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1. INTRODUCTION

Research in astronomy, the space sciences, and related fields at USC is carried through in the Space Sciences Center and Department of Physics and Astronomy. In September 1993 the Department of Astronomy and Department of Physics were combined. The Space Sciences Center is a section of these merged departments. Prior to 1989 the Astronomy Department submitted a separate report to the *BAAS*, but starting this year research from both the Space Sciences Center and Department of Physics & Astronomy in general will be summarized in one report. Due to the hiatus in the reports from the former Astronomy Department, this report will cover the period from September 1989 through August 1996 for the Physics/Astronomy Department but September 1995 through August 1996 for the Space Sciences Center.

2. PERSONNEL

Scientists whose research is reported below include Dr. Darrell L. Judge, Professor and Director of the Space Sciences Center, Dr. Werner Däppen, Professor, Dr. Melvin Daybell, Professor, Dr. C. Y. R. Wu, Research Professor, Drs. Geraldine J. Peters, Howard S. Ogawa, and Pradip Gangopadhyay, Research Scientists, Dr. Klaus Scherer, Visiting Scholar, Dr. Fang-Zhong Chen, Postdoctoral Fellow, Donald McMullin, Project Manager, and Tom Hung, graduate student.

Dr. Don C. Barry retired in December 1995. Drs. Gibson Reaves and John A. Russell continue active as Emeritus Professors.

3. RESEARCH

W. Däppen has been continuing his research on using the Sun as a plasma physics laboratory. To pursue this goal, he participates on the one hand in state-of-the art solar modeling and the analysis of helioseismic data. On the other hand, helioseismology is the first accurate ''experiment'' that puts strong constraints on the thermodynamic quantities of the plasma of stellar interiors. Däppen has ongoing collaborations, supported by his NSF grant, with the leading groups that model the statistical mechanics of reacting Coulomb systems (such as in Livermore, Lyon, Strasbourg, Rostock/Greifswald). His own contribution to the field [the Mihalas-Hummer- Däppen (MHD) equation of state] is currently being used in collaboration with several international solar and stellar modeling groups.

P. Gangopadhyay continues to compare various heliospheric plasma model predictions with the observed *Pioneer 10/11* and *Voyager 1/2* UV data. Some of the new results are discussed in the paper ''Comparison of *Voyager 2* UV Data with Hot Model, Subsonic and Supersonic Heliosphere Model Prediction'' by P. Gangopadhyay, D.L. Judge and P.C. Liewer (draft). In the paper ''Model-Insensitive and Calibration-Independent Method for the Determination of the Downstream Neutral Hydrogen Density through Lyα Glow Observations'' by Gangopadhyay and Judge (ApJ), the shape of the long distance *Pioneer 10* UV data was used to show that the large distance downstream (relative to the incoming interstellar flow) neutral hydrogen density is $< 0.1\ \mathrm{cm}^{-1}$. In another paper ''A Study of the Effect and Consequence of Solar Cycle Variation on Low Energy Galactic Cosmic Rays using *Pioneer 10* Lyα data as a Solar Cycle Proxy'' by K. Scherer, P. Gangopadhyay, D.L. Judge and M. Gruntman (accepted by JGR), a cross-correlation function between the *Pioneer 10* Lyα backscattered radiation, used as a solar cycle proxy, and the cosmic ray fluxes is obtained by a Fast Fourier Transform algorithm. The time lag in the anticorrelation function between the galactic cosmic rays and the Lyα line is used to determine the distance to the solar wind termination shock (75 AU), under the assumption that the cosmic ray modulation boundary for low-energy particles and the termination shock are coincident. The ratio of the upwind termination shock distance to the downwind shock distance is determined to be 2/3 using the *Voyager 1* position in 1996.

As the study of possible variation of solar radius is important both because of its intrinsic astrophysical significance and its possible connection to the Earth's climate, P. Gangopadhyay, H. S. Ogawa, W. Däppen, G. Reaves, D.L. Judge and K. Scherer are designing an exceedingly simple, light weight pinhole camera which will entirely avoid the atmospheric seeing problem and provide high precision measurements. A detailed description will be provided in ''A Pinhole Camera Technique for Measurement of the Solar Radius,'' by P. Gangopadhyay, H. S. Ogawa, W. Dappen, G. Reaves, D. L. Judge and K. Scherer (draft).

H. S. Ogawa, M. Daybell, D. R. McMullin, and D. L. Judge have continued their work on solar EUV irradiance observations from sounding rocket, shuttle, and satellite. Various instruments have been and are being utilized to obtain absolute solar EUV flux data. These include Rare Gas Ionization Cells (RGIC) to obtain absolute integral irradiance in a wavelength region shortward of the ionization limit of the working gas used, Helium Double Ionization Cells (HDIC) to obtain photoionization rates of helium, Free Standing and Film Deposited Photodiodes (FSFDP) to obtain absolute flux within the wavelength band pass of the metal filter used, Optic Free Spectrometer (OFS) to obtain spectral irradiance data in the EUV and soft x-ray wavelength region, and a Solar EUV Monitor (SEM) to obtain absolute solar EUV irradiance. The SEM aboard the Solar Heliospheric Observatory (SOHO) satellite is formally called the Charge Element and Isotope Analysis System (CELIAS/SEM) and was launched on December 2, 1995 and placed in a halo orbit around the sun at L1 (Lagrange point) at a distance of

1.5 million km from the earth along the earth-sun direction. Since December 15, 1995 when the CELIAS/SEM was first turned on to the present, the instrument has been obtaining high quality data that are reliable and indicate that the instrument is stable. The CELIAS/SEM monitors a wavelength band pass of 8 nm centered at the prominent solar 30.4 nm emission line, with another channel that monitors a broad wavelength band pass between 0.1 and 77 nm. The data has been placed on the world wide web (http://www.usc.edu/space_science/sscindex.html) in ten minute averaged intervals. The smallest time resolution is an integration time of 15 sec. On June 26, 1996 a sounding rocket underflight containing an ''identical'' instrument as the CELIAS/SEM was flown as a calibration of the instrument aboard SOHO. The mission was successful and the data shown on the web (revision Oct. 24, 1996) have been modified to reflect this recalibration. The CELIAS/SEM data have been presented at the Spring 1996 American Geophysical Union Meeting held in Baltimore, MD (May 20-24, 1996), and also at the 17th International Workshop (SOLERS 22 Workshop) held at the National Solar Observatory/Sacramento Peak, Sunspot, New Mexico (June 17-21, 1996). A paper entitled ''The First Solar EUV Irradiances obtained by the CELIAS/SEM'' by D. L. Judge et al. 1996 is being prepared and will be submitted to the Solar Physics Journal. In a paper ''Direct Measurements of the Helium Photoionization Rates from Sounding Rockets'' (submitted to JGR) Ogawa, E. Phillips, and Judge give absolute values from data obtained from three sounding rockets flown in 1983, 1989, and 1990 and review photoionization rates obtained over the past three decades.

G. J. Peters continued to study short-term (*daily*) photometric and spectroscopic variability in Be stars. In collaboration with H. F Henrichs (Univ. Amsterdam), D. R. Gies (Georgia State Univ.), E. F. Guinan (Villanova Univ.), D. McDavid (Limber Obs.), and N. Morrison & C. Mulliss (Ritter Obs.), she coordinated a multiwavelength campaign to study the activity in ω Ori. *IUE* observations that began on Feb. 2 and continued for the next 72 hours were supported by ground-based spectroscopy, photometry, and polarimetry. Seventy-three high dispersion SWP images were secured. The star, which has a quasi-period of 8-10 mo., went into outburst *just* prior to the *IUE* run! The EW of the C IV wind line displayed a modulation of about 21% in a period of about 1.20 days (the DACs did not vary!) and the FUV flux level was weakly correlated with this activity. Peters collaborated with D. R. Gies, M. L. Thaller, W. G. Bagnuolo, and L. R. Penny (Georgia State Univ.) on a study of *HST/GHRS* observations of the hot subdwarf in the Be binary system ϕ Per. She also continued to investigate FUV flux variability in Be stars using the *Voyager* UVS database and to serve as editor of the *Be Star Newsletter*, which is published at Georgia State University (D. R. Gies, technical editor) in both paper and electronic (http://chara.gsu.edu/BeNews/intro.html) versions for the IAU Working Group on Active B Stars.

G. J. Peters also continued an investigation of circumstellar material in Algol binary systems. She collaborated with M. Plavec (UCLA), I. Hubeny (USRA), C. D. Keyes (STScI), and S. Shore (Indiana Univ., So. Bend) on a study of accretion in the very active Algol system UX Mon. The data for this study include *IUE* high dispersion SWP images (7 hr. exposures!) at phases 0.16, 0.33, 0.46, & 0.86 (December 1995), *HST/GHRS* observations of the C IV and Si IV lines at ϕ = 0.52, 0.68, & 0.85, and ground-based Hα spectra taken at KPNO & Lick Observatory. Using *HST/FOS* spectropolarimetric date, Peters also participated in a study of the geometry of the circumstellar material in TT Hya and V356 Sgr with R. S. Polidan (NASA/GSFC), D. Lynch (Global Science & Technology), C. D. Keyes (STScI), & K. Nordsieck (Univ. Wisconsin). Work on both projects continues. In November, 1995 Peters presented two talks on Algol binaries at Wittenberg University that were sponsored by the Harlow Shapley Visiting Lectureship Program of the AAS.

G. J. Peters collaborated with J. Grigsby (Wittenberg Univ.) on a study of the abundances of the iron group elements in the early B, ultrasharp-lined abundance standard ι Her. Analyzing coadded, high dispersion *IUE* data with the Kurucz code SYNTHE and adopting a T_{eff}/log g of 17,500/3.75 they found underabundances relative to solar values averaging -0.4 dex in all elements from $22 \leqslant Z \leqslant 28$. Peters also continued a collaboration with S. J. Adelman (The Citadel) and Grigsby to produce high resolution, coadded *IUE* spectra in the region 1150–3100 Å of fundamental OB abundance standards including τ Sco, 10 Lac, HR 1887, ϵ CMa, γ Peg, and τ Her. These spectra are being used in conjunction with new Echelle CCD observations from the KPNO Coudé Feed Telescope and data from the *Voyager* UVS archives for studies of the abundances of both light and iron group elements in early B stars.

Reaves successfully applied his technique of using libration to date a drawing or photograph of the moon to Leonardo da Vinci's drawing in CA 674 verso (1993). From a careful examination of Leonardo's original notebook drawing in Codex Leicester/Hammer 2 recto showing earthshine on the moon, he was unable to identify any surface features that would have enabled him to use his dating method on that famous drawing. For the past few years, Reaves has been collaborating with K. Scherer on problems associated with the origins of the Hirayama families of asteroids. Reaves has discontinued his 40-year study of topics in extragalactic astronomy, especially dwarf galaxies in clusters. (While he no longer publishes in that field, he has not perished!) He has also ended his extensive study of the predictions and discovery of Pluto with the publication of three papers in 1992, 1994, & 1996. As part of the AAS Harlow Shapley Lecture Program, Reaves visited Wofford College in Spartanburg, NC in 1991 and East Kootenay College in Cranbrook, BC, Canada in 1993, and in June 1996 presented a paper at the Historical Astronomy Division meeting of the AAS in San Marino. Reaves continues to serve on the Advisory Board of Lowell Observatory in Flagstaff.

C. Y. Robert Wu has continued his work with F. Z. Chen and D. L. Judge and collaborators to obtain (1) high (383 K), room (295 K) and low (203 K) temperature cross sections of COS in the 1600-2600 Å region, (2) high (370 K), room (295 K) and low (170 K) temperature cross sections of H_2S in the 1600–2600 Å region, and (3) ultrahigh resolution (FWHM = 0.003 Å) high (550 K) and room (295 K) temperature

absorption spectra of N_2 in the 834 Å region. Much of the above data have been analyzed and made available to the planetary community. Our data have been applied in modeling various planetary atmospheres such as Earth, Saturn, Mars, Io, Titan, and Jupiter and in the evaluation and modeling of the effect of the recent Comet SL9 impact on Jupiter's atmosphere.

Wu, F. Z. Chen, Tom Hung, and D. L. Judge have continued their studies of fluorescence produced through photoexcitation of N_2, CO, and CO_2 in the 28-100 eV region. They have observed, for the first time, fluorescence processes correlated with excited electronic states of doubly and triply charged molecules. This observation was possible because the newest, brightest tunable synchrotron radiation source available at the Advanced Light Source, Laboratory Lawrence Berkeley, Berkeley, was employed in the experiment. The N I, N II, O I, and C I fluorescence excitation functions are useful in the modeling of dayglow in atmospheres of Earth, Venus and Mars. They also plan to examine the temperature effects on the absorption, dissociation, and ionization processes as the upper atmospheres of the mentioned planets are higher than the ambient temperature on the Earth's surface.

Wu, Chen, and P. Scoggins have continued their investigation of the solar photon sputtering/desorption of CH_4 clathrate hydrates, H_2O ices, D_2O ices and CH_3OH ices in the inner valence and core electron regions using tunable VUV photon source provided by synchrotron radiation. They have also measured the kinetic energy distributions of H^+ (D^+) desorbed from H_2O (D_2O) ices irradiated by the He II 304 Å line.

PUBLICATIONS

The publication list includes all papers published or submitted by the permanent staff.

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