and planar disturbances of the galactic disk. We show that the Sgr dwarf is the primary culprit responsible for producing the warp of the galactic disk. However, we find that the planar disturbances excited by all the eleven classical satellites (which closely matches the response due to the three main tidal players) is a factor of ~ 85 lower than what is required to explain the amplitude of the observed disturbances in the outer HI disk of the Milky Way. Thus, while the vertical structure of the galactic disk may be explained by the known satellites, the radial motions generated by the known Milky Way satellites are far less than what is required to explain the observed data. This large discrepancy of nearly two orders of magnitude between the observed planar disturbances and that produced by all the known classical satellites suggests that putative, new satellites (such as the one predicted by Chakrabarti & Blitz 2009) may be necessary to explain the observations.

Author(s): ***Sukanya Chakrabarti (Rochester Institute of Technology)***, Alice Quillen (University of Rochester), Philip Chang (University of Wisconsin-Milwaukee)

417.03 – Chandra Galaxy Atlas

The hot ISM in early type galaxies plays a crucial role for understanding their formation and evolution. Structural features of the hot ISM identified by Chandra (including jets, cavities, cold fronts, filaments and tails) point to key evolutionary mechanisms, e.g., AGN feedback, merging history, accretion/stripping and star formation and its quenching. In our new project, Chandra Galaxy Atlas, we will systematically analyze the archival Chandra data of 137 ETGs to study the hot ISM. Taking full advantage of the Chandra capabilities, we will derive uniform data products of spatially resolved dataset with additional spectral information. We will make these products publicly available and use them for our focused science goals.

Author(s): ***Dong-Woo Kim (Harvard-Smithsonian, CfA)***, Amy Mossman (Harvard-Smithsonian, CfA), Antonella Fruscione (Harvard-Smithsonian, CfA), Craig Anderson (Harvard-Smithsonian, CfA), Doug Morgan (Harvard-Smithsonian, CfA), Douglas Burke (Harvard-Smithsonian, CfA), E. O'Sullivan (Harvard-Smithsonian, CfA), Giuseppina Fabbiano (Harvard-Smithsonian, CfA), Jennifer Lauer (Harvard-Smithsonian, CfA), Mike McCollough (Harvard-Smithsonian, CfA)

417.04 – Parsec-Scale Radio Jet Characteristics of MOJAVE Hard-Spectrum Gamma-Ray Blazars

MOJAVE is a long term VLBA key project to probe the structure and evolution of parsec-scale radio jets associated with active galactic nuclei (AGN). Our program has found that apparent superluminal motion is common in compact radio-selected AGN, indicating Lorentz factors up to ~50 in outflows oriented at a few degrees from the line of sight. Recently we have begun regularly obtaining 2 cm VLBA full polarization images of a new AGN sample selected on the basis of hard-spectrum gamma-ray flux. Only about 10% of these AGN have previously been monitored with VLBA, and they show slow apparent jet speeds that appear to be inconsistent with the very high Doppler factors inferred from emission modelling and rapid variability at high photon energies. We discuss the first-epoch radio jet properties of our sample, and the detection of superluminal motion in the jet associated with the hard-spectrum TeV blazar 1ES 1011+496.

Author(s): ***Matthew Lister (Purdue Univ.)***

Contributing teams: The MOJAVE Collaboration

417.05 – Variability of the radio-loud NLS1 galaxy PKS 0558-504

We carried out photometric studies of the radio-loud Narrow-line Seyfert 1 galaxy (NLS1) PKS0558-504 using both the first Antarctic Survey Telescope (AST3-1, 0.5 m aperture) located at Dome A in Antarctica and the 0.6 m Southeastern Association for Research in Astronomy (SARA) South telescope located at the Cerro Tololo Inter-American Observatory in Chile. The AST3-1 telescope is equipped with a 10K×10K single-chip CCD camera, which is one of the largest single-chip CCD cameras ever used in astronomy, and its site provides the best observation conditions on earth’s surface. The photometric data taken with AST3-1 were obtained with cousin i band during 6 nights from April 30 to May 7, 2012. In order to compare and double check the data quality, this target was imaged again using the SARA 0.6 m telescope with SDSS-g and i bands during 10 nights from October 31 to December 16, 2012. We will present detailed data analyses, the light curves obtained from both telescopes, and the mechanism for the light variability.

Author(s): ***Xianming Han (Butler University)***, QiGuo Tian (Polar Research Institute of China), Tuo Ji (University of Science and Technology of China), WenJuan Liu (University of Science and Technology of China), HongYan Zhou (University of Science and Technology of China)

417.06 – UVUDF: Ultraviolet Imaging of the Hubble Ultra Deep Field with Wide-Field Camera 3

We present recent science results from the Ultraviolet Coverage of the Hubble Ultradeep Field (UVUDF) project, in which we obtained images of the HUDF with WFC3/UVIS in the F225W, F275W, and F336W filters (30 orbits per filter; half with UVIS post-flash). The UVUDF completes the Hubble Space Telescope wavelength coverage of the most studied field in the extragalactic sky in the major imaging bands (FUV through NIR). As illustrated by a new 13-band image of the HUDF, these data give us the best view yet obtained of the last 9-10 billion years of cosmic star-formation. The UVUDF data enable the analysis of star-forming galaxies at z~2 (Lyman break galaxies at the peak era of star formation) that would be inaccessible from the ground, including measurement of the slope of their UV continuum. The high spatial resolution of the UVUDF images are an unprecedented resource for studying the UV structure of galaxies at z~1 and understanding how galaxies are formed from clumps of hot stars.

Author(s): ***Harry Teplitz (Caltech)***, Marc Rafelski (Caltech), Peter Kurczynski (Rutgers University), Nicholas Bond (GSFC), Emmaris Soto (CUA), Norman Grogin (STScI), Anton Koekemoer (STScI), Hakim Atek (EPFL), Thomas Brown (STScI), Dan Coe (STScI), James Colbert (Caltech), Yu Dai (Caltech), Henry Ferguson (STScI), Steven Finkelstein (UT Austin), Jonathan Gardner (GSFC), Eric Gawiser (Rutgers University), Mauro Giavalisco (U. Mass.), Caryl Gronwall (Penn State), Daniel Hanish (Caltech), Kyoung-Soo Lee (Purdue), Zoltan Levay (STScI), Duilia De Mello (CUA), Swara Ravindranath (STScI), Russell Ryan (STScI), Brian Siana (UC Riverside), Claudia Scarlata (UMN), Elysse Voyer (CNRS), Rogier Windhorst (ASU)

417.07 – SuperBIT: Wide-field, Sub-arcsecond Imaging from the Super Pressure Balloon Platform

The scientific potential of near-diffraction-limited imaging from mid-latitude ultra-long duration balloon payloads is well known. The combination of diffraction-limited angular resolution, extreme stability, space-like backgrounds, and long integrations enables transformative opportunities in studies ranging from the weak lensing of galaxy clusters and cosmic shear to the search for exoplanets. Collaborators at the University of Toronto have recently integrated a half-meter class telescope with a prototype subarcsecond pointing system. SuperBIT will adapt the existing system to the requirements of the mid-latitude super-pressure balloon (SPB) payload, and demonstrate its imaging capability during an ultra-long duration balloon flight that will take off from Wanaka, New Zealand, in the 2016-17 Austral summer. The demonstration instrument will provide imaging with a half-degree field of view and 0.3-arcsecond resolution in five bands between 300 and 1000 nm, with sensitivities in the shape-band exceeding 24th magnitude (>5 sigma) in 300 seconds of integration. Our observing schedule will be split between a performance verification sample, a photometric and spectroscopic calibration set, a deep field, and a science catalog. The performance verification set prioritizes a sample of thirty clusters that have been previously well studied with the HST Advanced Camera for Surveys, the Chandra X-ray observatory, and for which there are Compton-Y parameter data from millimeter-wavelengths. The photometric calibration set will be selected from the COSMOS field. The science catalog will draw from a set of more than 150 Sunyaev-Zel’dovich, X-ray, and optically selected clusters spanning a wide range of cluster masses and morphologies. Aside from demonstrating the technical approach, these data will enable a systematic program to constrain the mass-observable relations over an unprecedented scale. A successful demonstration of the technical approach and the scientific potential will motivate future development of facility-class instruments on the SPB platform.

Author(s): ***Jason Rhodes (JPL)***, Aurélien Fraisse (Princeton), William Jones (Princeton), Calvin Barth Netterfield (University of Toronto), Richard Massey (Durham)

417.08 – Molecular Gas in the Cooling Flow Group NGC 5044 as Revealed by ALMA

An ALMA observation of the early-type galaxy NGC 5044, which resides at the center of an X-ray bright group with a moderate cooling flow, has detected 24 molecular structures within the central 2.5 kpc. The masses of the molecular structures vary from 3e5 Mo to 1e7 Mo and the CO(2-1) linewidths vary from 15 to 65 km/s. Given the large CO(2-1) linewidths, the observed structures are likely giant molecular associations (GMAs) and not individual molecular clouds (GMCs). Only a few of the GMAs are spatially resolved and the average density of these GMAs yields a GMC volume filling factor of about 15%. The observed masses of the resolved GMAs are insufficient for them to be gravitationally bound, however, the most massive GMA does contain a less massive component with a linewidth typical of an individual virialized GMC. There are no indications of any disk-like molecular structures and all indications suggest that the molecular gas follows ballistic trajectories after condensing out of the thermally unstable hot gas. The 230 GHz luminosity of the central continuum source is 500 times greater than its low frequency radio luminosity and probably reflects a recent accretion event by the central AGN. The spectrum of the central AGN also exhibits an absorption feature with a linewidth typical of an individual GMC and an infalling radial velocity of 250 km/s.

Author(s): ***Laurence David (Harvard Smithsonian, CfA)***, Jeremy Lim (University of Hong Kong), William Forman (Harvard Smithsonian, CfA), Jan Vrtilek (Harvard Smithsonian, CfA), Francoise Combes (Observatoire de Paris), Philippe Salome (Observatoire de Paris), Alastair Edge (Durham University), Ming Sun (University of Alabama), Fabio Gastaldello (INAF), Pasquale Temi (NASA/Ames), Henrique Schmitt (NRL), Youichi Ohyama (Institute of Astonomy and Astrophysics), Steven Hamer (Durham University), William Mathews (University of California Santa Cruz), Fabrizio Brighenti (Universit di Bologna), Simona Giacintucci (University of Maryland), Sandro Bardelli (NRL), Dinh-V Trungg (Vietnamese Academy of Science and Technology)

417.09 – Star Formation and Cooling in CLASH Brightest Cluster Galaxies

We present new constraints on star-formation in the brightest cluster galaxies (BCGs) of the 20 X-ray selected CLASH galaxy clusters. Using 16 HST passbands, we find evidence for significant UV and H? +[NII] emission in ? 50% of these intermediate redshift (? 0.2 - 0.6) BCGs. The emission appears to come from regions with morphologically irregular knots and filaments. The UV and H? fluxes are well correlated with one another. The extinction-corrected luminosities are consistent with the Kennicutt law for continuous star formation. For the largest emission structures we observe, we estimate that the SFRs are 100-200 Msun yr?1, under the assumption that the UV and H? emission is solely due to star formation. We hypothesize that the structures we observe are either direct features of a cooling mechanism in the cores of these clusters or are a direct consequence of the processes that regulate the cooling. Using data from the ACCEPT catalog of Chandra observations of these clusters, we find a correlation between the UV luminosity and several X-ray derived ICM properties. In particular, we find a possible scaling between either the UV or H?+[NII] luminosity and the 1 Gyr cooling radius. These UV and H? features are surprisingly prevalent in the CLASH sample and this new study provides us with new constraints on the physics of gas flows and star formation in cluster cores.

Author(s): ***Kevin Fogarty (Johns Hopkins University)***, Marc Postman (Space Telescope Science Instiitute), Megan Donahue (Michigan State University), John Moustakas (Siena College)

418 – Instrumentation Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

418.01 – Distorted Noise Properties of HST ACS/WFC Images after Pixel-based Correction for Poor Charge-transfer Efficiency

The HST Advanced Camera for Surveys (ACS) image calibration pipeline, CALACS, now performs a pixel-based correction for the Wide Field Camera's (WFC) imperfect CCD charge transfer efficiency (CTE). The degradation of the WFC CTE has become severe in recent years, requiring a correspondingly more aggressive correction in post-processing. This correction may be described as a spatially variable deconvolution, and unavoidably distorts the pixel-to-pixel noise properties of WFC images in complex ways that have not yet been fully quantified. The current study addresses this lack of knowledge by investigating the pixel variance and correlated noise in control samples of processed calibration files spanning the operational lifetime of ACS. We choose two cases of extreme CTE losses, due to their low backgrounds: 1) 1000-second dark frames (heavy contamination from cosmic rays and CCD hot pixels); and 2) bias frames (only contamination from cosmic rays during readout). In both cases, we spoof the CALACS pipeline into treating the calibration exposures as dithered science images, for the most faithful replication of the noise properties encountered by the typical WFC observer who stacks dithered exposures. The results of the analyses presented here will refine the CALACS-generated pixel error array that accompanies the calibrated science image.

Author(s): ***Josh Sokol (STScI)***, Norman Grogin (STScI)

418.02 – Development of Off-Plane Reflection Grating Alignment Fixtures

Currently, grating spectrometers are used onboard the Chandra X-ray Observatory and XMM-Newton in orbit around the Earth. However, future goals of greater spectral resolving power and greater effective areas necessitate a new generation of high-quality spectrometers. Off-plane reflection gratings can be used to provide high throughput and spectral resolution in the 0.3-2.0 keV band, allowing for unprecedented diagnostics of energetic astrophysical processes. A grating spectrometer consists of multiple aligned gratings intersecting the converging beam of a Wolter-I telescope. Each grating will be aligned such that the diffracted spectra overlap at the focal plane. Misalignments will degrade both spectral resolution and effective area. With analytical alignment tolerances calculated, laboratory techniques to achieve these tolerances for flight-like optics must be developed. We present the results from our first and second generation alignment fixtures, as well as wavefront stitching methods.

Author(s): ***Benjamin Donovan (University of Iowa)***, Ryan Allured (Harvard-Smithsonian Center for Astrophysics), Randall McEntaffer (University of Iowa)

418.03 – FIFI-LS - The Facility Far-Infrared Spectrometer for SOFIA

FIFI-LS is the German far-infrared integral field spectrometer for the SOFIA airborne observatory. The instrument offers medium resolution spectroscopy (R ~ a few 1000) in the far-infrared with two independent spectrometers covering 45-110um and 100-210um. The integral field units of the two spectrometers obtain spectra covering concentric square fields-of-views sized 30" and 60", respectively. Both spectrometers can observe simultaneously at any wavelength in their ranges making efficient mapping of far-infrared lines possible. FIFI-LS is being commissioned at the airborne observatory SOFIA first as a PI instrument in spring 2014. During 2015, the commissioning as facility instrument will be complete and the SOFIA observatory will take over the operation of FIFI-LS. The instrument can already be used by the community. Primary science cases are the study of the galactic and extra-galactic interstellar medium and star formation. The capabilities of FIFI-LS on the SOFIA telescope and observing modes will be explained. FIFI-LS offers observing modes for compact sources, extended sources, and mapping. All modes use spatial and spectral dithering. The resulting data products will be 3D-data cubes. The spectral extent will vary between 500km/s and 2500km/s depending on the observing wavelength. The observing parameters will be specified using AOTs, like the other SOFIA instruments, and created via the tool SSPOT which is similar to the Spitzer Space Telescope SPOT tool. The observations will be done in service mode, but SOFIA invites a few investigators to fly onboard SOFIA during (part of) their observations. After a flight, the data get pipeline reduced, quality checked by the SOFIA science staff, and provided to the investigator via the SOFIA data archive.

Author(s): ***Randolf Klein (USRA-SOFIA)***, Simon Beckmann (University Stuttgart), Aaron Bryant (University Stuttgart), Sebastian Colditz (University Stuttgart), Christian Fischer (University Stuttgart), Fabio Fumi (University Stuttgart), Norbert Geis (MPE), Rainer Hönle (University Stuttgart), Alfred Krabbe (University Stuttgart), Leslie Looney (UIUC), Albrecht Poglitsch (MPE), Walfried Raab (MPE), Felix Rebell (University Stuttgart), Maureen Savage (USRA-SOFIA)

418.04 – First Light with the EXES Instrument on SOFIA

The Echelon Cross Echelle Spectrograph (EXES) successfully carried out its first two flights with the Stratospheric Observatory for Infrared Astronomy (SOFIA) on the nights of April 7 and 9, 2014. EXES is a high-resolution (R=100,000) spectrograph that operates from 4.5 to 28.3 microns. Our commissioning targets included a mix of solar system and Galactic objects which were selected to characterize the performance of EXES onboard SOFIA as well as to provide unique science data. We present some of these high-resolution spectra and the preliminary science analysis, as well as our current characterization of the on-sky performance and sensitivity of EXES.

Author(s): ***Curtis DeWitt (NASA Ames)***, Matthew Richter (UC Davis), Kristin Kulas (NASA Ames), Mark McKelvey (NASA Ames), Michael Case (UC Davis), Robert McMurray (NASA Ames), William Vacca (Universities Space Research Association), Melanie Clarke (Universities Space Research Association), Adwin Boogert (Universities Space Research Association), Graham Harper (Trinity College), Thomas Greathouse (Southwest Research Institute), Nils Ryde (Lund University)

418.05 – The 20-20-20 Airship Challenge

A NASA Centennial Challenge; (http://www.nasa.gov/directorates/spacetech/centennial_challenges/index.html) is in development to spur innovation in stratospheric airships as a science platform. We anticipate a million dollar class prize for the first organization to fly a powered airship that remains stationary at **20km** (65,000 ft) altitude for over **20 hours** with a **20kg** payload. The design must be scalable to longer flights with more massive payloads. In NASA's constrained budget environment, there are few opportunities for space missions in astronomy and Earth science, and these have very long lead times. We believe that airships (powered, maneuverable, lighter-than-air vehicles) could offer significant gains in observing time, sky and ground coverage, data downlink capability, and continuity of observations over existing suborbital options at competitive prices. We seek to spur private industry (or non-profit institutions, including FFRDCs and Universities) to demonstrate the capability for sustained airship flights as astronomy and Earth science platforms. This poster will introduce the challenge in development and provide details of who to contact for more information.

Author(s): ***Alina Kiessling (JPL)***, Ernesto Diaz (JPL), Sarah Miller (UC Irvine), Jason Rhodes (JPL)

419 – Molecular Clouds, the ISM and YSOs Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

419.01 – H2 in the UV-rich Environment of Orion's Veil

Understanding the physics of molecular gas, almost by definition, requires understanding the physics of molecular hydrogen. H2 is the most abundant molecule in molecular clouds, the formation of H2 initiates the transition from warmer atomic to cooler molecular gas, and H2 serves as a catalyst in the formation of other molecules like CO that are widely used to study star-forming regions. It is no exaggeration to say that a fundamental understanding of the earliest phases of star formation is impossible without a fundamental understanding of the physics of H2. In this presentation, we will present high-resolution UV absorption spectroscopy towards the Trapezium stars in the Orion Nebula. Using the STIS E140H setting of HST, we now have an S/N = 50 - 150 spectral dataset between 1133 - 1335 Angstroms, with a spectral resolution of 2.5 km/s. This dataset will allow us to determine the H2 column density in a PDR which has a very low H2 column density (H2/H(tot) < 10^-5). By observing the column density of high rotational/vibrational levels of H2, and combining the observations a detailed model of ISM physics using Cloudy, we hope to better understand the physics of H2 in high-UV flux environments, which has applications to star-forming environments at the galactic and extra-galactic level.

Author(s): ***Nicholas Abel (University of Cincinnati, Clermont Campus)***, Gary Ferland (University of Kentucky), C. O'Dell (Vanderbilt University), Thomas Troland (University of Kentucky)

419.02 – TRAO Outer Galaxy Survey in 13CO

We present a result of 13CO(1-0) survey toward the Outer Galactic Plane using the multi-beam receiver system installed on the 14 m telescope at Taeduk Radio Astronomy Observatory(TRAO). Our target region is from l=120o to 140o and b=-1o to +1o, which is the part of the 12CO Outer Galactic Plane Survey (Heyer et al. 1998). All data are on 50" grid, and the beamsize is also 50". Velocity resolution is 0.63 km/sec, and the total velocity range is from -150 km/sec to 100 km/sec. A total of 23,000 spectra were obtained. The rms noise is about 0.15 K per channel for unsmoothed raw data. We will present a few initial results of the survey database, comparing with 12CO Outer Galactic Plane Survey database.

Author(s): ***Youngung Lee (Korea Astronomy and Space Science Institute)***

419.03 – Limits on the OVII Emission from the Local Hot Bubble

Constraining the properties of the gas in the local hot-bubble (LHB) is important for the understanding of the interstellar medium surrounding the sun. Much information about its energetic state is embedded in the observations of the low-energy diffuse X-ray background. From molecular-cloud shadowing observations (Galeazzi et al. 2006, R. Smith et al. 2007, Henley et al. 2007) it is known that a significant fraction of the 0.57keV OVII X-ray flux originates locally (< ~300 pc). To investigate the origin of this OVII emission, we analyze the correlation between OVII flux (extracted from Suzaku observations cleaned of point sources) against the local fraction of the ROSAT ¼ keV emission (R12 band), as separated from the distant (hot halo/extragalactic) component by Snowden (1998) and Kuntz (2000). Observations were selected to avoid galactic in-plane emission and features of other large-scale ISM structures. After correcting OVII flux for the more distant latitude-dependent emission, we find that it is essentially uncorrelated with the local ¼ keV emission, implying that the local hot bubble is not the source of the observed OVII emission. The lack of OVII emission further precludes temperatures above ~1E6K for the LHB gas (assuming collisional equilibrium models with solar abundance).

Author(s): ***Felix Jaeckel (University of Wisconsin - Madison)***, Yaqiong Li (University of Wisconsin - Madison), Kelsey Morgan (University of Wisconsin - Madison), Natalia Petre (University of Wisconsin - Madison), Patrick Sauter (University of Wisconsin - Madison), Dan McCammon (University of Wisconsin - Madison)

419.04 – High Amlitude Near-Infrared Variability Among YSOs in the ONC

We have carried out deep, comprehensive NIR time-series observations of the Orion Nebula Cluster using WFCAM on UKIRT, in an 0.9 x 0.9 degree J, H, K survey comprising ~100 nights in a ~900 day window. Out of 14,728 monitored objects brighter than J~20.5, we find 1202 highly variable stars with a Stetson variability index exceeding 1.0, including 539 periodic sources with periods between 2 and 50 days. We have calculated variability properties separately for Class I, II, and III objects, and find that Classes I and II have statistically larger amplitude variability than Class III stars. Many stars have significantly variable J-H and H-K color terms; most of the Class II color-variables show color changes that are consistent with changes in dust reddening, but a substantial fraction show color changes that indicate changes in accretion rate or accretion structure.

Author(s): ***Scott Wolk (Harvard-Smithsonian Center for Astrophysics)***, Thomas Rice (University of Michigan), Bo Reipurth (University of Hawaii)

419.05 – YSOVAR: Mid-IR variability in the star forming region Lynds 1688

The emission from young stellar objects (YSOs) in the mid-IR is dominated by the inner rim of their circumstellar disks. We present an IR-monitoring survey in the direction of the Lynds 1688 (L1688) star forming region over four visibility windows spanning 1.6 years using the Spitzer space telescope in its warm mission phase. Among the lightcurves, 57 sources are cluster members identified based on their spectral-energy distribution and X-ray emission. Almost all cluster members show significant variability. The amplitude of the variability is larger in more embedded YSOs. Ten out of 57 cluster members have periodic variations in the lightcurves with periods typically between three and seven days, but even for those sources, significant variability in addition to the periodic signal can be seen. No period is stable over 1.6 years. Non-periodic lightcurves often still show a preferred timescale of variability which is longer for more embedded sources. About half of all sources exhibit redder colors in a fainter state. This is compatible with time-variable absorption towards the YSO. The other half becomes bluer when fainter. These colors can only be explained with significant changes in the structure of the inner disk. No relation between mid-IR variability and stellar effective temperature or X-ray spectrum is found.

Author(s): ***Hans Moritz Guenther (SAO)***

Contributing teams: YSOVAR

419.06 – Accretion Shocks on T Tauri Stars: Plans for a Lab-Astro Experiment

We present plans for a laboratory astrophysics experiment of a scaled accretion shock at the surface of a classical T Tauri star. By creating a plasma jet (representing the accreting material) and colliding it with a solid block (representing the surface of the T Tauri star), we hope to gain insight into the structure and morphology of T Tauri accretion shocks. Magnetic fields may play crucial role in this phenomenon, and therefore we intend to conduct our experiment with imposed magnetic fields up to 8 T. We have a day of experiments planned on the OMEGA laser in May 2014; some preliminary data may be available in time for this conference. This work is funded by the U.S. Department of Energy, through the NNSA-DS and SC-OFES Joint Program in High-Energy-Density Laboratory Plasmas, grant number DE-NA0001840, and the National Laser User Facility Program, grant number DE-NA0000850, and through the Laboratory for Laser Energetics, University of Rochester by the NNSA/OICF under Cooperative Agreement No. DE-FC52-08NA28302.

Author(s): ***Rachel Young (University of Michigan)***, Carolyn Kuranz (University of Michigan), R. Paul Drake (University of Michigan), Dustin Froula (Laboratory for Laser Energetics), J. Ross (Lawrence Livermore National Laboratory), Chikang Li (Massachusetts Institute of Technology), Gennady Fiksel (Laboratory for Laser Energetics)

419.07 – Identifying New Members of Nearby Moving Groups

Our group has assembled a sample of 14,000 stars of spectral types B9-M9 with measured UVW Galactic space velocities and lying within 125 pc of Earth. We have identified candidate members of three nearby young (less than 100 Myr) moving groups. For stars of spectral types G5 and later, we have used the Kast spectrometer on the Shane 3m telescope at Lick Observatory to measure lithium abundance in order to determine stellar ages. With the data we have obtained from this run, we will be able to establish whether our candidates are bona fide members of the moving groups in question. I will be presenting the preliminary results from this survey, including spectra of the ~50 stars observed thus far. These nearby young stars will make excellent targets for direct imaging followup surveys, since any giant planets around young stars will still be warm, and will therefore be bright enough to detect with instruments like GPI.

Author(s): ***Erika Holmbeck (UCLA)***, Laura Vican (UCLA)

419.08 – Characterizing Turbulence in Protoplanetary Disks: Gravito-Turbulence vs. the MRI in 3D

Characterizing turbulence in protoplanetary disks is crucial for understanding how they accrete and spawn planets. Recent measurements of spectral line broadening promise to diagnose turbulence, with different lines probing different depths. We use 3D local hydrodynamic simulations of cooling, self-gravitating disks to resolve how motions driven by “gravito-turbulence” vary with height. We find that gravito-turbulence is practically as vigorous at altitude as at depth. The near-uniformity of turbulent velocities is enforced by the long-range nature of gravity. By contrast, turbulence driven by the magnetorotational instability (MRI) exhibits strong height dependence. The distinct vertical profiles of gravito-turbulence vs. MRI turbulence may be used in conjunction with measurements of non-thermal linewidths at various depths to identify the source of transport in protoplanetary disks.

Author(s): ***Ji-Ming Shi (University of California, Berkeley)***, Eugene Chiang (University of California, Berkeley)

419.09 – Herschel Observations of Dusty Debris Disks

We present results from several Herschel surveys of debris disks around nearby, young stars. The first survey was an OT-1 project based on Herschel PACS far-infrared photometry of six stars to search for the cold component of previously discovered warm debris disks. If the cold component exists, then collisions between cometary bodies in the cold belt may be feeding the grain population of the warm dust component. If no cold component is seen, then the observed warm dust is likely the result of a recent collision between planetary embryos in the terrestrial planet zone. A second survey was an OT-2 PACS program to further characterize the SEDs of more than a dozen known debris disks. In addition to these two surveys, we present PACS photometry of the debris disk at the star V488 Per that extends its SED into the far-infrared. V488 Per has the largest fractional infrared luminosity (percentage of its bolometric luminosity) known for any main sequence star.

Author(s): ***Laura Vican (UCLA)***, Joseph Rhee (California State Polytechnic University), Ben Zuckerman (UCLA), Carl Melis (UCSD), Inseok Song (University of Georgia)

420 – Stars, Stellar Evolution and So On Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

420.01 – Application of the 2013 Wilson-Devinney Program's Direct Distance Estimation procedure and enhanced spot modeling capability to eclipsing binaries in star clusters

A paradigm method to calibrate a range of standard candles by means of well-calibrated photometry of eclipsing binaries in star clusters is the Direct Distance Estimation (DDE) procedure, contained in the 2010 and 2013 versions of the Wilson-Devinney light-curve modeling program. In particular, we are re-examining systems previously studied in our Binaries-in-Clusters program and analyzed with earlier versions of the Wilson–Devinney program. Earlier we reported on our use of the 2010 version of this program, which incorporates the DDE procedure to estimate the distance to an eclipsing system directly, as a system parameter, and is thus dependent on the data and analysis model alone. As such, the derived distance is accorded a standard error, independent of any additional assumptions or approximations that such analyses conventionally require. Additionally we have now made use of the 2013 version, which introduces temporal evolution of spots, an important improvement for systems containing variable active regions, as is the case for the systems we are studying currently, namely HD 27130 in the Hyades and DS And in NGC 752. Our work provides some constraints on the effects of spot treatment on distance determination of active systems.

Author(s): ***Eugene Milone (University of Calgary)***, Stephen Schiller (University of Calgary)

420.02 – The X-ray Binary J1118+480: Starspots and the Resumption of Mass Transfer

We obtained high-speed optical photometry of the black hole X-ray binary J1118+480 on 25 nights in 2004 - 2005 and 2010 - 2012. The system was in quiescence during the 2004 - 2005 observations. The orbital light curve was dominated by a two-humped ellipsoidal variation of the secondary star. The light curve was highly stable and there was no detectable contribution to the light curve from mass transfer and accretion processes. The orbital light curve in 2004-2005 was, however, asymmetric in orbital phase, which is inconsistent with pure ellipsoidal variations. We attribute the asymmetry to spots on the secondary star. Synthetic light curves produced by models including just ellipsoidal variations and a single large spot on the surface of the secondary star fit the observed light curve well. J1118+480 was up to 20% brighter in 2010-2012 and its light curve displayed rapid flickering, indicating that mass transfer had resumed by then.

Author(s): ***Isaac Lopez (Univ. of Texas at El Paso)***, Paul Mason (Univ. of Texas at El Paso), Edward Robinson (Univ. of Texas at Austin), Robert Hynes (Louisiana State Univ.)

420.03 – Analysis of the Short period Solar Type binary, V1073 Herculis and the detection of a possible brown dwarf companion

V1073 Herculis is a very short period, P= 0.294281673(4) day eclipsing binary. It was observed on May 7, 9, 11, and 12, 2012 by at the Lowell Observatory 31" NURO reflector by Samec, Benkendorf and Dignan. The analysis was carried out by Kring, Samec and Shebs. The period study consisting of some 54 times of minimum light included four new timings determined through this study: JD Hel Min I = 2456056.8549±0.0002, 2456058.7685±0.0002, 2456058.91485±0.00008, 2456059.9455±0.0001. They reveal a very low amplitude, <0.003 d sinusoidal variation and a period of 11.25 years, which may indicate the presence of a Brown Dwarf third component and the first detection of such a body through an O-C study. 2MASS photometry reveals that the temperature of the binary is ~5200K. The Wilson-Devinney Program preliminary solution reveals that the system has a mass ratio of 0.4, nearly identical component temperatures and a cool magnetic spot with a T-factor of 0.88 with a spot radius of 23 degrees. The Roche Lobe fill-out is 0.18. The inclination is nearly 80 degrees. We wish to think NURO for its allocation of observing time.

Author(s): ***Travis Shebs (Bob Jones University)***, James Kring (Bob Jones University), Ronald Samec (Bob Jones University)

420.04 – On the Spectroscopic Properties of the Retired A Star HD 185351

Doppler-based planet surveys have shown that, besides metallicity, the planet occurrence is also correlated with stellar mass, increasing from M to F-A spectral types. However, it has recently been argued that the subgiants (which represent A stars after they evolve off the main sequence) may not be as massive as suggested initially, which would significantly change the correlation found. To start investigating this claim, we have studied the subgiant star HD 185351, which has precisely measured physical properties based on asteroseismology and interferometry. An independent spectroscopic differential analysis based on excitation and ionization balance of iron lines yielded the atmospheric parameters T_{eff} = 5035 ± 29 K, log g = 3.30 ± 0.08 and [Fe/H] = 0.10 ± 0.04. These were used in conjunction with the PARSEC stellar evolutionary tracks to infer a mass M = 1.77 ± 0.04 M?, which agrees well with the previous estimates. Lithium abundance was also estimated from spectral synthesis (A(Li) = 0.93 ± 0.30) and, together with T_{eff} and [Fe/H], allowed to determine a mass M = 2.0 [+0.1 -0.3] M?, which is independent of the star's parallax and surface gravity. Although a variation of up to ~0.4 M? can be observed between the different mass estimates, all values are higher than 1.6 M?, which supports the correlation between planet occurrence and stellar masses.

Author(s): ***Luan Ghezzi (Harvard-Smithsonian Center for Astrophysics)***, José-Dias Do Nascimento (DFTE/Universidade Federal do Rio Grande do Norte), John Johnson (Harvard-Smithsonian Center for Astrophysics)

420.05 – Testing Stellar Models with Accurate Parallaxes and Abundances of Metal-Poor Stars

An abundance analysis of nine low metallicity main sequence stars using high dispersion spectroscopy from the Keck/HiRES and Magellan/Mike spectrographs is presented. These stars have recently had their parallaxes determined using the Fine Guidance Sensors on HST. Currently, the van Leeuwen (2007) Hipparcos catalog contains only one star with [Fe/H] <-1.4 suitable for use in main sequence fitting; the results of this work, along with the HST parallax measurements, will increase the number of stars available for main sequence fitting by an order of magnitude. Preliminary [Fe/H] and [?/Fe] abundances have been obtained. Eight of the nine target stars have metallicity [Fe/H] < -1.5 that can be used in the development of accurate stellar models for low metallicity stars. These results extend the range of stellar metallicities that can be modeled and will help to improve the accuracy of distance determinations to metal-poor GCs.

Author(s): ***Erin O'Malley (Dartmouth College)***, Andrew McWilliam (The Observatories of the Carnegie Institute of Washington), Brian Chaboyer (Dartmouth College)

420.06 – Photometry on Metal-Poor Stars with HST Parallaxes

Stellar evolution models and isochrones of metal-poor stars are widely used in astrophysics. However, there are few observational tests of the validity of these models below metallicities of [Fe/H] = -1.5. To remedy this situation, HST has determined parallaxes for 9 metal-poor main sequence stars. Here, we present new ground-based photometry of these stars. The observations were obtained at MDM observatory in March of 2012 over the course of five nights. Our photometry is compared to literature values and combined with parallax results to obtain absolute magnitudes for these stars. The locations of the stars on a color-magnitude diagram are compared to theoretical models.

Author(s): ***Meridith Joyce (Dartmouth College)***, Brian Chaboyer (Dartmouth College), Gregory Feiden (Dartmouth College), Morgan Matthews (Dartmouth College), G. Benedict (McDonald Observatory), Barbara McArthur (McDonald Observatory), Thomas Harrison (New Mexico State University), Andrew McWilliam (Carnegie Institute of Washington), Edmund Nelan (Space Telescope Science Institute), Richard Patterson (University of Virginia), Ata Sarajedini (University of Florida)

420.07 – Numerical Simulations of Microturbulence in Hot Stellar Atmosphers

Microturbulence is one of the factors that determines the width of a spectral line in stellar atmospheres along with Doppler broadening and other forms. At this point in time it has been used as a parameter to match the observational results without explanation of why the microturbulence value is what it is. Here we are modeling hot stellar atmospheres with a 3D radiative hydrodynamic code to determine the causes and scale of microturbulent motions and their contributions to non-LTE scattering in resonance line transfer.

Author(s): ***Michelle Deady (University of Toledo)***, Lawrence Anderson-Huang (University of Toledo)

421 – Stars: Variable and Explosive Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

421.01 – Probing rotational dynamo extremes: X-ray and optical spectroscopy of the 0.5 day period eclipsing binary, HD 79826.

The highly modulated optical light curve of HD 79826 (spectral type G5) was discovered in the Chandra guide-star light curves, indicating a period of about 0.5 days, a strong and migrating distortion wave, and a shallow eclipse. We subsequently obtained simultaneous Chandra high resolution X-ray spectra and optical photometry, along with contemporaneous ground-based photometry and spectra. X-ray rotational or eclipse modulation was totally obscured by X-ray variability and flares. X-ray spectra are characterized by coronal emission near the saturation limit of Lx/Lbol = 0.001. Optical spectra show extremely rotationally broadened features, variable with orbital phase. Optical light curves show the modulation to be not only rapidly migrating in phase, but also of variable amplitude. We will further characterize the X-ray emission through measurements of line widths, velocities, and fluxes, and provide coronal plasma models. This star is near or at the limits of dynamo saturation, and since it is partially eclipsing, has potential to be well characterized in terms of fundamental stellar parameters. Acknowledgments: This work was supported by NASA through the Smithsonian Astrophysical Observatory (SAO) contract SV3-73016 for the Chandra X-Ray Center and Science Instruments.

Author(s): ***David Huenemoerder (MIT Kavli Institute)***, Joy Nichols (CfA), David DePalma (CfA), David Garcia-Alvarez (IAC), Norbert Schulz (MIT Kavli Institute), Claude Canizares (MIT Kavli Institute)

421.02 – Variable Star Discoveries for Research Education at the Phillips Academy Observatory

The discovery and publication of unknown variable stars by high school students is a highly engaging activity in a new hands-on research course developed at Phillips Academy in Andover, Massachusetts. Students use MPO Canopus software to recognize candidate variable stars in image series typically recorded for asteroid rotation studies. Follow-up observations are made using the 16-inch DFM telescopes at the Phillips Academy Observatory and at the HUT Observatory near Eagle, Colorado, as well as with a remote-access 20-inch at New Mexico Skies Observatory near Mayhill, New Mexico. The Catalina Sky Survey can provide additional photometric measurements. Confirmed variables, with light curves and periods, are submitted to the International Variable Star Index and Journal of the American Association of Variable Star Observers. Asteroid rotation studies are published in Minor Planet Bulletin.

Author(s): ***Caroline Odden (Phillips Academy)***, Seokjun Yoon (Phillips Academy), Emily Zhu (Phillips Academy), John Little (Phillips Academy), Isabel Taylor (Phillips Academy), Ji Seok Kim (Phillips Academy), John Briggs (HUT)

421.03 – The RR Lyrae Period-Luminosity Relation in IRAC Channels 1 and 2

We present new period-luminosity relations for RR Lyrae variables in the globular cluster ? Centauri derived from time-resolved IRAC data, the slopes of which are in reasonable agreement with those derived from WISE data by Madore et al (2013), Klein et al (2014), and Dambis et al (2014). We also present an investigation into the correlation of the PL residuals with individual metallicities from Rey et al (2000) and Sollima et al (2006). We find no compelling evidence for a metallicity correlation in the residuals, based on a spread of up to 1.19 dex in [Fe/H].

Author(s): ***Meredith Durbin (Pomona college)***, Victoria Scowcroft (Carnegie Observatories), Wendy Freedman (Carnegie Observatories), Barry Madore (Carnegie Observatories), Andrew Monson (Carnegie Observatories), Mark Seibert (Carnegie Observatories), Jeffrey Rich (Carnegie Observatories)

421.04 – Swift/BAT detection of hard X-rays from Tycho;s Supernova Remnant: Evidence for 44Ti

We report Swift/BAT survey observations of the Tycho supernova remnant, performed over a period of 104 month. A total exposure of 19.6 Ms was used to detect significant hard X-ray emission up to about 100 keV. Excess emission above this continuum in the 60-85 keV band was found, consistent with line emission from radioactive 44T. We discuss the implications of these results in the context of the galactic supernova rate, and nucleosynthesis in Type II and Type Ia supernova, with emphasis on the production of 44Ti.

Author(s): ***Dieter Hartmann (Clemson Univ.)***, Eleonora Troja (Clemson Univ.), Wayne Baumgartner (Clemson Univ.), Craig Markwardt (Clemson Univ.), Scott Barthelmy (Clemson Univ.), Neil Gehrels (Clemson Univ.), Alberto Segreto (Clemson Univ.), Valentina La Parola (Clemson Univ.)

Contributing teams: Swift/BAT

421.05 – Light Curves of Type IIL Supernovae

The absolute-magnitude light curves of 17 Type IIL supernovae are studied. A light curve model is used in the analysis. From the model, we are able to make estimates of the progenitor radius, the kinetic energy in the explosion, the total ejected mass and nickel mass in the explosion as well as the rise time for each supernova.

Author(s): ***Dean Richardson (Xavier University of Louisiana)***, Aaron Benner (Shippensburg University), Zachary Babyak (Purdue University), Benjamin Moore (Xavier University of Louisiana)

421.06 – Multi-Wavelength Light Curve of SN 2014G

SN 2014G received an initial spectral classification of Type IIn (CBET 3787) as a blue continuum with some sharp emission. Later spectra (ATEL 5935) showed that it is more likely it is a Type II-L. We present multi-band photometry for this object from the peak until approximately 100 days after.

Author(s): ***John Martin (U of Illinois Springfield)***, Alberto Betzler (Universidade Federal do Reconcavo da Bahia), Douglas Barrett (), Andy Cason (), Tõnis Eenmäe (Tartu Observatory), Raymond Kneip (), Massimiliano Martignoni ()

421.07 – An XMM-Newton Observation of the Spitzer-Detected Galactic Supernova Remnant Kesteven 69 (G21.8-0.6)

The Galactic supernova remnant (SNR) Kesteven 69 (G21.8-0.6) has been the subject of intensive study across a broad range of the electromagnetic spectrum (from X-ray through radio). These observations have revealed a source with a radio-luminous southern rim that is interacting dramatically with an adjacent molecular cloud, as indicated by the detection of masers toward this SNR as well as the identification by Spitzer of a prominent infrared counterpart to the radio luminous rim. To date, the X-ray properties of Kesteven 69 remain poorly explored: while hard X-ray sources seen toward this SNR have been classified as fast ejecta fragments, little study has been devoted to the diffuse X-ray emission. We present a spatially-resolved spectral analysis of this SNR where we consider both the global X-ray spectrum of the diffuse emission as well as the spectra of individual regions of the emission. We search for spatial variations in the temperature, ionization timescale and elemental abundances of the plasma and compare the X-ray properties of Kesteven 69 to other Galactic SNRs known to be interacting with adjacent molecular clouds. Initial results will be presented and discussed.

Author(s): ***Thomas Pannuti (Morehead State University)***

421.08 – A Reverse Shock in GRB 130427A

We present extensive radio and millimeter observations of the unusually bright GRB 130427A at z=0.340, spanning 0.67 to 12 days after the burst. Taken in conjunction with detailed multi-band UV, optical, NIR, and X-ray observations we find that the broad-band afterglow emission is composed of distinct reverse shock and forward shock contributions. The reverse shock emission dominates in the radio/millimeter and at <0.1 days in the UV/optical/NIR, while the forward shock emission dominates in the X-rays and at >0.1 days in the UV/optical/NIR. We further find that the optical and X-ray data require a Wind circumburst environment, pointing to a massive star progenitor. Using the combined forward and reverse shock emission we find that the parameters of the burst are an isotropic kinetic energy of E_Kiso~2e53 erg, a mass loss rate of Mdot~3e-8 Msun/yr (for a wind velocity of 1,000 km/s), and a Lorentz factor at the deceleration time of Gamma(200s)~130. Due to the low density and large isotropic energy, the absence of a jet break to ~15 days places only a weak constraint on the opening angle of theta_j>2.5 deg, and therefore a total energy of E_gamma+E_K>1.2e51 erg, similar to other GRBs. The reverse shock emission is detectable in this burst due to the low circumburst density, which leads to a slow cooling shock. We speculate that this is a required property for the detectability of reverse shocks in the radio and millimeter bands. Following on GRB 130427A as a benchmark event, observations of future GRBs with the exquisite sensitivity of VLA and ALMA, coupled with detailed modeling of the reverse and forward shock contributions will test this hypothesis.

Author(s): ***Tanmoy Laskar (Harvard University)***, Edo Berger (Harvard University), B. Zauderer (Harvard-Smithsonian CfA), Raffaella Margutti (Harvard-Smithsonian CfA), Alicia Soderberg (Harvard University), Ragnhild Lunnan (Harvard University), Ryan Chornock (Harvard-Smithsonian CfA)

422 – The Sun and The Solar System Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

422.01 – An Explanation of the Differences Between the Sunspot Area Scales of the Royal Greenwich and Mt. Wilson Observatories, and the SOON Program.

Several studies have shown that the sunspot areas recorded by the Royal Greenwich Observatory (RGO) between 1874 - 1976 are about 40-50 percent larger than those measured by the NOAA/USAF Solar Observing Optical Network(SOON) since 1966. We show here that, while the two measurement sets provide consistent total areas for large spots, the impossibility of recording small spots as anything except dots in the SOON drawings leads to an underestimate of of small spot areas. These are more accurately recorded by the RGO and other programs that use photographic or CCD images. The large number of such small spots is often overlooked. A similar explanation holds for the RGO umbral areas, which amount to 40 percent more than those measured from Mt. Wilson data between 1923 and 1982. The neglected small spots have a much lower photometric contrast. Our explanation suggests, therefore, that the adjustment to spot irradiance blocking at the 1976 transition from RGO to SOON areas is smaller than the almost 50 percent correction advanced by some recent, purely statistical, studies.

Author(s): ***Peter Foukal (Heliophysics, Inc.)***

422.02 – Calculated Sunspot and Quiet-Sun Mg II Profiles Compared With IRIS Data Eugene Avrett and Hui Tian Harvard-Smithsonian Center for Astrophysics 60 Garden Street, Cambridge, MA 02138

A new sunpsot model has been derived, consistent with the SUMER atlas data of Curdt, et al. and Mg II profile data from IRIS. Comparisons are made with Quiet-Sun results from both sources. It is necessary to include molecules in the sunspot model not only account for the low brightness temperatures near 1850 /AA but also for the density variations higher in the atmosphere. The minimum temperature is roughly 2500 K in the sunspot model and 4500 K for the quiet Sun. The Mg II H line profile is centrally reversed in both cases, with the peak intensity originating where the temperature rises abruptly from the minimum value. The line center is formed at the top of the chromosphere where the temperature rises abruptly from 10,000 K into the chromosphere-corona transition region. The calculated Mg II line center intensity is much smaller than observed, for models constrained by the EUV continuum data.

Author(s): ***Eugene Avrett (Harvard-Smithsonian CfA)***

422.03 – Coronal Diagnostics from Cometary Emission

The extreme ultraviolet (EUV) emission observed from sungrazing comets as they pass through the solar atmosphere can be used to infer the properties of the corona. In this paper we will discuss several of these properties that can be estimated from the EUV observations of Comet Lovejoy from AIA/SDO and SWAP/PROBA2. The longevity of the emission allows us to constrain the coronal electron density through which the comet passes. We will also discuss how dispersion of the emitting cometary material we can be used to estimate the local Alfven speed in the corona. Finally, measuring the deformation of the magnetic field as it is impacted by the comet can be used to estimate the magnetic field strength in this location. In the absence of the comet, none of these parameters are directly measurable in the corona. Sungrazing comets are thus unique probes of the solar atmosphere.

Author(s): ***Paul Bryans (NASA Goddard Space Flight Center)***, William Pesnell (NASA Goddard Space Flight Center), Daniel Seaton (Royal Observatory of Belgium), Matthew West (Royal Observatory of Belgium)

422.04 – Spectropolarimetric Observations of a Small Active Region with IBIS

We have used the Interferometric BI--dimensional Spectrograph (IBIS) instrument at the Dunn Solar Telescope to measure the polarimetric Stokes IQUV signals for the small active region, NOAA 11304. We used three lines generally corresponding to three atmospheric heights ranging from the photosphere to low corona: Fe I 6302?, NaI 5896?, and CaII 8542?. Each set of profiles has been inverted using the NICOLE code to determine the vector magnetic field at the three heights throughout the field of view, or the line--of--sight field, as allowed by the level of polarization signal. Comparisons are made between the magnetic and thermal structures with the goal of constraining chromospheric models with the information obtained at multiple heights.

Author(s): ***Lucas Tarr (Montana State University)***, Philip Judge (NCAR/HAO)

422.05 – The Quasi-Annual Forcing of The Sun’s Eruptive, Radiative, and Particulate Output

The eruptive, radiative, and particulate output of the Sun are modulated by our star’s enigmatic 11-year sunspot cycle. Over the past year we have identified observational signatures which illustrate the ebb and flow of the 11-year cycle – arising from the temporal overlap of migrating activity bands which belong to the 22-year magnetic activity cycle. (At the 2012 Fall AGU Meeting, Leamon & McIntosh presented a prediction of minimum conditions developing in 2017 and Cycle 25 sunspots first appearing in late 2019.) As a consequence of this work we have deduced that the latitudinal interaction of the oppositely signed magnetic activity bands in each hemisphere (and across the equator near solar minimum) dramatically impacts the production of Space Weather events such as flares and Coronal Mass Ejections (CMEs). The same set of observations also permits us to identify a quasi-annual variability in the rotating convecting system which results in a significant local modulation of solar surface magnetism. That modulation, in turn, forces prolonged periods of significantly increased flare and CME production, as well as significant changes in the Sun's ultraviolet (UV), extreme ultraviolet (EUV), and X-Ray irradiance.

Author(s): ***Robert Leamon (Montana State University)***, Scott McIntosh (HAO/NCAR)

Contributing teams: The Whomps Team

422.06 – Off Limb Solar Adaptive Optics

Long-exposure spectroscopy and spectro-polarimetry at near-infrared wavelengths is one of the preferred tools deployed to measure the physical properties of prominences, including the prominence magnetic field. However, until now, it was not possible to observe prominences in sufficient detail to allow us to understand their dynamical properties. In order to understand solar prominences, we need to observe them at sub-arcsecond spatial resolution, with a temporal cadence sufficient to make highly transient structures visible. Adaptive optics capable of locking-on to off-limb prominence structure has been proven successful. It has been shown to allow for diffraction limited spectroscopy and polarimetry of prominence structure. This adaptive optics system will allow scientists to come one step closer to understanding the true nature of solar prominences.

Author(s): ***Gregory Taylor (New Mexico State University)***

422.07 – Modeling of SDO/HMI spectro-polarimetric data and center-to-limb variation effects with 3D MHD simulations

Observations with the Solar Dynamics Observatory (SDO), and, in particular, Helioseismic and Magnetic Imager (HMI) provide a unique opportunity to investigate various phenomena simultaneously over the whole solar disk. Current state-of-the-art numerical simulations allow us to model the observational data with a high degree of realism, and use the artificial data for interpretation of observed properties ("observables") in terms of the physical conditions, for the testing of new data analysis techniques and the improvement of data calibration. In the current study we use realistic-type 3D radiative MHD simulations of the upper turbulent convective layer and atmosphere of the Sun, obtained with the SolarBox code, and employ the spectro-polarimetric radiative transfer code SPINOR to convert the simulated data into Stokes profiles of the HMI Fe I 6173 A line for different conditions in the solar atmosphere. For testing the HMI calibration the synthetic Stokes profiles are processed through the SDO/JSOC simplified data analysis pipeline. We investigate properties of the HMI observables for various solar features, variations of the line formation height for different angular distances from the disk center, effects of the spatial resolution and iron abundance, and pay particular attention to the center-to-limb variations effects playing important role in local helioseismology measurements.

Author(s): ***Irina Kitiashvili (Stanford University)***, Sebastien Couvidat (Stanford University)

422.08 – Limits of Astrometric and Photometric Precision on KBOs using Small Telescopes

We conducted photometric and astrometric measurements on Haumea and Makemake, two Kuiper Belt Objects which are typically observed by 1-meter class telescopes or larger, with the goal of testing the limitations of small telescopes. Here we present our measurements of Haumea and Makemake obtained between June 5th, 2013 and July 31st, 2013 with the 14-inch Wallace Astrophysical Observatory (WAO) telescopes. Using photometry, we determined that Haumea and Makemake have R-band magnitudes of 17.225 ± 0.347 and 16.850 ± 0.107 respectively. These values agree with the previous R-band measurements of 17.240 ± 0.030 (Lacerda et al. 2008) and 16.802 ± 0.041 (Rabinowitz et al. 2007) for Haumea and Makemake respectively. We obtained rotational light curves for Haumea and Makemake over eight separate nights, again by analysing the photometry observations. Astrometry yielded residuals of -0.039 ± 0.025 arcseconds in RA and 0.234 ± 0.017 arcseconds in DEC for Makemake, and 0.295 ± 0.077 arcseconds in RA and 0.184 ± 0.0554 arcseconds in DEC for Haumea. These results, when submitted to the minor planet center, are able to increase the accuracy of the JPL ephemeris. Additionally, we calculated that observing Haumea with two 14-inch telescopes and Makemake with four 14-inch telescopes, in ideal conditions, could resolve their periodicity. We conclude that with improved observing techniques and modern CCD cameras, it is possible to utilize small telescopes in universities around the world to observe large KBOs and obtain accurate photometric and astrometric results.

Author(s): ***Evangelia Anna Markatou (MIT)***, Amanda Wang (MIT), Molly Kosiarek (MIT), Emilie Dunham (Case Western Reserve University)

423 – Topics in Cosmology Posters

Poster Session – Essex Ballroom and America Foyer – 05 Jun 2014 09:00 AM to 02:00 PM

423.01 – The Effective Field Theory of Dark Matter and Structure Formation

We develop the effective field theory of cosmological large scale structure. We start from the collisionless Boltzmann equation and integrate out short modes of a dark matter/dark energy dominated universe (LambdaCDM) whose matter is comprised of massive particles as used in cosmological simulations. This establishes a long distance effective fluid, valid for length scales larger than the non-linear scale ~ 10 Mpc, and provides the complete description of large scale structure formation. Extracting the time dependence, we derive recursion relations that encode the perturbative solution. This is exact for the matter dominated era and quite accurate in LambdaCDM also. The effective fluid is characterized by physical parameters, including sound speed and viscosity. These two fluid parameters play a degenerate role with each other and lead to a relative correction from standard perturbation theory of the form ~ 10^{-6}c^2k^2/H^2. Starting from the linear theory, we calculate corrections to cosmological observables, such as the baryon-acoustic-oscillation peak, which we compute semi-analytically at one-loop order. Due to the non-zero fluid parameters, the predictions of the effective field theory agree with observation much more accurately than standard perturbation theory and we explain why. We also discuss corrections from treating dark matter as interacting or wave-like and other issues.

Author(s): ***Mark Hertzberg (MIT)***

423.02 – Cosmic Metallicity from ZnII-Selected QSO Absorption Line Systems near Redshift z=1.2

We present metallicity results for a sample of damped Lyman-alpha (DLA) quasar absorption line systems selected for strong ZnII absorption at redshift z ? 1.2. DLA systems track cosmologically intervening neutral gas regions that fall along the sightlines to background quasars. The sample was compiled from the University of Pittsburgh catalog of strong, intervening MgII systems observed in SDSS quasar spectra. We selected candidates by examining the spectral regions where weak, unsaturated metal lines (such as ZnII and CrII) for such systems were predicted to exist, with the aim of finding a representative sample of the strongest metal-line column density DLA systems in the universe. Follow-up HST-STIS G230L UV spectroscopy of the sample systems was obtained to measure their Lyman-alpha absorption profiles and derive their HI column densities. Since Zn is not depleted onto grains and exists primarily in the singly ionized state, measurement of N(HI) coupled with equivalent width measurements of ZnII lines allows a direct measurement of the metal abundance in such systems. Strong ZnII absorption may be due to either large columns (e.g., N(HI) ~3×10^{21} atoms cm^{-2}) of typically low-metallicity DLA gas, or weaker columns (e.g., N(HI)~ 2×10^{20} atoms cm^{-2}) of higher metallicity gas. Our sample, therefore, can test the upper envelope of the distribution of neutral-gas-phase metallicities near redshift z=1.2.Since these DLAs are selected on the basis of their extreme metal-line properties, analysis of their metallicities and dust-to-gas ratios can constrain the range of properties exhibited by DLA systems.

Author(s): ***Eric Monier (SUNY College at Brockport)***, David Turnshek (University of Pittsburgh), Sandhya Rao (University of Pittsburgh), Gendith Sardane (University of Pittsburgh), Daniel Burdette (SUNY College at Brockport)

423.03 – How Do Galaxy Pairs Populate the Dark Matter Haloes?

We Analyze the clustering of photometrically selected galaxy pairs by using the halo-occupation distribution (HOD) statistics. We measure the two-point auto-correlation functions, \omega_(\theta), for galaxies and galaxy pairs and find their HODs to model the clustering. Our results are successfully fit by the HOD models and we can see the separation of '1-halo' and '2-halo' clustering terms for both single galaxies and galaxy pairs. We find that the galaxy pairs generally have larger clustering amplitudes than single galaxies, and the quantities after the HOD fitting, i.e. effective mass M_{eff} and linear bias b_g, are also larger in pairs. We find the central fractions for galaxy pairs are significantly higher than that of the single galaxies, which confirms that the galaxy pairs are formed at the center of more massive haloes. We also fit HOD models to the correlation functions so that we can quantify the differences for i) early-early and late-late type galaxy pairs and find the former type one shows stronger clustering signals and have larger bias than the latter one; ii) high-flux-contrast and low-flux-contrast galaxy pairs and find the former has stronger clustering structures; and iii) bright and dim samples for galaxies and galaxy pairs and find the bright samples are stronger clustered than the dim samples.

Author(s): *Yiran Wang (University of Illinois at Urbana-Champaign)*, Robert Brunner (University of Illinois at Urbana-Champaign)

423.04 – Intrinsic Alignments of galaxies in SDSS-III BOSS LOWZ sample.

Intrinsic Alignments (IA) of galaxies, i.e. correlations of galaxy shapes with each other (II) or with the density field (gI), are one of the major astrophysical source of contamination for weak lensing surveys (Hirata & Seljak 2004, Mandelbaum+ 2006, Hirata+ 2007, Joachimi+ 2011). We will present the results of IA measurements of galaxies (II and gI) using the SDSS-III BOSS LOWZ sample, in redshift range $0.16<z<0.36$. Taking advantage of the size and luminosity range of LOWZ sample we have extended the IA measurements for spectroscopic LRGs to more typical lower luminosity galaxies. We also study the environment dependence of IA by splitting the sample into field and group galaxies, which are further split into satellite and central galaxies. We show that group galaxies have much stronger IA at small scales, while central and field galaxies have similar IA at large scales.

Author(s): *Sukhdeep Singh (McWilliams center for Cosmology, Carnegie Mellon University)*, Rachel Mandelbaum (McWilliams center for Cosmology, Carnegie Mellon University)

401 – Gamma-ray Constraints on the EBL and the IGMF I

Meeting-in-a-Meeting – America Ballroom North/Central – 05 Jun 2014 10:00 AM to 11:30 AM

The light emitted by stars throughout the history of the Universe is encoded in the intensity of the extragalactic background light (EBL). Characterization of the EBL and its evolution provides insight into the nature of star formation and galaxy evolution. Direct measurements of the EBL are difficult due to local intense foregrounds such as the zodiacal light and emission from our own Galaxy. Gamma-ray astronomy provides a valuable indirect probe of the EBL since high-energy gamma rays may interact with photons of the EBL and generate positron-electron pairs. This introduces an attenuation feature in the spectra of distant gamma-ray sources that can be used to place sensitive constraints on the opacity of the universe to gamma-rays and on the energy density of the EBL. Moreover, the electron-positron pairs can generate an electro-magnetic cascade that reprocessed the initial photon energy to lower gamma-ray energies producing spectral, spatial and temporal signatures that can be used to place sensitive constraints on the strength of the intergalactic magnetic field (IGMF). Recent studies using gamma-ray blazars claimed the detection of EBL-induced absorption signatures consistent with the minimum level of EBL intensity expected given the established star formation rate. Thus, there is little room for an additional, truly diffuse component generated at much higher redshifts. At the same time, other studies based on gamma-ray blazars constrained the strength of the IGMF to be >1e-17 Gauss (depending on the coherent length and source activity timescale). Our proposed meeting-in-meeting will focus on up-to-date results and currently on-going projects to constrain the strength of the IGMF and further characterize the EBL intensity, its evolution, and its impact on on our understanding of star formation. The first session will cover topics related to the EBL, and its constraints while the second one will deal with the cascade formation, composition and propagation in the intergalactic medium and the derived constraints on the strength of the IGMF.

Chair(s):
Justin Finke (US Naval Research Laboratory)

Organizer(s):
Marco Ajello (Berkeley)

401.01 – The Extragalactic Background Light and the Gamma-Ray Opacity of the Universe

The Extragalactic Background Light (EBL) is one of the fundamental observational quantities in cosmology. All energy releases from resolved and unresolved extragalactic sources, and the light from any truly diffuse background, excluding the cosmic microwave background (CMB), contribute to its intensity and spectral energy distribution. It therefore plays a crucial role in cosmological tests for the formation and evolution of stellar objects and galaxies, and for setting limits on exotic energy releases in the universe. The EBL also plays an important role in the propagation of very high energy gamma-rays which are attenuated en route to Earth by pair producing gamma-gamma interactions with the EBL and CMB, affecting the GeV-TeV spectrum of blazars. Knowledge of the EBL intensity and spectrum will therefore allow the determination of the intrinsic blazar spectrum, and conversely, knowledge of the intrinsic gamma-ray spectrum will set strong limits on the EBL and its evolution. In this talk I will review the latest developments in the determination of the EBL and its effect on the gamma-ray opacity of the universe.

Author(s): ***Eli Dwek (NASA's GSFC)***

401.02 – The Gamma-Ray Opacity of the Universe & Indirect Measurements of the EBL

As gamma rays with energies of 20 GeV to 10s of TeV travel over extragalactic distances, their energy-dependent cross section with diffuse photons from the EBL (Extragalactic Background Light) results in electron-positron pair production. Thereby, absorption by the EBL affects the energy spectra of all extragalactic gamma-ray sources, effectively creating an energy dependent gamma-ray horizon. Observations of blazars with current generation satellite- and ground-based telescopes have revealed low gamma-ray opacities, much lower than previously expected. In turn, the energy spectra of blazars at GeV to TeV energies now also provide strong constraints to the EBL in the UV/optical light, the near-IR and the mid-IR. While photons with energies of 1 TeV or larger photons should not reach the observer from a redshift of z ~ 1 or larger, the production of secondary photons via hypothesized new physics (Axion-Like Particles), or cosmic-ray induced cascades could render high-redshift sources observable at TeV energies. Therefore, measurements of the gamma-ray opacity of the universe are also relevant for testing propagation models that are build on physical scenarios beyond gamma-ray absorption via pair production. A completely self-consistent picture, where direct measurements of the EBL or lower limits from galaxy counts, converge with indirect measurements with gamma rays is yet to be achieved with observations. Recent results from gamma-ray observations, their interpretation and caveats will be discussed.

Author(s): ***Frank Krennrich (Iowa State University)***

401.03 – Gamma-ray Cosmology in the Pre-CTA Era

Gamma-ray astronomy at TeV energies has been envisioned as a powerful tool to probe the extragalactic background light (EBL) since the early '60s, three decades before the first extragalactic TeV sources were even detected. Gamma rays can indeed interact along the line of sight with the EBL, creating electron-positron pairs. This results in an energy- and redshift-dependent absorption of the emitted spectra which, when detected, would convey information on the broad-band density of the EBL and on its evolution across the billion-years journey of the gamma rays. The coarse structure of the energy dependence of the absorption, that softens the gamma-ray spectrum, has been used in the '90s and '00s to set indirect upper limits on the EBL density. The main limitation arose from accounting for the intrinsic spectral softening, related to the radiative processes and acceleration mechanisms at play in the emitters. The beginning of the '10s has seen the overcoming of this limitation, yielding the first indirect measurements of the EBL absorption by H.E.S.S, below $z<0.2$, and by Fermi-LAT, mostly above $z>0.5$. In this talk, I will discuss the method employed by H.E.S.S. and Fermi-LAT to detect the EBL absorption, by means of a scaling of the EBL density, and compare their results with direct limits in the UV, optical and near-infrared bands. I will propose an extension of this method to constrain the spectrum and evolution of the EBL, and/or to search for anomalies in gamma-ray spectra. An abnormal level of absorption could probe a large panel of physical processes, be they cosmic-ray acceleration and reprocessing along the line of sight, or physics beyond the standard model such as Lorentz invariance violation or photo-axion conversion. The golden age of gamma-ray cosmology is yet to come during the next decade, with the upgrade of current-generation instruments and the upcoming Cherenkov Telescope Array, CTA.

Author(s): ***Jonathan Biteau (SCIPP / UCSC)***

401.04 – The Gamma-ray Opacity of the Universe up to redshift 3

The extragalactic background light (EBL) leaves a distinct imprint on the gamma-ray spectra of distant sources that can be used to constrain its intensity. The data collected by the Fermi Large Area Telescope (LAT) have already allowed us to constrain the EBL intensity up to redshift 1.6. In this talk we will report on a new measurement, using flat-spectrum radio quasars, of the EBL attenuation up to redshift 3. We will discuss how this new measurement, together with previous ones at different gamma-ray energies, can be used to constrain the evolution of the EBL intensity.

Author(s): ***Marco Ajello (Clemson University)***, Anita Reimer (Innsbruck University), Luis Reyes (California Polythenic State University), Alberto Dominguez (University of California Riverside), Sara Buson (Istituto Nazionale di Fisica Nucleare)

Contributing teams: Fermi-LAT team

402 – Solar Wind and Heliospheric Connections

Meeting-in-a-Meeting – America Ballroom South – 05 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Mari Paz Miralles (Harvard-Smithsonian CfA)

402.01 – Coronal Density Structure Revealed by Comet Lovejoy (C/2011 W3)

Images of Comet Lovejoy (C/2011 W3) obtained with AIA are dominated by emission from moderately ionized oxygen (O III - O VI). The images show striations due to magnetic field structure. In each striation, the oxygen emission moves along the magnetic field and stretches with time. The speed and the rate of broadening are related to the parallel and perpendicular components of the velocities of the cometary neutrals when they become ionized and behave as pickup ions. The intensity structure indicates density contrasts of a factor of 6 between neighboring magnetic flux tubes on scales of around 4000 km. That implies substantial variation in Alfven speeds, which results in dispersion and dissipation of Alfven waves. This observation imposes an upper limit in the outer scale of the turbulence spectrum in the corona and suggests that density structures may affect the heating of the corona and the driving of the solar wind.

Author(s): ***John Raymond (Harvard-Smithsonian, CfA)***, Patrick McCauley (Harvard-Smithsonian, CfA), Steven Cranmer (Harvard-Smithsonian, CfA), Cooper Downs (Predictive Sciences, INC)

402.02 – Periodic Density Structures and the Source of the Slow Solar Wind

Periodic density structures with length-scales of hundreds to several thousands of megameters, and frequencies of tens to hundreds of minutes, are observed regularly in the solar wind at 1 AU. These structures coexist with, but are not due to, fluctuations in the plasma resulting from the turbulent cascade. Two lines of evidence suggest that periodic density structures are formed in the solar corona as part of the slow solar wind release and/or acceleration processes. The first is the identification of corresponding changes in compositional data in situ, and the other is the identification of periodic density structures in the inner Heliospheric Imaging data onboard the STEREO/SECCHI suite. In this presentation, we show the results of tracking periodic structures identified in the SECCHI/Hi1 images down through the corresponding SECCHI/Cor2 images. We demonstrate that the periodic density structures are formed around or below 2.5 Rs – the inner edge of the Cor2 field of view. Further, we compute the occurrence rate of periodic density structures in 10 days of Cor2 images as a function of location in the solar corona. We find that periodic density structures do not occur throughout the entire space-filling volume of the solar wind; rather, there are particular places where they occur preferentially, suggesting source locations for periodic density structures in the slow solar wind.

Author(s): ***Nicholeen Viall (NASA Goddard Space Flight Center)***, Angelos Vourlidas (Naval Research Laboratory)

402.03 – Simulation of S-Web Corridor Dynamics

The higher average charge-state composition and bias towards heavier elements (Zurbuchen et al. 1999) of the slow solar wind suggest that its source is the release of coronal plasma from high-temperature, closed-field regions. The S-Web (separatrix web) model for the source of the slow solar wind is based on the conclusion that the apparent multiple coronal holes observed within single-polarity regions are connected by narrow corridors at scales smaller than the spatial resolution of current measurements. Magnetic field lines from the boundary of such a corridor map to the heliospheric current sheet, while field lines from the interior of the corridor map to an arc extending to high latitudes in the heliosphere (Antiochos et al. 2011). In this work, we simulate the dynamics of an S-Web corridor using the Adaptively Refined MHD Solver (ARMS). The objective is to quantify the release of coronal plasma at high heliospheric latitudes and show that the dynamics support the S-Web model as an explanation for the source of the slow solar wind. We will present results from our efforts to simulate open-field corridor dynamics, outline plans for further work, and discuss implications for understanding the slow solar wind. This work was supported, in part, by the NASA TR&T and SR&T programs.

Author(s): ***Aleida Young (University of Michigan)***, Spiro Antiochos (NASA Goddard Space Flight Center), C. DeVore (NASA Goddard Space Flight Center), Thomas Zurbuchen (University of Michigan)

402.04 – MAG4 versus Alternative Techniques for Forecasting Active-Region Flare Productivity

MAG4 is a technique of forecasting an active region's rate of production of major flares in the coming few days from a free-magnetic-energy proxy. We present a statistical method of measuring the difference in performance between MAG4 and comparable alternative techniques that forecast an active region's major-flare productivity from alternative observed aspects of the active region. We demonstrate the method by measuring the difference in performance between the "Present MAG4" technique and each of three alternative techniques, called "McIntosh Active-Region Class," "Total Magnetic Flux," and "Next MAG4." We do this by using (1) the MAG4 database of magnetograms and major-flare histories of sunspot active regions, (2) the NOAA table of the major-flare productivity of each of 60 McIntosh active-region classes of sunspot active regions, and (3) five technique-performance metrics (Heidke Skill Score, True Skill Score, Percent Correct, Probability of Detection, and False Alarm Rate) evaluated from 2000 random two-by-two contingency tables obtained from the databases. We find that (1) Present MAG4 far outperforms both McIntosh Active-Region Class and Total Magnetic Flux, (2) Next MAG4 significantly outperforms Present MAG4, (3) the performance of Next MAG4 is insensitive to the forward and backward temporal windows used, in the range of one to a few days, and (4) forecasting from the free-energy proxy in combination with either any broad category of McIntosh active-region classes or any Mount Wilson active-region class gives no significant performance improvement over forecasting from the free-energy proxy alone (Present MAG4). Funding for this research came from NASA's Game Changing Development Program, Johnson Space Center's Space Radiation Analysis Group (SRAG), and AFOSR's Multi-University Research Initiative. In particular, funding was facilitated by Dr. Dan Fry (NASA-JSC) and David Moore (NASA-LaRC).

Author(s): ***David Falconer (NASA/MSFC)***, Ronald Moore (NASA/MSFC), Abdulnasser Barghouty (NASA's MSFC), Igor Khazanov (UAH)

402.05 – Solar Wind Acceleration: Modeling Effects of Turbulent Heating in Open Flux Tubes

We present two self-consistent coronal heating models that determine the properties of the solar wind generated and accelerated in magnetic field geometries that are open to the heliosphere. These models require only the radial magnetic field profile as input. The first code, ZEPHYR (Cranmer et al. 2007) is a 1D MHD code that includes the effects of turbulent heating created by counter-propagating Alfven waves rather than relying on empirical heating functions. We present the analysis of a large grid of modeled flux tubes (> 400) and the resulting solar wind properties. From the models and results, we recreate the observed anti-correlation between wind speed at 1 AU and the so-called expansion factor, a parameterization of the magnetic field profile. We also find that our models follow the same observationally-derived relation between temperature at 1 AU and wind speed at 1 AU. We continue our analysis with a newly-developed code written in Python called TEMPEST (The Efficient Modified-Parker-Equation-Solving Tool) that runs an order of magnitude faster than ZEPHYR due to a set of simplifying relations between the input magnetic field profile and the temperature and wave reflection coefficient profiles. We present these simplifying relations as a useful result in themselves as well as the anti-correlation between wind speed and expansion factor also found with TEMPEST. Due to the nature of the algorithm TEMPEST utilizes to find solar wind solutions, we can effectively separate the two primary ways in which Alfven waves contribute to solar wind acceleration: 1) heating the surrounding gas through a turbulent cascade and 2) providing a separate source of wave pressure. We intend to make TEMPEST easily available to the public and suggest that TEMPEST can be used as a valuable tool in the forecasting of space weather, either as a stand-alone code or within an existing modeling framework.

Author(s): ***Lauren Woolsey (Harvard University)***, Steven Cranmer (Harvard University)

402.06 – A new relaxation technique for determining the structure of coronal magnetic fields

The existence of force-free equilibria for arbitrary field topology is a long-standing and unresolved problem (c.f. the 'Parker problem'). We introduce a new numerical method for obtaining force-free equilibria. From an initial non-equilibrium field, an evolution towards a force-free field is followed that strictly preserves the magnetic topology (i.e. connectivity and linkage of all magnetic field lines). The method is based on a Lagrangian formulation, and employs a so-called mimetic method for calculating finite differences on the computational mesh. We demonstrate that this provides a significant improvement in the accuracy of the force-free equilibrium obtained, compared with the traditional finite difference approach previously employed. The method is a powerful tool to understand the properties of coronal loops, which are typically modelled as consisting of ideal plasma threaded by a force-free magnetic field. We present some examples of equilibria representative of coronal loops.

Author(s): ***David Pontin (University of Dundee)***, Simon Candelaresi (University of Dundee), Gunnar Hornig (University of Dundee)

403 – SPD/LAD Joint Session: Bridging Laboratory and Solar Plasma Studies I

Meeting-in-a-Meeting – Staffordshire – 05 Jun 2014 10:00 AM to 11:30 AM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This joint meeting will focus on the interplay between laboratory astrophysics, plasma physics and solar physics.

Chair(s):
Vyacheslav Lukin (Naval Research Laboratory)

403.01 – Role of ambient magnetic field in driving the eruption of an arched laboratory magnetoplasma

Eruptions of arched magnetoplasma structures cover a wide spatiotemporal scale on the Sun and drive energetic phenomena such as coronal mass ejections. Due to presence of an electrical-current and associated twist in the magnetic-field, the term “arched magnetic flux rope” (AMFR) is used for these structures. Contemporary models of solar eruptions predict that solar AMFRs are confined for relatively long duration (days to weeks) by ambient magnetic fields (known as strapping field) before their sudden eruption. The structure of the ambient-magnetic-field plays an important role in the evolution of the confined and erupting solar AMFRs. In a laboratory plasma experiment, the interaction between an AMFR and its ambient magnetic field has been investigated. The AMFR (plasma ? ? 10^{-3}, Lundquist number ?10^{2}–10^{5}, AMFR radius/ion-gyroradius ? 20, B ? 1000 G at footpoints) was produced using a LaB6 plasma source in an ambient magnetoplasma (B ? 0 – 100 G). The ambient magnetic field was oriented normal to the symmetry plane of the AMFR. The experiment runs continuously and generates reproducible AMFR eruptions with a period of 2 s. Hence, the plasma parameters were recorded with a good resolution (spatial-resolution/AMFR-length ? 10^{-2} – 10^{-3}, temporal-resolution/eruption-time ? 10^{-3}) using computer-controlled movable probes. A fast-CCD camera was utilized to capture the evolution of the AMFR. The pre-eruption phase of the AMFR remained quiescent for ? 100 Alfven transit times and the camera images evinced its persistent appearance. In contrast, the post-eruption phase of the AMFR was observed to be associated with significant changes in its magnetic topology. Our initial results suggest that linkage of the magnetic-field of the AMFR with the ambient magnetoplasma (which is ignored in the models of solar eruptions) plays the most important role in the ejection of a large flux rope from the leading edge of the AMFR. Implications of these results to actual solar eruptions will be discussed. References: (1) Tripathi and Gekelman, Phys. Rev. Lett. 105, 075005 (2010) (2) Tripathi and Gekelman, Solar Phys. 286, 479 (2013) (Work performed at the Basic Plasma Science Facility, UCLA and supported by US DOE and NSF)

Author(s): ***Shreekrishna Tripathi (UCLA)***, Walter Gekelman (UCLA)

403.02 – Equilibrium features and eruptive instabilities in laboratory magnetic flux rope plasmas

One avenue for connecting laboratory and solar plasma studies is to carry out laboratory plasma experiments that serve as a well-diagnosed model for specific solar phenomena. In this paper, we present the latest results from one such laboratory experiment that is designed to address ideal instabilities that drive flux rope eruptions in the solar corona. The experiment, which utilizes the existing Magnetic Reconnection Experiment (MRX) at Princeton Plasma Physics Laboratory, generates a quasi-statically driven line-tied magnetic flux rope in a solar-relevant potential field arcade. The parameters of the potential field arcade (e.g., its magnitude, orientation, and vertical profile) are systematically scanned in order to study their influence on the evolution and possible eruption of the line-tied flux rope. Each flux rope discharge is diagnosed using a combination of fast visible light cameras and an *in situ* 2D magnetic probe array that measures all three components of the magnetic field over a large cross-section of the plasma. In this paper, we present the first results obtained from this new 2D magnetic probe array. With regard to the flux rope equilibrium, non-potential features such as the formation of a characteristic sigmoid shape and the generation of core toroidal field within the flux rope are studied in detail. With regard to instabilities, the onset and evolution of two key eruptive instabilities—the kink and torus instabilities—are quantitatively assessed as a function of the potential field arcade parameters and the amount of magnetic energy stored in the flux rope. This research is supported by DoE Contract Number DE-AC02-09CH11466 and by the NSF/DoE Center for Magnetic Self-Organization (CMSO).

Author(s): ***Clayton Myers (Princeton Plasma Physics Laboratory)***, Masaaki Yamada (Princeton Plasma Physics Laboratory), Elena Belova (Princeton Plasma Physics Laboratory), Hantao Ji (Princeton Plasma Physics Laboratory), Jongsoo Yoo (Princeton Plasma Physics Laboratory), William Fox (Princeton Plasma Physics Laboratory)

403.03 – CME Initiation Driven by Velocity-Shear Kinetic Reconnection Simulations

In the standard model for coronal mass ejections (CME) and/or solar flares, the free energy for the event resides in the strongly sheared magnetic field of a filament channel. The pre-eruption force balance consists of an upward force due to the magnetic pressure of the sheared field countered by a downward tension due to overlying unsheared field. Magnetic reconnection is widely believed to be the mechanism that disrupts this force balance, leading to explosive eruption. For understanding CME/flare initiation, therefore, it is critical to model the onset of reconnection that is driven by the build-up of magnetic shear. In MHD simulations, the application of a magnetic-field shear is a trivial matter. However, kinetic effects are important in the diffusion region and thus, it is important to examine this process with PIC simulations as well. The implementation of such a driver in PIC methods is nontrivial, however, and indicates the necessity of a true multiscale model for such processes in the solar environment. The field must be sheared self-consistently and indirectly to prevent the generation of waves that destroy the desired system. In the work presented here, we discuss methods for applying a velocity shear perpendicular to the plane of reconnection in a system with open boundary conditions. This material is based upon work supported by the National Science Foundation under Award No. AGS-1331356.

Author(s): ***Carrie Black (CUA)***, Spiro Antiochos (NASA/GSFC), Judith Karpen (NASA/GSFC), C. DeVore (NASA/GSFC), Kai Germaschewski (UNH)

403.05 – Spectral Diagnostics of High Resolution Plasmas using AtomDB 3.0

AtomDB is a collection of atomic data for modeling X-ray emission from optically thin collisional plasmas. Previous versions of the database have included data required for equilibrium modeling, but have omitted some of the data required for modeling inner shell processes which are relevant to non-equilibrium plasmas. We present the new AtomDB 3.0, which includes significant updates to both the atomic data collection, and the collisional plasma model. We describe the new calculations which have been preformed for inner shell ionization and excitation-autoionization, and compare with literature results. As well as the well known diagnostics of non-equilibrium plasmas, such as the iron K-alpha centroid position, we highlight features in the spectra of ionizing and recombining plasmas which will appear in high resolution spectra such as the high resolution micro-calorimeter on Astro-H, the Soft X-ray Spectrometer

Author(s): ***Adam Foster (Harvard Smithsonian, CfA)***, Randall Smith (Harvard Smithsonian, CfA), Nancy Brickhouse (Harvard Smithsonian, CfA), Li Ji (Purple Mountain Observatory), Hiroya Yamaguchi (NASA GSFC), Timothy Kallman (NASA GSFC), Jörn Wilms (Universität Erlangen-Nürnberg)

403.06 – The Onset of Fast Magnetic Reconnection in Solar and Laboratory Plasmas

Magnetic reconnection is widely believed to be the physical process underlying explosive activity in both solar and laboratory plasmas. The question of what determines whether and when magnetic reconnection will produce explosive energy release has long been one of the most important problems in all plasma physics. We examine this problem using numerical simulations of major solar eruptions, coronal mass ejections and eruptive flares. These events are among the most energetic and the best observed examples of the onset phenomenon. Our calculations show that reconnection in the solar corona invariably exhibits two distinct phases. First, we observe an initial slow growth characterized by the appearance of an extended current sheet and magnetic islands, somewhat analogous to resistive tearing. Eventually, however, the reconnection transitions to an explosive phase characterized by well-developed jets and further island formation. We discuss how these results scale with numerical refinement level, i.e., effective Lundquist number. We conclude that, at least for the case of solar plasmas, fast reconnection onset requires an interaction between reconnection and an ideal instability. We discuss the implications of our results for observations of both solar and laboratory plasmas. This work was supported in part by the NASA TR&T and SR&T Programs.

Author(s): ***Spiro Antiochos (NASA GSFC)***, C. DeVore (NASA GSFC), Judith Karpen (NASA GSFC), Silvina Guidoni (NASA GSFC)

404 – Stellar Atmospheres and Outflows

Oral Session – St. George AB – 05 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Derek Buzasi (Florida Gulf Coast University)

404.02 – Radiative 3D Modeling of Convection of Main-Sequence Stars

Recent progress in observational capabilities, and particularly, the large amount of photometric data from Kepler, require the development of realistic numerical simulations for data interpretation and validation of theoretical models. Current state-of-the-art of computational modeling based on first principles makes it possible to build realistic models of stellar convection zones and atmospheres, which can take into account chemical composition, effects of radiation, ionization and turbulence. I present large-scale 3D time-dependent radiative hydrodynamics simulations for a series of Kepler-target stars with masses from 1.01 Ms to 1.52 Ms and effective temperature varying from 5780 K to 6982 K, and investigate the properties of convection, the surface structure and oscillations. For massive A-type stars, the simulations include the whole outer convection layer and the overshoot region at the interface with the radiative zone. The simulations reveal that in stars that are more massive than the Sun, turbulent convection is highly supersonic and produces multiscale granulation patterns on the surface. These simulation results also show that contrary to current paradigm, turbulent convection plays a very important role in the surface dynamics of A-type stars, and leads to stochastic excitation of acoustic oscillations observed by Kepler. I will also discuss the dynamics of the overshooting region and excitation of internal gravity waves.

Author(s): *Irina Kitiashvili (NASA Ames Research Center)*

404.03 – Temperatures and Radii of Low-Mass Dwarf Stars Estimated from Near Infrared Spectra

We present estimates of the temperatures and radii of M dwarfs targeted by the MEarth transiting planet survey. The fundamental properties of M dwarfs are difficult to constrain by direct measurement, and we instead use empirical relationships that are based on the strengths of near infrared spectral features. We establish our relationships for radius and temperature using cool dwarfs with interferometric measurements. Our calibrations use the equivalent widths of H-band spectral features as tracers of these parameters and have an accuracy of 0.03 solar radii and 60 K for late K to mid M dwarfs. We validate our method by comparing our inferred stellar parameters to absolute magnitudes, which we calculate using 2MASS magnitudes and parallaxes from Dittmann et al. (2014). We also identify candidate over-luminous objects within our sample, which may be binaries or young stars.

Author(s): *Elisabeth Newton (Harvard-Smithsonian Center for Astrophysics)*, David Charbonneau (Harvard-Smithsonian Center for Astrophysics), Jonathan Irwin (Harvard-Smithsonian Center for Astrophysics)

404.04 – A Photometric (griz) Metallicity Calibration for Cool Stars

We present results from a study that uses wide pairs as tools for estimating and constraining the metal content of cool stars from their spectra and broad band colors. Specifically, we will present results that optimize the Mann et al. M dwarf metallicity calibrations (derived using wide binaries) for the optical regime covered by SDSS spectra. We will demonstrate the robustness of the new calibrations using a sample of wide, low-mass binaries for which both components have an SDSS spectrum. Using these new spectroscopic metallicity calibrations, we will present relations between the metallicities (from optical spectra) and the Sloan colors derived using more than 20,000 M dwarfs in the SDSS DR7 spectroscopic catalog. These relations have important ramifications for studies of Galactic chemical evolution, the search for exoplanets and subdwarfs, and are essential for surveys such as Pan-STARRS and LSST, which use griz photometry but have no spectroscopic component.

Author(s): *Andrew West (Boston Univ.)*, James Davenport (University of Washington), Saurav Dhital (Embry-Riddle), Andrew Mann (University of Texas, Austin), Angela Massey (Boston Univ.)

404.05 – Update on the Stellar Surface Imaging Project at NPOI

We are working on a project to carry out stellar surface imaging at the Navy Precision Optical Interferometer (NPOI). The project is recently funded by the NSF, and will extend the baseline bootstrapping capability of the NPOI to 6-station observations in each of the three arms of the NPOI Y-configuration array. The project requires the commissioning of one telescope station beyond what is already in place or in the process of commissioning, and upgrades to the data acquisition and fringe-tracking system. 6-station bootstrapping is not possible with any other existing interferometer and the number of image elements is directly related to the length of the bootstrapping chain. Additionally we expect to take advantage of wavelength bootstrapping for additional resolution at short wavelength. Here we will provide an update on the project and also discuss some modeling results showing the kind of imaging resolution that will be possible and amount of observing time required to produce an image.

Author(s): *Anders Jorgensen (New Mexico Tech)*, Henrique Schmitt (Naval Research Laboratory), Matthew Landavazo (New Mexico Tech), Brian Sun (New Mexico Tech), David Mozurkewich (Seabrook Engineering), Gerard van Belle (Lowell Observatory), Donald Hutter (Naval Observatory Flagstaff Station), J. Armstrong (Naval Research Laboratory), Ellyn Baines (Naval Research Laboratory), James. Clark (Naval Research Laboratory), Kyle Newman (New Mexico Tech), Sergio Restaino (Naval Research Laboratory)

404.06 – Radio Emission from Macroclumps in Massive Star Winds

Massive star winds are understood to be structured. Structures can come in the form of co-rotating interaction regions, which are globally organized flow streams that thread the winds. Structures can also be stochastic in nature, generically referred to as "clumps". The theory for interpreting the radio emissions from randomly distributed microclumps in single star winds is established. Results are presented here for macroclumping, in which the radiative transfer is sensitive to the clump geometry. Two cases are compared: spherical clumps and pancake-like fragments. The geometry of macroclumps can influence the power-law slope of the long wavelength spectral energy distribution.

Author(s): ***Richard Ignace (East Tennessee State Univ.)***

404.07 – TIME-DOMAIN SPECTROSCOPY OF A T TAURI STAR

High resolution optical and near-infrared spectra of TW Hya, the nearest accreting T Tauri star, cover a decade and reveal the substantial changes in accretion and wind properties. Our spectra suggest that the broad near-IR, optical, and far-uv emission lines, centered on the star, originate in a turbulent post-shock region and can undergo scattering by the overlying stellar wind as well as absorption from infalling material. Stable absorption features appear in H-alpha, apparently caused by an accreting column silhouetted in the stellar wind. The free-fall velocity of material correlates inversely with the strength of the post-shock emission, consistent with a dipole accretion model. Terminal outflow velocities appear to be directly related to the amount of post-shock emission, giving evidence for an accretion-driven stellar wind.

Author(s): ***Andrea Dupree (Harvard-Smithsonian CfA)***, Nancy Brickhouse (Harvard-Smithsonian CfA), Steven Cranmer (Harvard-Smithsonian CfA), Perry Berlind (Harvard-Smithsonian CfA), Jay Strader (MIchigan State University), Graeme Smith (Lick Observatory)

404.08 – Magnetic Field Structure of the Outflows in NGC1333 IRAS4A Protostellar Core

We present the polarization map of CO J = 3-2 line in the molecular outflows launched from NGC1333 IRAS 4A protostellar core. The spectral line polarization arises from the Goldreich-Kylafis effect, which predicts that the polarization could be either parallel or perpendicular to the magnetic field direction. To resolve the orientation of CO polarization to magnetic field direction, comparisons between CO polarization and dust polarization are made with the knowledge that the dust polarization is perpendicular to the magnetic field. We found that within the IRAS 4A dusty envelope, the CO J = 3-2 polarization directions are mostly perpendicular to the dust polarization, suggesting that the CO polarization is parallel to the magnetic field. The directions of the CO polarization appear to vary smoothly from the dust continuum to the red-shifted lobe of the outflows without any abrupt changes, implying that the CO polarization remains parallel to the magnetic field direction in the outflows. We speculate that a helical field may be wrapping around the outflows, which is consistent with the theoretical expectations for outflows associated with a rotating disk. Considering that the CO J = 3-2 polarized emission is mainly contributed from low velocity component of outflows and the polarization detections distribute around the wall of outflows, the magnetic field revealed by CO J = 3-2 polarization may be at the wall of outflows and associated to the interaction between envelope and outflows. Additional observations of line polarization from different density traces are needed to test our proposed scenario.

Author(s): ***Tao-Chung Ching (Harvard-Smithsonian Center for Astrophysics)***, Shih-Ping Lai (National Tsing Hua University), Qizhou Zhang (Harvard-Smithsonian Center for Astrophysics)

405 – Instrumentation, Surveys, and Data

Oral Session – St. George CD – 05 Jun 2014 10:00 AM to 11:30 AM

Chair(s):
Rosanne Di Stefano (Harvard-Smithsonian CfA)

405.01 – ALTAIR: Precision Photometric Calibration via Low-Cost Artificial Light Sources Above the Atmosphere

Understanding the properties of dark energy via SNIa surveys (and to a large extent other methods as well) requires unprecedented photometric precision. Laboratory and solar photometry and radiometry regularly achieve precisions on the order of parts in ten thousand, but photometric calibration for non-solar astronomy presently remains stuck at the percent or greater level. We present our project, ALTAIR, sponsored by federal agencies in the U.S. and Canada, to erase this discrepancy, and current steps toward achieving laboratory-level photometric precision for major sky surveys late this decade. In particular, we show far- and near-field imaging of the balloon-borne light source we presently launch to altitudes of approximately 20 km, and our initial calibration results (in addition to prior work with a present calibrated source in low-Earth orbit). Our technique is additionally applicable to microwave astronomy. Observation of gravitational waves in the polarized CMB will similarly require unprecedented polarimetric and radiometric precision, and we briefly present our plans for a calibrated microwave source above the atmosphere as well.

Author(s): ***Justin Albert (Univ. of Victoria)***, Yorke Brown (Dartmouth College), Christopher Stubbs (Harvard University), Karun Thanjavur (Univ. of Victoria), Divya Bhatnagar (Univ. of Victoria), J. Paul Kovacs (Univ. of Victoria), Ryan Thomas (Univ. of Victoria), Claire Cramer (NIST), Keith Vanderlinde (University of Toronto), Matt Dobbs (McGill University), Arnold Gaertner (NRC (Institute for National Measurement Standards))

405.02 – A Low Cost and High Capability X-ray Grating Spectrometer on the ISS

We present the scientific motivation for a X-ray grating spectrometer mission to be deployed on the International Space Station. The primary goals of this mission would be to address the "missing baryon" problem, finally detecting and characterizing the Warm-Hot Intergalactic Medium that should exist as filaments threading through intergalactic space. The mission parameters are similar to those of the IXO X-ray Grating Spectrometer of R=3000 and 1000 sq. cm at 0.5 keV and a bandpass from 0.3-1.0 keV. This would also enable studies of feedback from supermassive black holes, stellar coronae, and the structure of the interstellar medium and halo of the Milky Way, amongst other goals.

Author(s): ***Randall Smith (Smithsonian Astrophysical Observatory)***, Jay Bookbinder (Smithsonian Astrophysical Observatory), Nancy Brickhouse (Smithsonian Astrophysical Observatory), Adam Foster (Smithsonian Astrophysical Observatory), Robert Petre (NASA's Goddard Space Flight Center), Andrew Ptak (NASA's Goddard Space Flight Center), Randall McEntaffer (University of Iowa), Mark Bautz (MIT), David Burrows (Pennsylvania State University), Abraham Falcone (Pennsylvania State University), Joel Bregman (University of Michigan), Jörn Wilms (Friedrich-Alexander Universitaet), Richard Willingale (University of Leicester)

405.03D – An Advanced Scattered Moonlight Model

In the current era of precision astronomy, a complete sky background model is crucial, especially as the telescopes become even larger in the next decade. Such a model is needed for planning observations as well as understanding and correcting the data for the sky background. We have developed a sky model for this purpose, and it is the most complete and universal sky model that we know of to date (Noll et al. 2012). It covers a wide range of wavelengths from 0.3 to 30 microns up to a resolution of 1,000,000 and is instrument independent. Currently it is optimized for the telescopes at Cerro Paranal and the future site Cerro Armazones in Chile. Its original purpose was to improve the ESO (European Southern Observatory) ETC (Exposure Time Calculator) used for predicting exposure times of observations with a given signal to noise ratio for a set of conditions, as part of the Austrian ascension to ESO. Improving the ETC allows for better scheduling and telescope efficiency, and our new sky model has already been implemented by ESO. The brightest natural source of optical light at night is the Moon, and it is the major contributor to the astronomical sky background. We have an improved scattered moonlight model (Jones et al. 2013), where all of the components are computed with physical processes or observational data with less empirical parametrizations. This model is spectroscopic from 0.3 to 2.5 microns and was studied with a FORS1 (Patat et al. 2008) and dedicated X-Shooter data set. To our knowledge, this is the first spectroscopic model extending into the infrared. It includes fully 3-D single and double scattering calculations with extrapolations to higher orders (Noll et al. 2012), a complex treatment for aerosol scattering (Jones et al. 2013), and a lunar fit based on the ROLO survey (Kieffer & Stone 2005). In addition to its original astronomical purpose, since the model is more physical, we can use the scattered moonlight to probe the properties of the atmosphere, such as the distribution of aerosols. We present the current status of the advanced scattered moonlight model as well as its performance in the optical and near-infrared.

Author(s): ***Amy Jones (University of Innsbruck)***, Stefan Noll (University of Innsbruck), Wolfgang Kausch (University of Innsbruck), Stefan Kimeswenger (University of Innsbruck)

405.04 – Analysis and Modeling of HST Observations of the Martian Exosphere

We present an analysis of HST ACS/SBC UV images of the extended hydrogen Lyman alpha emissions from the Martian Exosphere obtained during Oct/Nov 2007 using a radiative transfer code developed by our group. This code corrects for multiple scattering effects in the atmosphere of Mars. We assume a spherically symmetric atmosphere and have used the standard Chamberlain approach to model the exospheric number density profile. For the lower part of the atmosphere, we have used a simplified diffusion model with only diffusion of H in carbon di-oxide for constructing a number density profile of H. By varying the temperature of the hydrogen population at the exobase and their number densities, we obtain the best fit to the data. We observe that there was a 40% decrease in brightness in the data, which correlates to almost a factor of 10 decrease in number density in just a span of a month. We also calculate the escape flux of hydrogen based on the modeled exobase temperature and number densities, which could then be related to the amount of water lost from Mars.

Author(s): ***Dolon Bhattacharyya (Boston University)***, John Clarke (Boston University), Jean-Loup Bertaux (LATMOS), Jean-Yves Chaufray (LATMOS)

405.05 – Analysis of multivariate data: algorithms for physical clustering, with application to extended time series data on XRBs

We have explored recent developments in machine learning algorithms, such as diffusion mapping (Richards et al. 2009) which allow us to identify physically similar clusters independent of prior knowledge. We have successfully used this method to separate out different classes of X-ray binaries and of different spectral states within a given system. Beyond the immediate astronomical application, a strength of our approach is to offer new and useful insight into the vast and rapidly growing multi-dimensional data collections in essentially all fields of investigation, not only the astrophysical ones which form our testbed and the immediate focus of our scientific interest.

Author(s): ***Saeqa Vrtilek (Harvard-Smithsonian, CfA)***, Bram Boroson (Clayton State University), Joseph Richards (Berkeley)

405.06 – SETI Searches for Radio Transients from Kepler Field Planets and Astropulse Candidates

We present a search for fast radio transients in targeted observations of planet candidates in the Kepler Field and candidate Astropulse sources. Kepler Field observations were conducted in the band 1.1 and 1.9 GHz using the Green Bank Telescope in Green Bank, West Virginia and are centered on 86 stars hosting candidate planets identified by the Kepler spacecraft. These stars were chosen based on the properties of their putative planetary system thought to be conducive to the development of advanced life, including all systems known (as of May 2011) hosting a Kepler Object of Interest (KOI) with a calculated equilibrium temperature between 230 and 380 K, at least 4 KOIs or a KOI with an inferred radius < 3.0 r_earth and a period > 50 d. The Kepler Field is centered at an intermediate galactic latitude, $b = 13.5°$, which presents an additional opportunity to detect signals from the older population of millisecond and recycled pulsars located above the galactic plane. The Astropulse radio survey searches for brief wide-band pulses in a 2.5 MHz band centered at 1420 MHz using commensal data recorded from the Arecibo ALFA receiver. In early Astropulse analysis, 108 candidate sources were identified that passed a series of tests designed to eliminate potential sources of radio frequency interference (RFI). We have performed targeted re-observations of these sources at Arecibo over the full (1214–1536 MHz) ALFA band. We have developed a software pipeline to locate fast dispersed transients in these observations, leveraging components of the PRESTO software library. This pipeline consists of finding and removing RFI, conducting de-dispersion to remove the effects of dispersion from the interstellar medium (ISM) on the signal and identifying over- threshold events. We also perform de-dispersion at negative dispersion measures, proposed to be a potential technique for intelligent civilizations to distinguish their emission from natural sources. We carry out both a periodicity and single-pulse search on de-dispersed time series. The outputs from these steps are examined to look for both technological and astrophysical sources of impulsive radio emission.

Author(s): ***Abhimat Gautam (University of California, Berkeley)***, Andrew Siemion (University of California, Berkeley), Eric Korpela (University of California, Berkeley), Jeff Cobb (University of California, Berkeley), Matt Lebofsky (University of California, Berkeley), Dan Werthimer (University of California, Berkeley)

405.07 – The SPT-GMOS Spectroscopic Survey of Galaxy Clusters Identified By the South Pole Telescope

The SPT-GMOS survey is a large NOAO program that uses the Gemini Multi-Object Spectrograph (GMOS) on the Gemini-South telescope to acquire optical spectroscopy for 85 galaxy clusters selected via the Sunyaev-Zel'dovich (SZ) effect from the South Pole Telescope (SPT) microwave background survey. The SPT survey is delivering a uniformly-selected high-mass cluster sample that is essentially volume-complete beyond z >0.3. The SPT-GMOS follow-up survey targets a large subset of the full SPT cluster catalog in the redshift range, 0.3 < z < 0.8, providing precision redshifts and velocity dispersion measurements for the observed clusters. A primary goal of the SPT-SZ galaxy cluster survey is to establish competitive, independent constraints on cosmological parameters -- including the nature of the dark energy -- using measurements of the growth of structure. Achieving this goal requires a precise understanding of the relationship between the observed SZ signature and the intrinsic cluster mass; uncertainty in this mass normalization is currently the source of the largest systematic error in SPT's cosmological constraints. The SPT-GMOS survey contributes to reducing this source of uncertainty by measuring galaxy cluster masses using the dispersion in the distribution of individual galaxy velocities as a probe of the the total matter potential of SPT galaxy clusters. Velocity dispersion measurements from a large cluster sample will average over random projection effects, and will enable the calibration of the SZ-mass scaling relation, in conjunction with X-ray and lensing data on a smaller sample. The SPT-GMOS survey data also provides legacy value to the community in the form of a powerful dataset that can be used to address a wide range of questions in galaxy evolution and cluster astrophysics.

Author(s): ***Matthew Bayliss (Harvard-Smithsonian Center for Astrophysics)***, Christopher Stubbs (Harvard-Smithsonian Center for Astrophysics), Jonathan Ruel (Harvard University)

Contributing teams: South Pole Telescope Collaboration

405.08 – Data Citation in Astronomy

Many observatories maintain bibliographies to document their impact and justify their continued funding[1], an effort that requires humans to discover and curate links between the scientific papers and the data that was used as evidence. The "Best Practices for Creating a Telescope Bibliography", endorsed by IAU C5 WG Libraries, recommends full text searching and human examination of each paper.[2] These efforts do not scale well. It is unlikely that articles published in journals from other disciples would be found. This is particularly a problem for solar physics, as solar data has applicability in astrophysics, space weather, and even the earth sciences. As our scientists are not on the editorial boards of the journals from other disciplines, we can't ensure proper attribution to allow these relationships to be discovered via full text searching. To better deal with tracking cross-discipline data usage, a number of groups have come up with guidelines and principles for data citation. In 2012, the National Academy's Board on Research Data and Information released the report "For Attribution-Developing Data Attribution and Citation Practices and Standards" [3] and it was followed last year by the CODATA-ICSTI report "Out of Cite, Out of Mind".[4] Participants from a number of groups synthesized a single set of principles for data citation that could be endorsed by all groups involved in research.[5] Implementing these principles can help to improve the scientific ecosystem by giving proper attribution to all contributors to data, improving transparency and reproducability, and making data more easily reusable to both astronomers and other researchers. We will present the Joint Declaration of Data Citation Principles, discuss the implications of them for astronomical data, and recommend steps towards implementation. References: [1] Accomazzi, et.al, 2012. http://adsabs.harvard.edu /abs/2012SPIE.8448E..0KA [2] Bishop, Grothkopf & Lagerstrom, 2012. http://iau-commission5.wikispaces.com /file/view/Best+Practices+Final.pdf [3] National Research Council, 2012. http://www.nap.edu /catalog.php?record_id=13564 [4] CODATA, 2013. http://dx.doi.org/10.2481/dsj.OSOM13-043 [5] FORCE11, 2014. http://www.force11.org/datacitation

Author(s): ***Joseph Hourcle (Wyle IS)***

Contributing teams: Virtual Solar Observatory, FORCE11 Data Citation Synthesis Group

406 – Steve Kawaler: The Kepler Mission's "Other" Legacy: The Coming of Age of Space-based Asteroseismology

Plenary Session – America Ballroom North/Central – 05 Jun 2014 11:40 AM to 12:30 PM

Chair(s):
Paula Szkody (Univ. of Washington)

406.01 – The Kepler Mission's "Other" Legacy: The Coming of Age of Space-based Asteroseismology

By awakening us to the amazing abundance of other planetary systems, the Kepler mission has been a landmark in advancing our understanding of the Universe. The almost-too-simple basis for these discoveries is accurate photometry, with high duty cycle, of over 100,000 stars. Thousands of planetary candidates emerged through detection of rare transit events. The data corresponding to transit events, though, is far less than 0.1% of the total amount of data obtained. The remaining >99.9% of the data is an exquisite record of the time-domain behavior of an enormous variety of stars. In this talk I'll discuss the remarkable strides that asteroseismology has been able to make using the remarkable archive of Kepler photometry.

Author(s): ***Steven Kawaler (Iowa State Univ.)***

407 – Gamma-ray Constraints on the EBL and the IGMF II

Meeting-in-a-Meeting – America Ballroom North/Central – 05 Jun 2014 02:00 PM to 03:30 PM

The light emitted by stars throughout the history of the Universe is encoded in the intensity of the extragalactic background light (EBL). Characterization of the EBL and its evolution provides insight into the nature of star formation and galaxy evolution. Direct measurements of the EBL are difficult due to local intense foregrounds such as the zodiacal light and emission from our own Galaxy. Gamma-ray astronomy provides a valuable indirect probe of the EBL since high-energy gamma rays may interact with photons of the EBL and generate positron-electron pairs. This introduces an attenuation feature in the spectra of distant gamma-ray sources that can be used to place sensitive constraints on the opacity of the universe to gamma-rays and on the energy density of the EBL. Moreover, the electron-positron pairs can generate an electro-magnetic cascade that reprocessed the initial photon energy to lower gamma-ray energies producing spectral, spatial and temporal signatures that can be used to place sensitive constraints on the strength of the intergalactic magnetic field (IGMF). Recent studies using gamma-ray blazars claimed the detection of EBL-induced absorption signatures consistent with the minimum level of EBL intensity expected given the established star formation rate. Thus, there is little room for an additional, truly diffuse component generated at much higher redshifts. At the same time, other studies based on gamma-ray blazars constrained the strength of the IGMF to be >1e-17 Gauss (depending on the coherent length and source activity timescale). Our proposed meeting-in-meeting will focus on up-to-date results and currently on-going projects to constrain the strength of the IGMF and further characterize the EBL intensity, its evolution, and its impact on on our understanding of star formation. The first session will cover topics related to the EBL, and its constraints while the second one will deal with the cascade formation, composition and propagation in the intergalactic medium and the derived constraints on the strength of the IGMF.

Chair(s):
Luis Reyes (California Polytechnic State Univ. San Luis Obispo)

Organizer(s):
Marco Ajello (Berkeley)

407.01 – Must is a Four Letter Word: The Role of Plasma Instabilities in the Intergalactic Magnetic Field Story

The detection of inverse Compton halos from cosmological TeV sources provide a direct means to constrain the putative intergalactic magnetic field. However, the converse may not be the case! The fate of the pairs generated by TeV gamma rays annihilating on the extragalactic background light is presently unclear, clouded by the possibility that cosmological scale plasma instabilities may dominate their energetic evolution. I will briefly motivate these plasma instabilities theoretically, summarize some empirical evidence that they may be occurring in practice, and assess their potential impact upon studies of intergalactic magnetic fields.

Author(s): ***Avery Broderick (Perimeter Institute for Theoretical Physics)***

407.02 – Does the near-infrared extragalactic background light excess come from the extragalactic sky?

Extragalactic background light (EBL) is one of the most fundamental observables in the sky. In the optical and infrared bands, it is widely believed that galaxies explain the EBL. However, the IRTS and AKARI measurements reported an excess in the NIR EBL. On the contrary, gamma-ray observations independently confirm that the level of EBL is the same as galaxy counts. In this talk, I will review the current EBL constraints from gamma-ray observations and discuss their problems. Then, I will introduce possible explanations for the NIR EBL excess.

Author(s): ***Yoshiyuki Inoue (ISAS/JAXA)***

407.03 – Cascaded Gamma Rays as a Probe of Cosmic Rays

Very-high-energy (VHE) and ultra-high-energy (UHE) gamma rays from extragalactic sources experience electromagnetic cascades during their propagation in intergalactic space. Recent gamma-ray data on TeV blazars and the diffuse gamma-ray background may have hints of the cascade emission, which are especially interesting if it comes from UHE cosmic rays. I show that cosmic-ray-induced cascades can be discriminated from gamma-ray-induced cascades with detailed gamma-ray spectra. I also discuss roles of structured magnetic fields, which suppress inverse-Compton pair halos/echoes but lead to guaranteed signals - synchrotron pair halos/echoes.

Author(s): ***Kohta Murase (Institute for Advanced Study)***

407.04 – Sensitivity of H.E.S.S. II to Detect a Reduced Gamma-ray Opacity Due to Photon-axion-like Particle Oscillations

Gamma rays originating from extragalactic sources can interact with soft energy photons of background radiation fields leading to an attenuation of the primary photon flux. Extensions of the Standard Model of particle physics commonly predict the existence of light pseudo-scalars. Photons may oscillate into such axion-like particles (ALPs) in ambient magnetic fields. ALPs propagate unimpeded over cosmological distances and a conversion back into photons before reaching Earth can give rise to an increased gamma-ray flux at high optical depths. The sensitivity to detect this increase with the second phase of the H.E.S.S. Experiment as well as with the future Cherenkov Telescope Array (CTA) will be presented. For observations compatible with the standard predictions for the opacity, limits on the photon-ALP coupling can be derived.

Author(s): ***Manuel Meyer (OKC / Stockholm University)***

407.05 – Isolating the first populations in cosmic infrared background: from Spitzer to Euclid

I will review the current measurements of potential contribution to the Cosmic Infrared Background (CIB) from first stars and black holes. Intriguing indications of the possible emissions from these objects have been obtained over the last several years from CIB fluctuation measurements using Spitzer/IRAC deep images. The uncovered source-subtracted CIB fluctuations substantially exceed those from remaining known populations. The spatial spectrum of these fluctuations is consistent with populations clustering according to high-z LCDM model. The SED of the CIB fluctuations is blue and consistent with emissions produced by hot objects at high z. Cross-correlation analysis with Chandra X-ray data suggests that the unresolved CIB and CXB are coherent at a remarkably high level implying fractional abundance of black holes, among the emitters of the CIB, which significantly exceeds that in known populations. I will also discuss a new CIB project, LIBRAE (Looking at Infrared Background Radiation Anisotropies with Euclid), planned by NASA and ESA for the future Euclid satellite mission. LIBRAE will identify the net emissions from the first stars era, lead to a better understanding of the condition of intergalactic medium at that epoch, isolate the contributions from the first black holes and shed light on dust content at those times. The project has potentially transformative implications for understanding the emergence of the Universe out of the "Dark Ages".

Author(s): ***Alexander Kashlinsky (NASA's GSFC)***

407.06 – Secondary Photons and Neutrinos from Distant Blazars and the Intergalactic Magnetic Fields

Secondary photons and neutrinos produced in the interactions of cosmic ray protons and gamma rays emitted by distant Active Galactic Nuclei (AGN) with the photon background along the line of sight can reveal a wealth of new information about the intergalactic magnetic fields (IGMF), extragalactic background light (EBL), and the acceleration mechanisms of cosmic rays. The secondary photons may have already been observed by gamma-ray telescopes. With the inclusion of secondary photons the current upper limits on the extragalactic background light are significantly weakened and new limits are set for the intergalactic magnetic fields for a wide range of cosmic ray and gamma ray models. Recent results from IceCube may also hint at the first observation of secondary neutrinos. Ramifications for the cosmic backgrounds, magnetic fields, and AGN models will be discussed.

Author(s): ***Warren Essey (University of California Los Angeles)***

408 – Corona II

Meeting-in-a-Meeting – America Ballroom South – 05 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Stephen Bradshaw (Rice University)

408.01 – Observing MHD Waves in the Solar Wind Acceleration Region

We have, for the first time, observed and characterized compressive waves propagating both outward and inward in the outer solar corona above 4 Rs. In addition to detecting the waves, we have used them to measure outflow in the all-important wind acceleration region. Because the corona is an MHD system, any disturbance in the corona launches low-frequency waves that propagate at the familiar MHD speeds and serve to communicate that disturbance to other parts of the system. Through careful filtration of synoptic STEREO-A/COR-2 data, we have been able to measure both inbound and outbound waves at all locations in the solar corona. By measuring in/out asymmetries in the wave characteristics we have been able to estimate the solar wind acceleration profile. Further, we are able to estimate the location of the Alfvén surface - the hard-to-measure transition between the corona and the superalfvénic solar wind, and the boundary at which solar magnetic field lines transition from "closed" to "open". There is a great deal of work to be done beyond these preliminary results, which - it is hoped - open a new avenue for understanding coronal dynamics and the origin of the solar wind.

Author(s): ***Craig DeForest (Southwest Research Inst.)***, Dave McComas (Southwest Research Institute), Tim Howard (Southwest Research Inst.)

408.02 – A Model for the Formation of Filament Channels on the Sun

A major unexplained feature of the solar atmosphere is the accumulation of magnetic shear, in the form of filament channels, at photospheric polarity inversion lines (PILs). In addition to free energy, this shear also represents magnetic helicity, which is conserved under reconnection. Consequently, the observations raise the question: Why is the magnetic shear observed to be concentrated along PILs? Results of 3D MHD simulations using the Adaptively Refined MHD Solver (ARMS) are presented that support the magnetic-helicity condensation model of filament-channel formation (Antiochos 2013). In this work, we consider the supergranular twisting of a quasi-potential flux system that is bounded by a PIL and contains a coronal hole (CH). The magnetic helicity injected by the small-scale photospheric motions is shown to inverse-cascade up to the largest allowable scales that define the closed flux system: the PIL and the CH boundary. This process produces field lines that are both sheared and smooth, and are sheared in opposite senses at the PIL and the CH, in agreement with Antiochos (2013). The accumulated helicity and shear flux are shown to be in excellent quantitative agreement with the helicity-condensation model. We present a detailed analysis of the simulation, including comparisons of our analytical and numerical results, and discuss their implications for observations. This work was supported, in part, by the NASA TR&T and SR&T programs.

Author(s): ***Kalman Knizhnik (NASA Goddard Space Flight Center)***, Spiro Antiochos (NASA Goddard Space Flight Center), C. DeVore (NASA Goddard Space Flight Center)

408.03 – Magnetic Untwisting in Jets that Go into the Outer Solar Corona in Polar Coronal Holes

We present results from a study of 14 jets that were observed in SDO/AIA EUV movies to erupt in the Sun’s polar coronal holes. These jets were similar to the many other jets that erupt in coronal holes, but reached higher than the vast majority, high enough to be observed in the outer corona beyond 2 solar radii from Sun center by the SOHO/LASCO/C2 coronagraph. We illustrate the characteristic structure and motion of these high-reaching jets by showing observations of two representative jets. We find that (1) the speed of the jet front from the base of the corona out to 2-3 solar radii is typically several times the sound speed in jets in coronal holes, (2) each high-reaching jet displays unusually large rotation about its axis (spin) as it erupts, and (3) in the outer corona, many jets display lateral swaying and bending of the jet axis with an amplitude of a few degrees and a period of order 1 hour. From these observations we infer that these jets are magnetically driven, propose that the driver is a magnetic-untwisting wave that is basically a large-amplitude (non-linear) torsional Alfven wave that is put into the open magnetic field in the jet by interchange reconnection as the jet erupts, and estimate that the magnetic-untwisting wave loses most of its energy before reaching the outer corona. These observations of high-reaching coronal jets suggest that the torsional magnetic waves observed in Type-II spicules can similarly dissipate in the corona and thereby power much of the coronal heating in coronal holes and quiet regions. This work is funded by the NASA/SMD Heliophysics Division’s Living With a Star Targeted Research & Technology Program.

Author(s): ***Ronald Moore (NASA's MSFC)***, Alphonse Sterling (NASA's MSFC), David Falconer (NASA's MSFC)

408.04 – Mass Flows in a Prominence Spine as Observed in EUV

We analyze a quiescent prominence observed by the Solar Dynamics Observatory's Atmospheric Imaging Assembly with a focus on mass and energy flows in the spine measured using Lyman continuum absorption. This is the first time this sort of analysis has been applied with an emphasis on individual features and flows in a quiescent prominence. The prominence, observed on 2010 Sept. 28, is detectable in most AIA wavebands in absorption and/or emission. Flows along the spine exhibit horizontal bands 5-10 arcsec wide and kinetic energy fluxes consistent with quiet sun coronal heating estimates. For a discrete moving feature we estimate a mass of a few times 10^{11} g. We discuss the implications of our derived properties for models of prominence dynamics, in particular the thermal non-equilibrium model. This project was supported by NASA's LWS TR&T program.

Author(s): ***Therese Kucera (NASA's GSFC)***, Holly Gilbert (NASA's GSFC), Judith Karpen (NASA's GSFC)

408.05 – Modeling the multi-ion structure of the solar corona

The solar corona is typically observed in EUV by SDO/AIA and other instruments using the heavy ion emission lines such as Fe IX, Fe XII, and other ion emission lines. However, the relative (to protons) abundance of the emitting ions is very low and the collisional coupling between the Fe ions and electrons decreases rapidly with height in the low corona, while gravitational settling may become significant in quiescent long-lived magnetic structures, such as streamers. Thus, the structure of the weakly collisional solar corona imaged in Fe IX (and other heavy ions) may differ significantly from the structure of the main electron-proton constituents of the corona. The electron structure is observed by white light coronagraphs, and during solar eclipses in the low corona. I present the results of multi-fluid modeling of coronal streamers and other magnetic structures that demonstrate the effects of weak coupling between the heavy ions and the coronal electron-proton components, and show that the multi-ion coronal structure must be taken into account in interpretation of EUV observations.

Author(s): ***Leon Ofman (Catholic University and NASA's GSFC)***, Elena Provornikova (Catholic University and NASA's GSFC), Tongjiang Wang (Catholic University and NASA's GSFC)

408.06 – Observations of Alfvèn Wave Damping in the Quiet Corona

We present a measurement of line widths in quiet Sun regions of the corona. The non-thermal line width is proportional to the amplitude of Alfvèn waves. Using a Potential Field Source Surface (PFSS) magnetic field model to identify magnetic field lines, we trace the evolution of line widths along the inferred field lines. In order to mitigate line of sight effects, we select regions that are isothermal and where the field lines remain oriented close to perpendicular to the line of sight. Our results indicate that the waves are damped starting at a height that is positively correlated with the overall length of the loop. That is, for longer loops, the damping occurs starting at a larger height. This suggests that heating of quiet Sun loops occurs over a region centered on the loop top and extends over a large fraction of the loop. We estimate that there is enough energy flux in waves injected at the base of quiet Sun regions to account for coronal heating in such structures.

Author(s): ***Michael Hahn (Columbia University)***, Daniel Savin (Columbia University)

409 – SPD/LAD Joint Session: Bridging Laboratory and Solar Plasma Studies II

Meeting-in-a-Meeting – Staffordshire – 05 Jun 2014 02:00 PM to 03:30 PM

Laboratory astrophysics is the Rosetta Stone that enables astronomers to understand and interpret the cosmos. This joint meeting will focus on the interplay between laboratory astrophysics, plasma physics and solar physics.

Chair(s):
Daniel Savin (Columbia Astrophysics Lab.)

409.01 – On Cosmic Ray Propagation

Cosmic ray propagation is diffusive because of pitch angle scattering by waves. We demonstrate that if the high-amplitude magnetic turbulence with (delta B)/B ~ 1 is present on top of the mean field gradient, the diffusion becomes asymmetric. As an example, we solve this diffusion problem in one dimension analytically with a Markov chain analysis. The cosmic ray density markedly differs from the standard diffusion prediction. The equation for the continuous limit is also derived, which shows limitations of the convection-diffusion equation. There is an interesting connection of this problem to laboratory experimental studies of particle transport in multi-mirror machines. The implications of the results are discussed. Supported by grant DOE grant DE-FG02-07ER54940 and NSF grant AST-1209665.

Author(s): ***Mikhail Medvedev (University of Kansas)***

409.02 – Role of Z-pinches in magnetic reconnection in space plasmas

A generally accepted scenario of magnetic reconnection in space plasmas is the breakage of magnetic field lines in X-points. In laboratory, reconnection is widely studied in pinches, current channels embedded into twisted magnetic fields. No model of magnetic reconnection in space plasmas considers both null-points and pinches as peers. We have performed a particle-in-cell simulation of magnetic reconnection in a three-dimensional configuration where null-points are present initially, and Z-pinches are formed during the simulation. The X-points are relatively stable, and no substantial energy dissipation is associated with them. On the contrary, turbulent magnetic reconnection driven by kinking of the pinches causes the magnetic energy to decay at a rate of 1.5% per ion gyro period. Current channels and twisted magnetic fields are ubiquitous in turbulent space plasmas, so pinches can be responsible for the observed high magnetic reconnection rates.

Author(s): ***Vyacheslav Olshevsky (KU Leuven)***, Giovanni Lapenta (KU Leuven), Stefano Markidis (KTH Royal Institute of Technology), Andrey Divin (Swedish Institute of Space Physics)

409.03 – Two LANL laboratory astrophysics experiments

Two laboratory experiments are described that have been built at Los Alamos (LANL) to gain access to a wide range of fundamental plasma physics issues germane to astro, space, and fusion plasmas. The over arching theme is magnetized plasma dynamics which includes significant currents, MHD forces and instabilities, magnetic field creation and annihilation, sheared flows and shocks. The Relaxation Scaling Experiment (RSX) creates current sheets and flux ropes that exhibit fully 3D dynamics, and can kink, bounce, merge and reconnect, shred, and reform in complicated ways. Recent movies from a large data set describe the 3D magnetic structure of a driven and dissipative single flux rope that spontaneously self saturates a kink instability. Examples of a coherent shear flow dynamo driven by colliding flux ropes will also be shown. The Magnetized Shock Experiment (MSX) uses Field reversed configuration (FRC) experimental hardware that forms and ejects FRCs at 150km/sec. This is sufficient to drive a collision less magnetized shock when stagnated into a mirror stopping field region with Alfven Mach number MA=3 so that super critical shocks can be studied. We are building a plasmoid accelerator to drive Mach numbers MA >> 3 to access solar wind and more exotic astrophysical regimes. Unique features of this experiment include access to parallel, oblique and perpendicular shocks, shock region much larger than ion gyro radii and ion inertial length, room for turbulence, and large magnetic and fluid Reynolds numbers. *DOE Office of Fusion Energy Sciences under LANS contract DE-AC52-06NA25396, NASA Geospace NNHIOA044I, Basic, Center for Magnetic Self Organization

Author(s): ***Thomas Intrator (Los Alamos Natl Lab)***, Thomas Weber (Los Alamos Natl Lab), Yan Feng (Los Alamos Natl Lab), Trevor Hutchinson (Los Alamos Natl Lab), John Dunn (Los Alamos Natl Lab), Cihan Akcay (Los Alamos Natl Lab)

409.04 – Magnetic structure of sites of braiding in Hi-C active region

High-resolution Coronal Imager (Hi-C) observations of an active region (AR) corona, at a spatial resolution of 0.2 arcsec, have offered the first direct evidence of field lines braiding, which could deliver sufficient energy to heat the AR corona by current dissipation via magnetic reconnection, a proposal given by Parker three decades ago. The energy required to heat the corona must be transported from the photosphere along the field lines. The mechanism that drives the energy transport to the corona is not yet fully understood. To investigate simultaneous magnetic and intensity structure in and around the AR in detail, we use SDO/HMI+AIA data of + / - 2 hours around the 5 minute Hi-C flight. In the case of the QS, work done by convection/granulation on the inter-granular feet of the coronal field lines probably translates into the heat observed in the corona. In the case of the AR, as here, there could be flux emergence, cancellation/submergence, or shear flows generating large stress and tension in coronal field loops which is released as heat in the corona. However, to the best of our knowledge, there is no observational evidence available to these processes. We investigate the changes taking place in the photospheric feet of the magnetic field involved with brightenings in the Hi-C AR corona. Using HMI 45s magnetograms of four hours we find that, out of the two Hi-C sub-regions where the braiding of field lines were recently detected, flux emergence takes place in one region and flux cancellation in the other. The field in these sub-regions are highly sheared and have apparent high speed plasma flows at their feet. Therefore, shearing flows plausibly power much of the coronal and transition region heating in these areas of the AR. In addition, the presence of large flux emergence/cancellation strongly suggests that the work done by these processes on the pre-existing field also drives much of the observed heating. For this work, SKT and CEA were supported by an appointment to the NASA Postdoctoral Program at the NASA Marshall Space Flight Center, administered by Oak Ridge Associated Universities through a contract with NASA, and AW and RLM were supported by funding from the Living With a Star Targeted Research and Technology Program of the Heliophysics Division of NASA's Science Mission Directorate.

Author(s): ***Sanjiv Tiwari (NASA's MSFC)***, Caroline Alexander (NASA's MSFC), Amy Winebarger (NASA's MSFC), Ronald Moore (NASA's MSFC)

409.05 – Alfven Wave Collisions, the Fundamental Building Block of Plasma Turbulence: Theoretical, Numerical, And Experimental Verification

Turbulence plays a key role in the evolution of space and astrophysical plasmas, mediating the transfer of energy from large-scale turbulent motions to small scales where the turbulent energy is ultimately converted to plasma heat. In the solar corona, turbulence is believed to play a key, yet incompletely understood, role in the heating of the plasma to temperatures nearly three orders of magnitude hotter than the photosphere. The cascade of energy from large to small scales is mediated by the nonlinear interaction between counterpropagating Alfven waves, or Alfven wave "collisions," the fundamental building block of astrophysical plasma turbulence. First, I present an analytical solution for the nonlinear evolution of Alfven wave collisions that elucidates the physical mechanism by which energy is transferred from large to small scales. Next, I show that the analytical solution is validated using nonlinear gyrokinetic simulations of weakly collisional plasma turbulence. Finally, I present the experimental verification of the physics of Alfven wave collisions in the laboratory using the Large Plasma Device (LAPD) at UCLA.

Author(s): ***Gregory Howes (University of Iowa)***, Kevin Nielson (University of Iowa), Dereth Drake (Valdosta State University), James Schroeder (University of Iowa), Frederick Skiff (University of Iowa), Craig Kletzing (University of Iowa), Troy Carter (University of California)

409.06 – Hybrid Kinetic and Radiative Hydrodynamic Simulations of Solar Flares and Comparison With Multiwavelength Observations

We present a unified simulation which combines two physical processes: how the particles are accelerated and the energy is transported along a coronal loop, and how the atmosphere responds. The “flare” code from Stanford University (Petrosian et al, 2001) models the stochastic acceleration and transport of particles and radiation of solar flares. It includes pitch angle diffusion and energy loss, and computes collisional heating to the background plasma and bremsstrahlung emission along the loop. The radiative hydrodynamic RADYN Code (Carlsson et al, 1992, 1996; Allred et al, 2005) computes the energy transport by the injected non-thermal electrons at the top of a 1D coronal loop. Recently, we have combined the two codes by updating the non-thermal heating in the RADYN code from the "flare" code, allowing us to develop a self-consistent simulation. In addition, we can now model more realistically the multi-wavelength emission of solar flares and compare it with observations, e.g., at optical wavelengths from IBIS at the Dunn Solar Telescope and in X-rays from RHESSI. The high resolution UV observations from the recently launched IRIS imaging spectrograph will be particularly useful in this regard. These will allow us to compare numerically modeled and observed emissions of solar flares in several lines using more robust simulations than possible before.

Author(s): ***Fatima Rubio Da Costa (Stanford University)***, Vahe Petrosian (Stanford University), Wei Liu (Stanford University), Mats Carlsson (University of Oslo), Lucia Kleint (University of Applied Sciences North Western Switzerland)

410 – AGN, QSO, Blazars

Oral Session – St. George AB – 05 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Laura Brenneman (Harvard-Smithsonian Center for Astrophysics)

410.01 – Searching for Obscured Quasars with WISE and the Southern African Large Telescope

We present the results of an optical spectroscopic survey of a sample of 43 obscured quasars identified on the basis of their mid-infrared emission detected by the Wide-Field Infrared Survey Explorer (WISE). Optical spectra for this survey were obtained using the Robert Stobie Spectrograph (RSS) on the Southern African Large Telescope (SALT). Our target objects are selected to have red WISE colors characteristic of AGN, as well as red optical to mid-IR colors indicating that the optical/UV AGN continuum is obscured by dust. We obtain secure redshifts for the majority of the objects that comprise our sample (37/43), and find that sources that are bright in the WISE 22?m band are typically at moderate redshift (0.2-0.5) while 22?m fainter sources are at higher redshifts. The majority of the sources have narrow emission lines, with optical colors and emission line ratios of our WISE-selected sources that are consistent with the locus of AGN on the color-excitation diagram between rest-frame g - z color and [NeIII]?3869 / [OII]??3726+3729 line ratio. These results verify the efficiency of WISE color criteria in selecting luminous obscured AGN.

Author(s): ***Kevin Hainline (Dartmouth College)***, Ryan Hickox (Dartmouth College), Christopher Carroll (Dartmouth College), Adam Myers (University of Wyoming), Laura Trouille (Northwestern University), Michael DiPompeo (University of Wyoming)

410.02 – Through the Ring of Fire: A Study of the Origin of Orphan Gamma-ray Flares in Blazars

Blazars exhibit flares across the electromagnetic spectrum. Many gamma-ray flares are highly correlated with flares detected at optical wavelengths; however, a small subset appear to occur in isolation, with no counterpart in the other wave bands. These "orphan" gamma-ray flares challenge current models of blazar variability, most of which are unable to reproduce this type of behavior. We present numerical calculations of the time variable emission of a blazar based on a proposal by Marscher et al. (2010) to explain such events. In this model, a plasmoid ("blob") consisting of a power-law distribution of electrons propagates relativistically along the spine of a blazar jet and passes through a synchrotron emitting ring of electrons representing a shocked portion of the jet sheath. This ring supplies a source of seed photons that are inverse-Compton scattered by the electrons in the moving blob. As the blob approaches the ring, the photon density in the co-moving frame of the plasma increases, resulting in an orphan gamma-ray flare that then dissipates as the blob passes through and then moves away from the ring. The model includes the effects of radiative cooling and a spatially varying magnetic field. Support for the plausibility of this model is provided by observations by Marscher et al.(2010) of an isolated gamma-ray flare that was correlated with the passage of a superluminal knot through the inner jet of quasar PKS 1510-089. Synthetic light-curves produced by this new model are compared to the observed light-curves from this event. In addition, we present polarimetric observations that point to the existence of a jet sheath in the quasar 3C 273. A rough estimate of the bolometric luminosity of the sheath results in a value of ~10^45 erg s^-1 (~ 10% of the jet luminosity). This inferred sheath luminosity indicates that the jet sheath in 3C 273 can provide a significant source of seed photons that need to be taken into account when modeling the non-thermal emission due to inverse-Compton scattering processes. Funding for this research was provided by an NSERC PGS D2 Doctoral Fellowship and NASA under Fermi Guest Investigator grants NNX12AO79G and NNX12AO59G.

Author(s): ***Nicholas MacDonald (Boston Univ.)***, Alan Marscher (Boston Univ.), Svetlana Jorstad (St. Petersburg University), Manasvita Joshi (Boston Univ.)

410.03 – Using Long-term Optical-Infrared Color Variability to Probe the Disk-Jet Connection in Blazars

We undertook a 5 year, multiwavelength program to observe a sample of blazars in various Fermi γ-ray states, using the Small and Medium Aperture Research Telescope System (SMARTS) 1.3 m + ANDICAM instrument in Cerro Tololo, Chile. We present near daily, optical-infrared (OIR) color variability to constrain competing emission in the OIR wavebands, presumably from the accretion disk and highly variable jet. The main results of previous short-term color variability studies are reproduced in most cases, namely that BL Lacs are bluer when brighter and FSRQs are redder when brighter. However, we extend this interpretation by providing a self-consistent way to explain blazars that did not behave as predicted by the existing dichotomy in blazar color variability. We show that over long timescales, patterns emerge in the OIR color variability that are not seen on shorter timescales due to the selection effects introduced by only observing blazars in γ-ray flaring states. By observing a large sample of blazars on up to 5 year timescales, we show that these short-term color variability 'snapshots' can be incorporated into a more comprehensive understanding of blazar OIR color variability, and by extension the contribution of non-thermal jet flux in the OIR regime. Finally, we address how long-term OIR color variability can constrain the disk-jet interaction in blazars.

Author(s): ***Jedidah Isler (Syracuse University)***, Charles Bailyn (Yale University), Paolo Coppi (Yale University), Imran Hasan (Yale University), Emily MacPherson (Yale University), Michelle Buxton (Yale University), C. Urry (Yale University)

Contributing teams: Yale-SMARTS

410.04 – Jet Feedback on the Interstellar Medium of the Radio Galaxy 3C 293

We present a 70 ks Chandra observation of the radio galaxy 3C 293. This galaxy belongs to the class of molecular hydrogen emission galaxies (MOHEGs) that have very luminous emission from warm molecular hydrogen. In the case of radio galaxies, the molecular gas appears to be heated by jet-driven ISM turbulence. 3C 293 contains 3.7 x 10^9 solar masses of shock-heated, 100 K molecular hydrogen in an extended 10 kpc scale region. With Chandra, we observe emission from the jets both within the host galaxy and outside of the galaxy, along the 100 kpc radio jets. Some of the soft X-rays are coincident with the radio hotspots, but one X-ray emitting feature is anti-coincident with the radio emission. We model the X-ray spectra of the nucleus, the inner jets, and the X-ray features along the extended radio jets. Both the nucleus and the inner jets show evidence of 10^7 K shock-heated gas. The kinetic power of the jets is more than sufficient to heat the X-ray emitting gas, which serves as a reservoir of thermal and turbulent energy to maintain the molecular hydrogen emission over a time scale of 10^7 years.

Author(s): ***Lauranne Lanz (California Institute of Technology)***, Patrick Ogle (California Institute of Technology), Philip Appleton (California Institute of Technology), Bjorn Emonts (Australia Telescope National Facility), Daniel Evans (National Science Foundation)

410.05 – DASCH detection of a ~17y QPO in the 100y light curve of 3C273

The Digital Access to a Sky Century @ Harvard (DASCH) project is digitizing the ~500,000 plates in the Harvard plate collection which are (primarily) direct images ranging from 4 x 5deg through 30 x 40deg and covering full sky from 1885 - 1992 (see dasch.rc.fas.harvard.edu). This results in ~1000 - 3000 images of any object. Astrometric positions for each resolved object are measured on each plate to 0.3 -3arcsec (depending on plate scale) and B band photometry is derived to +/-0.1mag using the APASS survey for spatially dependent photometric calibration and color corrections. Limiting magnitudes are typically B = 13 - 17. We report the 100y lightcurve (~1100 points) of the bright quasar 3C273 and the analysis of its ~1mag variability on timescales ranging from days to decades. We have used generalized Lomb-Scargle techniques, which handle the inherently unevenly spaced data sampling and seasonal gaps, to investigate the preferred variability timescales and possible quasi-periodic oscillations (QPOs) present in this unique dataset. An advantage of the DASCH data and processing is the ready availability of a large comparison sample of nearby non-variable objects (foreground stars) of comparable magnitude which then directly measure the noise due to both photometric errors and (particularly) the uneven sampling. The generalized L-S periodogram shows significant excess (vs. field stars) power on several well defined timescales, the most prominent being at ~17.2y. The full power spectrum is derived using the CARMA model fitting technique described by Kelly et al, arXiv:1402.5978 and will be compared with a variety of models for the origin of the ~17y QPO as well as the significance of the several shorter timescale features. Models for the physical origin of the QPO features are discussed, including optical emission from precession of the jet in 3C273. Prospects for detection of similar longterm variability in other bright AGN with DASCH, when the full production scanning is available (only 12% of the plates are now scanned), are also discussed. DASCH gratefully acknowledges support from NSF grants AST-0407380, AST-0909073, and AST-1313370.

Author(s): ***Jonathan Grindlay (Harvard-Smithsonian, CfA)***, George Miller (Harvard-Smithsonian, CfA), Aneta Siemiginowska (Harvard-Smithsonian, CfA), Edward Los (Harvard-Smithsonian, CfA), Brandon Kelly (UCSB), Sumin Tang (UCSB)

410.06 – Mid-Infrared Selected Quasars I: Virial Black Hole Mass and Eddington Ratios

We provide a catalog of 391 mid-infrared-selected (MIR, 24?m) broad-emission-line (BEL, type 1) quasars in the 20 square deg SWIRE Lockman Hole field. This quasar sample is selected in the MIR from Spitzer MIPS with S24 > 0.4mJy, and jointly with an optical magnitude limit of r (AB)= 22.5. The catalog is based on MMT spectroscopy to select BEL quasars, and extends the SDSS coverage to fainter magnitudes and a more complete quasar population. The MIR-selected quasar sample peaks at z ?1.4, and shows a significant and constant (20%) fraction of objects with extended SDSS photometry, previously missed by the SDSS optical point source dominant color selection. This sample also recovers a significant population of z < 3 quasars at i > 19.1, previously dropped by SDSS for efficiency consideration. We also investigate the continuum luminosity and line profile of these MIR quasars, estimate their virial black hole masses, and provide the Eddington ratios. The SMBH mass shows evidence of downsizing, though the Eddington ratios remain constant at 1 < z < 4. Compared to point sources in the same redshift range, extended sources at z < 1 show systematically lower Eddington ratios. The catalog and spectra will be publicly available online.

Author(s): ***Yu Dai (Harvard-Smithsonian Center for Astrophysics)***, Martin Elvis (Harvard-Smithsonian Center for Astrophysics), Jacqueline Bergeron (Institut d?Astrophysique de Paris), Giovanni Fazio (Harvard-Smithsonian Center for Astrophysics), Jiasheng Huang (Harvard-Smithsonian Center for Astrophysics), Belinda Wilkes (Harvard-Smithsonian Center for Astrophysics), Christopher Willmar (University of Arizona)

410.07 – Using Quasars from SDSS-III/SEQUELS to Characterize SDSS-IV/eBOSS selection

As part of the fourth incarnation of the Sloan Digital Sky Survey (SDSS-IV) the extended Baryon Oscillation Spectroscopic Survey (eBOSS) will compile optical spectroscopy of by far the largest sample of quasars to date. A homogeneous sample selection that takes advantage of SDSS ugriz imaging coupled with information from the WISE 3.4 micron and 4.6 micron bands will target about three-quarters of a million total quasars over an area of 7500 square degrees across the North and South Galactic caps. Some eBOSS quasars will have existing spectroscopy from earlier versions of the SDSS, but spectroscopy of over half-a-million new quasars will be obtained over a wide range of redshifts (mostly z > 0.9) close to the faint limits of the SDSS imaging (r < 22). A precursor survey to eBOSS, the Sloan Extended QUasar, ELG and LRG Survey (SEQUELS) has already been conducted over ~500 square degrees near the North Galactic Cap. I will discuss target selection for eBOSS, and the results of applying this target selection as part of SEQUELS. ADM was partially supported through NSF Grant 1211112 and NASA ADAP award NNX12AE38G

Author(s): ***Adam Myers (University of Wyoming)***, Eric Armengaud (CEA-Saclay), Jo Bovy (Institute for Advanced Study), W. Brandt (The Pennsylvania State University), Etienne Burtin (CEA-Saclay), Johan Comparat (LAM/CNRS), Kyle Dawson (University of Utah), Timothee Delubac (EPFL/Observatoire de Sauverny), Shirley Ho (Carnegie Mellon University), Jean-Paul Kneib (EPFL/Observatoire de Sauverny), Dustin Lang (Carnegie Mellon University), Cameron McBride (CfA/Harvard), Ian McGreer (University of Arizona), Jeffrey Newman (University of Pittsburgh), Nathalie Palanque-Delabrouille (CEA-Saclay), Isabelle Paris (Universidad de Chile), William Percival (University of Portsmouth), Patrick Petitjean (Institut d?Astrophysique de Paris), Ashley Ross (University of Portsmouth), David Schlegel (Lawrence Berkeley National Laboratory), Yue Shen (Carnegie Observatories), Christophe Yeche (CEA-Saclay)

Contributing teams: The SDSS-III Collaboration, The SDSS-IV Collaboration

410.08 – Unveiling Obscured AGN with X-ray Spectral Analysis

With the recent advent of physically motivated, self-consistent X-ray models, the circumnuclear medium enshrouding AGN can now be investigated in unprecedented detail. We applied these models to 19 SDSS [OIII] 5007 Angstrom selected Type 2 AGN, where 9 are local Seyfert 2 galaxies and 10 are more luminous and distant Type 2 quasars. For the first time in a sample of AGN, we constrained both the line-of-sight and global column densities, finding that over half (11/19) are heavily obscured or Compton-thick (NH > 10^23 cm^-2). Four objects have different global from line-of-sight column densities. When correcting the observed X-ray luminosities for obscuration, the L_x/L_[OIII] ratio for these Type 2 AGN is essentially identical to the Seyfert 1 (i.e., unabsorbed AGN) value, which is consistent with both parameters cleanly probing AGN emission.

Author(s): ***Stephanie LaMassa (Yale University)***, Tahir Yaqoob (NASA-GSFC), Andrew Ptak (NASA-GSFC), Jianjun Jia (The Johns Hopkins University), Timothy Heckman (The Johns Hopkins University), Poshak Gandhi (Durham University), C. Urry (Yale University)

410.09 – The Cosmic Evolution of Fermi BL Lacertae Objects

It has been notoriously difficult in the past to measure the cosmological evolution of BL Lacs because of the challenges related to measure their redshift. Extensive optical follow-up observations of a sample of ~200 Fermi-detected BL Lac objects have provided much-needed redshift information for many of them. This stands as the largest and most complete sample of BL Lacs available in the literature and was used to determine the cosmological properties of this elusive source class. This talk will review the cosmic evolution of BL Lacs and discuss the link to their siblings flat-spectrum radio quasars (FSRQs). Evidence suggests that BL Lacs of the high-synchrotron peaked class might be an accretion-starved end-state of an earlier merger-driven gas-rich phase.

Author(s): ***Marco Ajello (Clemson)***, Dario Gasparrini (ASI Space Data Center), Roger Romani (Stanford University), Michael Shaw (Stanford University)

Contributing teams: Fermi-LAT team

411 – Relativistic Astrophysics, Gravitational Lenses & Waves

Oral Session – St. George CD – 05 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
James Aguirre (University of Pennsylvania)

411.01 – Microlensing with Hubble

Microlensing can be used to study dark matter, galactic structure, and to search for extra-solar planets. However, a significant problem with microlensing is the mass determination of the lens. Typically, microlensing events provides only a single measured quantity that depends on the lens mass, the Einstein angle crossing time, ?, which also depends on the distances to the lens and source as well as the relative transverse velocity. Thus, it is difficult to derive unique mass estimates for the lens. Non-degenerate solutions are possible, as was shown by Alcock et al. for MACHO LMC-5, when the source and lens can be resolved. It may be possible to distinguish between the lens and source by re-observing a microlensing candidate years after the first observation. As it turns out, a substantial number of fields containing microlensing events have been observed by the Hubble Space Telescope (HST). We currently have identified over 180 possible matches to lensing events. In many of these cases, there was a time difference of years between the HST observation (or observations) and the ground-based detection. We present initial results from our archival program and discuss the implications for future studies.

Author(s): ***Idan Ginsburg (Center for Astrophysics)***, Rosanne Di Stefano (Center for Astrophysics), Sebastien Lepine (Georgia State University), Francis Primini (Center for Astrophysics), Antonia Oprescu (Center for Astrophysics), Ben Tunbridge (Center for Astrophysics)

411.02 – An overview of LIGO and Virgo -- status and plans

Interferometric gravitational-wave detectors, the most sensitive position meters ever operated, aim to detect the motion of massive bodies throughout the universe by pushing precision measurement to the standard quantum limit and beyond. A global network of these detectors is currently under construction, promising unprecedented sensitivity and the ability to determine the sky position of any detected signals. I will describe the current status and expected performance of this network with a focus on limiting noise sources and the techniques currently being developed to combat them.

Author(s): ***John Miller (MIT)***

Contributing teams: LIGO-Virgo Collaboration

411.03 – Sky localization of gravitational wave sources in the early years of Advanced LIGO and Virgo

Advanced LIGO and Virgo, the ground-based km-scale laser interferometers for gravitational wave detection, will start collecting data in 2015-2016. Many of the most promising sources of gravitational waves, such as compact binary coalescences, are also expected to emit in the electromagnetic spectrum. The detection of the electromagnetic counterpart to a gravitational-wave source should help answering open questions, e.g. if compact binary systems are the progenitors of short gamma ray bursts. In this talk I will report on sky localization capabilities for signals emitted by binary neutron stars, focusing on the first two years of activity of Advanced LIGO and Virgo.

Author(s): ***Salvatore Vitale (MIT)***, Leo Singer (Caltech), Larry Price (Caltech), Benjamin Farr (Northwester University), Alex Urban (University of Wisconsin-Milwaukee), Chris Pankow (University of Wisconsin-Milwaukee), John Veitch (University of Birmingham), Will Farr (University of Birmingham), Chad Hanna (Pennsylvania State University), Kipp Cannon (Canadian Institute for Theoretical Astrophysics), Tom Downes (University of Wisconsin-Milwaukee), Philip Graff (NASA Goddard Space Flight Center), Carl-Johan Haster (University of Birmingham), Ilya Mandel (University of Birmingham), Trevor Sidery (University of Birmingham), Alberto Vecchio (University of Birmingham)

411.04 – Expected sky localization capabilities for un-modeled gravitaitonal-wave transients in 2015 and 2016

The LIGOs and Virgo, advanced ground-based Gravitational-wave detectors, are expected to begin collecting science data in the next few years. With first detections expected to follow, it is important to quantify how well gravitational-wave transients can be localized on the sky. This is crucial for correctly identifying electromagnetic counterparts as well as understanding gravitational-wave physics and source populations. We present a study of sky localization capabilities for several searches for un-modeled gravitational-wave signals. We focus on Coherent WaveBurst, a maximum likelihood algorithm used by gravitational-wave observatories, and LALInferenceBurst, a Monte Carlo Markov Chain parameter estimation algorithm developed to recover transient signals. Because these searches are sensitive to unexpected sources of radiation, it is vital to correctly localize them on the sky to facilitate electromagnetic follow up. Furthermore, we focus on the first few years of the advanced detector era, when we expect to only have two operational detectors (2015) and when we expect to have three operational detectors (2016). These detector configurations can produce significantly different sky localizations, which we quantify in detail.

Author(s): ***Reed Essick (MIT)***, Salvatore Vitale (MIT), Erotokritos Katsavounidis (MIT), Sergey Klimenko (University of Florida), Gabriele Vedovato (University of Trento)

411.05 – Measuring the spin of black holes in binary systems using gravitational waves

Compact binary coalescences are promising sources of gravitational waves for ground based detectors. Binary systems containing one or two spinning black holes are particularly interesting due to spin-orbit (and eventual spin-spin) interactions, and these systems present an opportunity to measure spins directly through gravitational wave observations. In this talk we analyze simulated signals emitted by spinning binaries with several values of masses, spins, orientation, and signal-to-noise ratio. We find estimates for the measurement accuracy of the spin magnitudes and spin angles and analyze how these measurement capabilities vary with the binaries' orientations.

Author(s): ***Ryan Lynch (MIT)***

411.06 – Multi-messenger Observations of Gravitational-Wave Sources in the Advanced Detectors Era

In the near future the advanced ground-based gravitational-wave detectors will open a new direction in observational astronomy. Detection of gravitational waves will allow us to perform the first unambiguous observations of coalescence of compact binaries consisting of neutron stars and stellar-mass black holes. The multi-messenger and multi-wavelength observations of such transient gravitational-wave events with other instruments will help us to identify their location, understand their environment and examine their hypothesized connection with the short gamma-ray bursts. They will also provide a wealth of complementary data from which we can infer new information about compact objects and various physical processes taking place during or after the coalescence. In addition to coalescing binaries, we should also be prepared to discover completely new classes of gravitational-wave transients, for which verification and understanding the multi-messenger observations at other wavelengths would be equally important. In this talk I will give an overview of the observing plans for the advanced detectors in the second half of this decade, and their projected capabilities in discovering and localizing the transient gravitational-wave sources. I will describe the main challenges in performing the multi-messenger observations of such sources and what we do to overcome them in preparation for future observational campaigns. I will conclude by presenting the initiative led by the LIGO and Virgo collaborations to involve a wider astronomical community in the follow-up multi-messenger observations starting with the very first advanced detectors science run in 2015.

Author(s): ***Ruslan Vaulin (MIT)***

Contributing teams: The LIGO Scientific Collaboration, The Virgo Collaboration

412 – Supernovae and White Dwarfs

Oral Session – Gloucester, 2nd Floor – 05 Jun 2014 02:00 PM to 03:30 PM

Chair(s):
Lynn Matthews (MIT Haystack Observatory)

412.01 – Measuring the Spin Rate Change of V455 And

V455 And (HS2331+3905) is an unusual cataclysmic variable that displays both an orbital (81 min) and a spin (67s) period, thus classifying it as an Intermediate Polar. The magnetic field of this interacting white dwarf channels the accretion stream from the secondary towards the white dwarf poles, which become heated, resulting in the visibility of both the spin period and its harmonic in the lightcurves of V455 And. Our group has been observing this object since its discovery. In 2007, V455 And underwent a large amplitude dwarf nova outburst. This provided an unique opportunity to gauge the overall angular momentum gain due to its long-term accretion as well as its 2007 outburst. Using these data that span the timebase of a decade from 2003 to 2013, we constrain the rate of change of its spin period with time to be dP/dt = (-6.8 +/- 4.8) 10^{-15} s/s for the spin period of 67.61970396 +/- 0.00000024s. We were able to fit the pre- and post-outburst data together because we did not find any evidence for a significant discontinuity in the O-C diagram due to the 2007 outburst. This implies that the magnetic field couples the angular momentum gain to the white dwarf interior. Our next goal is to constrain the angular momentum evolution of a non-magnetic accreting white dwarf to probe how the gain in angular momentum due to accretion is transferred to the envelope and core of the white dwarf.

Author(s): *Paula Szkody (Univ. of Washington)*, Anjum Mukadam (Univ. of Washington), Boris Gaensicke (University of Warwick), JJ Hermes (McDonald Observatory)

412.02 – Testing the Hibernation Model for Cataclysmic Variable Evolution with Very-Long Very-Well-Sampled Light Curves of Old Novae

The Hibernation Model for the evolution of cataclysmic variables predicts that old novae should be fading at a rate of order one-magnitude-per-century or so, with no mechanism for the accretion rate to significantly increase. This old prediction has been basically impossible to test due to the absence of very long term light curves where all the magnitudes have been placed onto a single consistent photometric system. However, in the past year, I have created very-long and very-well sampled light curves for old novae with the magnitudes fully corrected into the Johnson B & V system. I have these long light curves for Q Cyg (Nova Cyg 1876), V603 Aql (Nova Aql 1918), GK Per (Nova Per 1901), BT Mon (Nova Mon 1939), and QZ Aur (Nova Aur 1964) plus its orbital period change across its 1964 eruption. The comparison with the Hibernation prediction is mixed.

Author(s): *Bradley Schaefer (Louisiana State Univ.)*

412.03 – The Post-merger Magnetized Evolution of White Dwarf Binaries: The Double-degenerate Channel of Sub-Chandrasekhar Type Ia Supernovae and the Formation of Magnetized White Dwarfs

Type Ia supernovae (SNe Ia) play a crucial role as standardizable cosmological candles, though the nature of their progenitors is a subject of active investigation. Recent observational and theoretical work has pointed to merging white dwarf binaries, referred to as the double-degenerate channel, as the possible progenitor systems for some SNe Ia. Additionally, recent theoretical work suggests that mergers which fail to detonate may produce magnetized, rapidly rotating white dwarfs. In this presentation, I will present the first multidimensional simulations of the post-merger evolution of white dwarf binaries to include the effect of the magnetic field. In these systems, the two white dwarfs complete a final merger on a dynamical timescale, and are tidally disrupted, producing a rapidly rotating white dwarf merger surrounded by a hot corona and a thick, differentially rotating disk. The disk is strongly susceptible to the magnetorotational instability (MRI), and I will demonstrate that this leads to the rapid growth of an initially dynamically weak magnetic field in the disk, the spin-down of the white dwarf merger, and to the subsequent central ignition of the white dwarf merger. Additionally, these magnetized models exhibit new features not present in prior hydrodynamic studies of white dwarf mergers, including the development of MRI turbulence in the hot disk, magnetized outflows carrying a significant fraction of the disk mass, and the magnetization of the white dwarf merger to field strengths ~2 × 10^8 G. I discuss the impact of these findings on the origins, circumstellar media, and observed properties of SNe Ia and magnetized white dwarfs.

Author(s): *Robert Fisher (University of Massachusetts Dartmouth)*, Enríque Garcia-Berro (Universitat Politècnica de Catalunya), Suoqing Ji (University of Massachusetts Dartmouth), Rahul Kashyap (University of Massachusetts Dartmouth), Gabriela Aznar-Siguán (Universitat Politècnica de Catalunya), Petros Tzeferacos (University of Chicago), Dongwook Lee (University of Chicago), Pablo Lorén-Aguilar (University of Exeter)

412.04 – N103B: A Type Ia Supernova with Circumstellar Interaction and Kepler's Older Cousin?

A small but growing subclass of Type Ia supernovae shows signs of interaction with material in a circumstellar medium (CSM). Among Type Ia supernova remnants (SNRs), only the remnant of Kepler's supernova has been shown to be interacting with a dense CSM, likely the result of significant pre-supernova mass loss from the progenitor system. We report here on Spitzer infrared observations of N103B, a Type Ia remnant in the Large Magellanic Cloud approximately 1,000 years old, that also shows signs of a dense CSM. Spectroscopy of the remnant shows a continuum from warm dust heated in the post-shock environment. Model fits to the data give a post-shock gas density of 45 cm^{-3}, virtually identical to what is seen in Kepler. The dust spectrum is dominated by silicate grains, implying an oxygen-rich environment in the stellar atmosphere of at least one star in the progenitor system. In light of the densities we derive from IR fits, we examine X-ray spectra and find that while a significant amount of oxygen is present, the oxygen is consistent with an origin in the CSM, not the ejecta. Detailed morphological comparisons with X-ray images show a connection between dust emission and oxygen-rich material, while optical comparisons clearly show that dust originates in the fast, non-radiative, Balmer-dominated shocks, and not the slower, radiative shocks. We see no obvious evidence for freshly formed ejecta dust. Again, N103B shares all of these characteristics with Kepler. We conclude that N103B is an older analog of Kepler, and thus only the second known member of the subclass of Type Ia SNRs interacting with dense CSM material long after their explosion.

Author(s): ***Brian Williams (NASA Goddard)***, Kazimierz Borkowski (North Carolina State University), Stephen Reynolds (North Carolina State University), Parviz Ghavamian (Towson University), Knox Long (Space Telescope Science Institute), P. Winkler (Middlebury College), John Raymond (Harvard CfA), Ravi Sankrit (SOFIA/USRA), Sean Hendrick (Millersville University), William Blair (Johns Hopkins University)

412.05 – Multi-wavelength analysis of supernova remnant MSH11-61A

Due to its centrally bright X-ray morphology and limb brightened radio profile, supernova remnant (SNR) MSH11-61A (G290.1-0.8) is classified as mixed morphology. The evolutionary sequence which leads to this centrally bright X-ray morphology is not well understood and currently different models can only explain some of the features seen in individual cases. In this analysis we present a study of MSH11-61A using archival Suzaku data. Our preliminary results indicate enhanced abundances, as previously suggested by ASCA observations and we derive the associated age, energy and ambient density of the remnant using models that we constructed in an attempt to reproduce the observed X-ray properties. Additionally, MSH11-61A is thought to be interacting with a molecular cloud towards the west/south west of the remnant. As observations of thermal and non-thermal emission of SNRs have provided increasing support in favour of cosmic rays being accelerated at the shock front of the remnant, SNRs known to be interacting with molecular clouds provide an effective target for detecting and studying gamma-rays. Using 64 months of Fermi-LAT gamma-ray data, we perform a spatial and spectral analysis of the gamma-ray emission in the region of this remnant, allowing us to constrain the origin of the detected emission.

Author(s): ***Katie Auchettl (Monash University)***, Patrick Slane (Harvard Smithsonian Center for Astrophysics), Daniel Castro (Kavli Institute for Astrophysics & Space Research)

412.06 – Non Parametric Determination of Acceleration Characteristics in Supernova Shocks Based on Spectra of Cosmic Rays and Remnant Radiation

We have developed an inversion method for determination of the characteristics of the acceleration mechanism directly and non-parametrically from observations, in contrast to the usual forward fitting of parametric model variables to observations. This is done in the frame work of the so-called leaky box model of acceleration, valid for isotropic momentum distribution and for volume integrated characteristics in a finite acceleration site. We consider both acceleration by shocks and stochastic acceleration where turbulence plays the primary role to determine the acceleration, scattering and escape rates. Assuming a knowledge of the background plasma the model has essentially two unknown parameters, namely the momentum and pitch angle scattering diffusion coefficients, which can be evaluated given two independent spectral observations. These coefficients are obtained directly from the spectrum of radiation from the supernova remnants (SNRs), which gives the spectrum of accelerated particles, and the observed spectrum of cosmic rays (CRs), which are related to the spectrum of particles escaping the SNRs. The results obtained from application of this method will be presented.

Author(s): ***Vahe Petrosian (Stanford Univ.)***, Qingrong Chen (Stanford Univ.)

412.07 – Constraints on the dimensionless age of the Universe from Pan-STARRS supernovae

We present the constraints on the dimensionless age of the universe H_o t_o determined from the latest compilation of Type Ia Supernovae (SN Ia) of the Pan-STARRS1 Medium Deep Survey, combined with low-z supernovae from the CfA, Carnegie, and other sources. The cosmological fit to these SN Ia, assuming a spatially flat universe as suggested by Planck, yields a value of H_o t_o = $1.039^{+0.04}_{-0.05}$. In this talk we briefly discuss the procedure and implications of this result.

Author(s): ***Arturo Avelino (Harvard-Smithsonian Center for Astrophysics)***, Robert Kirshner (Harvard-Smithsonian Center for Astrophysics), Daniel Scolnic (Department of Physics and Astronomy, Johns Hopkins University)

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