

## Raytheon ITSS CASP

Lanham, Maryland 20706 <http://www.stx.com>

[S0002-7537(90)04601-7]

The following report covers CASP activities from 1 October 1998 through 30 September 1999.

### 1. INTRODUCTION

#### 1.1 Company Background

Raytheon ITSS was founded in 1973 as Systems and Applied Sciences Corporation, and subsequently changed its name to STX. On October 1, 1991, STX was acquired by Hughes Aircraft Company and became Hughes STX Corporation headquartered in Lanham, Maryland. During 1997, the company was acquired by Raytheon as part of a merger between Hughes and Raytheon, and became Raytheon STX. During this last year, we became fully integrated into the Raytheon corporate structure and renamed Raytheon Information Technology and Scientific Services (RITSS).

Raytheon ITSS is a for profit corporation of more than 2,000 employees who are skilled in a wide range of technical and administrative disciplines, including scientific research, software systems development, systems integration, and local-area network planning. Approximately 80% of our employees hold academic degrees, with 40% of this group at the Masters or Ph.D. level.

RITSS offers on site professional support at locations such as NASA's Goddard Space Flight Center (GSFC), the EROS Data Center, the Naval Research Laboratory, Edwards Air Force Base, the Pentagon, Marshall Space Flight Center, National Weather Service, the National Environmental Satellite and Data Information Service, NASA's Ames Research Center and JPL. During the past year RITSS also won a contract with the National Science Foundation to provide science support for its South Pole Station.

This report focuses on RITSS science and computer support for a number of NASA's scientific programs at NASA's GSFC in Greenbelt, MD.

#### 1.2 CASP

RITSS understands that in order to attract and retain scientists with outstanding credentials, it must support their need to perform *both* project oriented *and* independent research. Consequently, in addition to providing membership dues to professional societies, such as the AAS, for its professional staff it also established the Center for Astronomy and Space Physics (CASP). CASP's charge is to promote and facilitate professional achievement within RITSS, and is one of the RITSS centers of excellence,

<http://www.stx.com/about/centers.html>

CASP is made up of roughly 75 RITSS Astronomers and Space Scientists, primarily on site at GSFC. Its purpose is to provide RITSS scientists with a framework in which to meet and discuss scientific and professional matters, to stimulate cross disciplinary ideas, and to provide an identity and voice

for our employees, in science related matters. CASP is employee organized and supervised and its current chairperson is A. Danks.

CASP has maintained its identity and continues to receive corporate sponsorship throughout the transition from Hughes STX to Raytheon ITSS. CASP organizes monthly talks, produces a newsletter in which RITSS scientists discuss their science and project contributions, maintains a mailing list to inform its members of announcements of opportunity and encourages employees to apply for grants to pursue independent scientific research. CASP uses a small budget provided by RITSS to support company scientists while writing personal science proposals and to fund travel to scientific meetings and to cover publication costs, when no other sources are available. In addition, during this past year, CASP scientists K. Borne and L. Mayo were the first beneficiaries of the RITSS/CASP sabbatical program. Under this program, CASP scientists are awarded 50% support for six months by company funds to pursue their own scientific research.

CASP recently became a corporate affiliate of the Astronomical Society of the Pacific, primarily because RITSS supports the ASP's strong commitment to educational and public outreach. Since joining the ASP, a CASP member, K. Borne, has been nominated to the ASP Publications Committee.

#### 1.3 Personnel

As of October 1999, Raytheon ITSS staff scientists with astronomy, solar physics or space physics related interests include: J. Allen, L. Allen, R. Arendt, E. Bell, D. Berdichevsky, D. Bilitza, J. Blackwell, S. Boardson, K. Borne, L. Breedon, J. Brosius, L. Brown, R. Cebula, S. Chen, N. Collins, J. Cooper, R. Cornett, A. Danks, M. Deland M. Dueterhaus, E. Einfalt, R. Fettig, D. Fixsen, H. Freudenreich, D. Friedlander, M. Greason, J. Hill, R.J. Hill, R.S. Hill, K. Hilldrup, K. Hills, J. Hollis, Z. Huang, P. Jackson, K. Jensen, S. Kashlinsky, P. Keegstra, E. Kemper, C. Klipsch, A. Kutryev, M. Kuznetsova, W. Landsman, P. Lawton, P. Leonard E. Malumuth, D. Massa, L. Mayo, J. Mullins, T. Norton, N. Odegard, S. Odenwald, J. Offenberger, L. Ofman, B. O'Neil, M. Peredo, B. Perry, E. Pier, T. Powers, B. Puc, G. Rohrbach, G. Schneider, R. Schwartz, J. Silvis, K. Smale, A. Szabo, L. Tan, W. Taylor, B. Thomas K. Tolbert, M. Tripicco, N. Tsyganenko P. Tyler, P. Uribe, F. Varosi, W. Waller, W. Warren, J. Weiland, D. Williams.

### 2. SPACE INSTRUMENTATION AND MISSION SUPPORT

Raytheon ITSS scientists and IT professionals provide support for the following projects.

**FUSE:** *FUSE* is a NASA-supported astronomy mission that was launched on June 24, 1999 to explore the Universe using the technique of high-resolution spectroscopy in the far-

ultraviolet spectral region. The Johns Hopkins University has the lead role in developing and now operating the mission, in collaboration with The University of Colorado at Boulder, The University of California at Berkeley, the Canadian Space Agency (CSA) the French Space Agency (CNES), and corporate sponsors. The spectral region opened up by *FUSE* will allow astronomers to measure the cosmic abundance of deuterium (a primary constraint on cosmological models), molecular hydrogen (a fundamental constituent of the interstellar medium) and highly excited gas in the hot stars and galaxies which cannot be examined at other wavelengths.

**GLAST:** The Gamma-ray Large Area Space Telescope (*GLAST*) is a proposed astrophysics mission to study the high-energy gamma-ray sky at energies between 10 MeV and 300 GeV. The primary instrument is a pair-conversion telescope based on solid-state particle-tracking technology. *GLAST* will be 30 times more sensitive than the Energetic Gamma Ray Experiment Telescope (EGRET) on board the Compton Gamma Ray Observatory (CGRO). *GLAST* is a two-year mission (with planning for five years) with an anticipated launch in 2005. Observing targets include 1) active galactic nuclei, 2) gamma-ray burst sources, 3) pulsars, 4) supernova remnants, 5) diffuse emission sources (including interstellar gas in our Galaxy, and the isotropic component which is probably extragalactic), 6) unidentified EGRET sources, and 7) solar flares.

*GLAST* is a collaboration of several institutions. GSFC scientists are deeply involved in the planning of the project and Raytheon ITSS scientists are assisting all levels of the effort including simulations of its astronomical performance.

More information about *GLAST*'s science objectives can be found at

<http://glast.gsfc.nasa.gov/LHEA/>

**HEASARC:** The High Energy Astrophysics Science Archive and Research Center (HEASARC) supports a multi-mission archive facility in high energy astrophysics for scientists all over the world. Data from space-borne instruments on spacecraft, such as *ROSAT*, *ASCA*, *CGRO*, *BBXRT*, *HEAO-1*, *HEAO-2*, *EXOSAT*, and *XTE* are provided, along with a knowledgeable science-user support staff and tools to analyze multiple datasets. For further information, see

<http://heasarc.gsfc.nasa.gov/>

**HESSI:** is the High Energy Solar Spectrometer-Imager (*HESSI*), a Small Explorer, or SmEx mission currently under development for a planned 2000 launch. Using Fourier transform imaging and spectroscopy of solar X- and  $\gamma$ - radiation derived from observations through rotating grids, *HESSI* will provide uniquely high resolution spectral and image data of solar flares and related events. RITSS scientists support includes instrument characterization and testing, data system development, design and integration of the software system (being developed world-wide by the science team), and will include pipeline and analysis software and processing.

More information about *HESSI* is available from

<http://hesperia.gsfc.nasa.gov/hessi/>

**IMAGE:** is a MIDEX mission, scheduled for launch in 2000, to study the global response of the Earth's magnetosphere to changes in the solar wind. *IMAGE* will use neutral atom, ultraviolet, and radio imaging techniques to:

1. Identify the dominant mechanisms for injecting plasma into the magnetosphere on substorm and magnetic storm time scales;

2. Determine the directly driven response of the magnetosphere to solar wind changes; and,

3. Discover how and where magnetospheric plasmas are energized, transported, and subsequently lost during substorms and magnetic storms.

<http://image.gsfc.nasa.gov/>

RITSS scientists are involved with developing tools to reduce and interpret *IMAGE* data. This includes software to simulate the expected observations, models which will be used to interpret the physical processes *IMAGE* will observe and complex algorithms to reduce the raw data into a usable form.

The *IMAGE* Mission Team is also committed to a strong program of Public Outreach, and Education, and Raytheon ITSS scientists are also contributing to this aspect of the mission as well.

**MAP:** The Microwave Anisotropy Probe (*MAP*) is a MIDEX class mission, selected by NASA in 1996, to probe conditions in the early universe. *MAP* is scheduled for launch in 2000 and will measure temperature differences ("anisotropy") in the cosmic microwave background radiation over the entire sky in bands from 22 to 90 GHz. RITSS support has included hardware specification and benchmarking, data system design, development, and integration, and pipeline and analysis software development, and instrument integration and test support.

For further information on *MAP*, see

<http://map.gsfc.nasa.gov/>

**NGST:** *The Next Generation Space Telescope*, *NGST* is a mission currently under study by NASA as a follow on to the *Hubble Space Telescope*, *HST*. It's aims are to further our understanding of how the universe evolved following the Big Bang using capabilities unavailable in either existing ground-based or space telescopes. Simply put, its goal is to observe the first stars and galaxies in the Universe. Launch is scheduled for 2008, and the project is currently in Phase A, or the conceptual development stage. This ends late this year and in 2000 there will be a selection of the instrument teams and the primary contractors who will develop the spacecraft and its instrumentation. Currently, RITSS scientists Danks, Cornett, Offenberg and Fixsen are working with Lockheed Martin and GSFC scientists on several *NGST* studies. These include acting as an interface between Lockheed Martin and GSFC scientists in characterizing the *NGST* Integrated Science Instrument Module (ISIM), and studies of onboard computational capabilities. More information about *NGST* is available from

<http://ngst.gsfc.nasa.gov/>

**SOHO:** The Solar and Heliospheric Observatory (*SOHO*) is one of ESA and NASA's most ambitious projects for the 1990's. Its mission is to understand the interactions between the Sun and the Earth's environment and to address some of the most perplexing riddles about the Sun, including the heating of its corona, the acceleration of its wind, and the physical conditions of the solar interior. It is giving solar physicists their first long term view of the Sun by operating

from a permanent vantage point 1.5 million km ahead of the Earth in a halo orbit around the *LI* Lagrangian point. Further information may be obtained at

<http://sohowwww.nascom.nasa.gov/>

**SSDOO:** The Space Sciences Data Operations Office (SSDOO) is responsible for the project management of selected missions and the development and operations of data and information systems which support processing, management, archiving, and distribution of space physics, astrophysics, and planetary data. The SSDOO includes the Astrophysics Data Facility (ADF) and Space Physics Data Facility (SPDF)

<http://ssdoo.gsfc.nasa.gov/c630/>

The ADF is responsible for the processing and distribution of proprietary data from missions such as *ROSAT*, *ASCA*, and *XTE*. The staff is now in the process of developing similar capabilities for the new *ASTRO-E* X-ray mission.

During this last year, the ADF has begun to turn over its multi-mission and multi-spectral data archives to the new MAST facility at STScI. This includes its extensive browse facilities for UV missions, which can still be accessed at

<http://adf.gsfc.nasa.gov/uv/>

The ADF group includes the Astronomical Data Center (ADC) which acquires, verifies, formats, and distributes astronomical catalog data in computer-readable form. The ADC's archives contain more than 2500 catalogs and journal tables of astrometric, photometric, morphological, spectroscopic, polarization, kinematic, and multi-wavelength data for stellar and non-stellar objects. The ADC group also develops and maintains software tools to access these data. The ADC is part of an international federation of astronomical data centers. The capabilities of the ADF and ADC allow researchers to identify scientifically interesting objects and correlations, to carry out archival data-mining searches, to locate existing archival data on user-selected objects, and to prepare observing lists for further observational studies. The ADF and ADC can be accessed via

<http://adf.gsfc.nasa.gov/adf/> <http://adc.gsfc.nasa.gov/>

During this last year, the ADC staff have begun development of XML tools to enhance connectivity among the ADC tables and metadata. This is part of a NASA funded program to incorporate XML's display language and protocols to display astronomical table data and metadata, and to allow enhanced forms of metadata visualization. They also intend to create XML tools that will allow scientists to convert their data and metadata into XML and create conversion software to ingest journal tables into the ADC XML archive. Together, these tools will provide quicker and more comprehensive access to the wealth of data stored in the ADC data base. More information about this program is available from links on the ADC homepage.

The ADF has also developed extensive educational and outreach resources for cosmology based on the *COBE* results. These are now available at:

[http://www.gsfc.nasa.gov/astro/cobe/ed\\_resources.html](http://www.gsfc.nasa.gov/astro/cobe/ed_resources.html)

The ADF also maintains access to legacy data and software tools from the *COBE* mission:

<http://www.gsfc.nasa.gov/astro/cobe/cgis.html>

The ADC has recently developed several new data visualization tools which can be accessed via

<http://adf.gsfc.nasa.gov/adf/visualization/>

These include AMASE, which is an object-oriented multi-spectral astrophysics database search engine that is being prototyped at the ADF. AMASE can be accessed through the ADC home page.

The SPDF also part of the SSDOO and is responsible for the development of a variety of space physics mission planning tools and facilitating correlative data analysis for the International Solar Terrestrial Physics (ISTP) program. For additional information, see

<http://nssdc.gsfc.nasa.gov/spdf/spdf.html>

**STIS:** The Space Telescope Imaging Spectrograph (STIS), is one of the second-generation instruments for the Hubble Space Telescope (*HST*). It was successfully installed on *HST* during the second servicing mission in 1997 February and is now providing a unique combination of spectrographic and imaging capabilities in the UV and visible. In addition to general science support, A. Danks (Raytheon ITSS) is a Co-Investigator on the STIS science team.

With the STIS now fully functional, RITSS support for STIS is peaking. RITSS astronomers: R.S. Hill, N.R. Collins, R.H. Cornett, R.J. Hill, W.B. Landsman and E.M. Malumuth are contributing to the scientific calibration and to the analysis and interpretation of the observations. Contributions by several RITSS STIS team members will be found throughout this report. Further information about STIS can be found at:

<http://hires.gsfc.nasa.gov/>

### 3. RESEARCH

Many of the RITSS scientists perform research as part of their programmatic duties. In addition, RITSS scientists are Principal or Co-investigators on more than 50 individual scientific research grants. This section reviews the research performed by RITSS scientists under both of these activities.

#### 3.1 Instrumentation and Data Processing

K. Borne (RITSS) and colleagues at the NASA ADC (R. White, C. Cheung, D. Leisawitz (NASA), and E. Shaya (RITSS)) have conducted an archival survey of on-line data and catalogued objects around the HDF-S (Hubble Deep Field - South) position. They have identified many astrophysically interesting objects in the vicinity of the HDF-S, including quasars and clusters of galaxies, which have been catalogued and observed at a wide range of wavelengths. The byproducts of this and similar user-selected surveys can be used to study classes of objects that may potentially be represented among the faint objects discovered within the HDF-S. This survey was conducted using a suite of new data search, browse, and visualization tools available at the NASA ADC (<http://adc.gsfc.nasa.gov/>).

J. Offenberg and D. Fixsen (RITSS) along with R. Sengupta, M.A. Nieto-Santisteban (STScI), H.S. Stockman and R.J. Hanisch (STScI) have been studying methods to handle, process and enhance the unprecedented data volumes of data expected to be collected by *NGST*. Since *NGST* will perform wide-field imaging in the high-radiation environment of deep space, cosmic rays will produce many charged-particle events on the imaging detector. Furthermore, it will accumu-

late an immense volume of data which will have to be transmitted from an orbit which is very distant from Earth. These factors make it imperative to develop novel methods to automatically reject cosmic ray events, perform on-board data compression and to process the data products once they are received on the ground.

D. Fixsen and R. Arendt (RITSS) have continued their work with H. Moseley (NASA's GSFC) to develop a self-calibration algorithm for the Infrared Array Camera (IRAC) imaging array to fly on Space Infrared Telescope Facility, *SIRTF*. Their studies of dithering strategies have led to the adoption of efficient dither patterns for use with IRAC. They have applied the current code to the *HST* NICMOS observations of the Hubble Deep Field - South with encouraging results.

A. Kutyrev (RITSS) collaborated with H. Moseley (GSFC) and Fetting (RITSS) on the technology study of a two-dimensional array of microshutters for *NGST*. The goal is to create a high efficiency, high contrast field selection device for a multi-object spectrometer. The device is a close packed array of shutters, with a typical size of  $100 \mu\text{m}^2$  and an area filling factor of up to 80% with each of the shutters individually selectable. An original double-shutter actuation mechanism is currently under study. Small size arrays have been built and tested under an electron microscope. First results of the project have been presented at a number of meetings and published (Fetting *et al.*, 1999, Moseley *et al.* 1999a,b).

A. Kutyrev (RITSS) in collaboration with K. Stewart (GSFC) has been studying the optical performance of selected optical materials at cryogenic temperatures. Results of these measurements will be used for selection of material for cryogenic temperature tunable solid IR Fabry-Perot etalon. Preliminary FTIR spectrometer measurements demonstrated that some materials have high enough refractive coefficient to allow required spectral tuning with reasonably small temperature change. First etalons are in the process of polishing and coating and will be tested for optical performance soon. These etalons when built will allow high efficiency and high spectral resolving power spectroscopy of the emission diffuse objects in the infrared.

A. Kutyrev (RITSS) continued work on the development of Infrared Spatial Heterodyne Spectrometer for high resolution infrared spectroscopy with E. Smith (GSFC) and F. Roesler (U. of Wisc-Madison). Prototype instrument has been built and tested. Further development and adaptation of this device to cryogenic temperature environment is currently in process.

D. Massa (RITSS) and E.F. Fitzpatrick (Villanova) showed that low dispersion *IUE* NEWSIPS data contain serious systematic effects, including 10-15% residual temporal and THDA dependencies. In addition, they showed that the NEWSIPS flux calibration is inconsistent by nearly 10%. They have formulated and applied algorithms to correct the systematics to the 3% level – a factor of 5 improvement. In addition, they have derived a transformation between the corrected *IUE* data and the *HST* FOS system – placing the data from both telescopes onto a single system (Massa & Fitzpatrick 1999).

W. Warren (RITSS), in collaboration with C.B. Sande, A.C. Miller, J.R. Myers, A.T. Home (CSC), and D.A. Tracewell (GSFC), completed Version 2 of the SKY2000 Master Star Catalog, the source catalog for NASA satellite acquisition and attitude determination. The new catalog contains highly accurate astrometric data almost exclusively from the *Hipparcos* and Tycho output catalogs. Observed CCD magnitudes from the star trackers aboard the *RXTE* spacecraft have also been added. Working with D.W. Dunham, Warren is also preparing a new set of asteroid and lunar occultation prediction catalogs based on *Hipparcos* and other modern sources of high accuracy astrometric data.

### 3.2 Space Physics

D. Berdichevsky (RITSS), A. Szabo, R.P. Viñas and F. Mariani, investigated the interplanetary fast shocks and associated drivers observed through the 23-rd solar minimum by *WIND* over its first 2.5 years. This work presents to researchers in the field a useful table of the fast forward and reverse interplanetary shocks observed at 1 AU by *WIND* from November 1994 to June 1997, and the accurate determination of their thermodynamic Rankine-Hugoniot parameters. The work further organizes the observed shocks by their drivers. The statistical analysis of the orientations of the shock normals suggests that interplanetary shocks would in general have an orientation of propagation in longitude from almost nearly eastward to close to normal to a tightly winding Parker spiral. The winding angle of this Parker spiral would be of approximately  $36^\circ$ , close in value at 1 AU to the one derived in the theoretical model by Acuña and Whang of the propagation of the solar wind.

D. Berdichevsky (RITSS), I.G. Richardson (Univ. Maryland), B.J. Thompson, D.V. Reames, R. MacDowall, M.L. Kaiser, R.P. Lepping, K.W. Ogilvie, and R.G. Stone (all NASA/GSFC), and S.P. Plunkett, D.J. Michels (both NRL) presented past and current examples of fast solar wind transients, their sources and the forecast of possible geomagnetic activity at the fifth Latin-American conference of Geophysics in Costa Rica. They presented examples of transients at the Sun tracked to the Earth and explored similarities between these solar ejecta, including possible interplanetary magnetic clouds observed in 1982 during the decreasing part of the 21 solar cycle and in 1998 during the rising phase of the 23 solar cycle. The space-weather significance of the observations and the possibility to forecast these most disruptive occurrences of the geomagnetic environment were discussed.

D. Bilitza (RITSS) continued his work in ionospheric modelling. He is developing a new model for the topside electron density based on data from the Alouette and ISIS topside sounders in the framework of a NSF-funded Space Weather project (Bilitza and Williamson, 1999). This data base is being increased considerably through a data restoration effort funded by NASA's Applied Information Systems Research Program (AISRP). The project is using automated scaling and inversion software to obtain the topside electron density profiles from more than 200,000 digitized ISIS-2 ionograms.

As chair of the IRI Working Group of URSI and COSPAR, D. Bilitza organized the 1999 IRI Workshop at the Univ. of Mass. in Lowell. The special focus of the meeting was ionospheric variability and ray tracing through the ionosphere and the development of IRI-2000. Together with S. Radicella (Italy), D. Bilitza organized and chaired the annual IRI Task Force Activity at the International Center for Theoretical Physics (ICTP) in Trieste, Italy. This activity resulted in several important improvements of the IRI bottomside electron density profile especially at low and equatorial latitudes (Bilitza *et al.*, 1999a). All of these improvements will be included in IRI-2000. In collaboration with Spanish colleagues, D. Bilitza is exploring the possibilities of updating the IRI model with GPS measurements (Bilitza *et al.*, 1999b).

D. Bilitza (RITSS) participated as ionospheric expert and COSPAR liaison in several meetings of the International Standardization Organization (ISO) Working Group on Earth Environment Models. IRI and other COSPAR models are being proposed as ISO standard. Bilitza reviewed science tools on the internet for IAGA 97 (Bilitza, 1999) and in a special session that he convened during the URSI General Assembly in Toronto, Canada.

M. Kuznetsova (RITSS) continued her collaboration with M. Hesse (GSFC) and D. Winske (LANL). Their recent research was devoted to the development of transport model of collisionless magnetic reconnection and kinetic modeling of the reconnection-related changes in Earth's magnetosphere. They developed a model of the essential electron kinetic effects in terms of the evolution of the full electron pressure tensor. They found a simple way to represent electron and ion non-gyrotropic effects and some Hall effects essential for the reconnection rate in MHD models.

A statistical study was made of the near-earth equatorial magnetic field depression, based on a set of data from 20 months of *POLAR* magnetometer experiment in 1996-1998, supported by simultaneous solar wind data by *WIND* and *IMP-8* spacecraft. The work addressed the spatial distribution of the geomagnetic field near the dipole equator at radial distances between 2.0 and 4.5  $R_{\oplus}$ , and its dependence on the Dst index, solar wind pressure, and the interplanetary magnetic field. The inner field was found to have a significant noon-midnight and dawn-dusk asymmetry, depending on Dst and the solar wind pressure.

In collaboration with C.T. Russell (IGPP, UCLA), a study was performed of the magnetic field depression associated with the dayside magnetospheric polar cusps. In the noon sector, the cusp depression was found from the data of *POLAR* spacecraft in a relatively narrow latitudinal interval, but extending over a wide range of the geocentric distance. At closer distances the cusp depression was found to fade out due to a rapid increase of the geomagnetic field towards Earth. A mathematical method was developed for representing of the observed polar cusp depression in the geomagnetic field models. A new model of the magnetopause was devised, taking into account the effects of the dipole tilt angle upon its global shape and the observed deformation of the magnetospheric boundary in the vicinity of the polar cusps.

In collaboration with G. Lu (NCAR), first attempt was

made to quantitatively represent the dynamics of the magnetospheric magnetic field during the substorm expansion phase, using the data of simultaneous observations by *GEO-TAIL* and *GOES* spacecraft and a global model of the field, including the contribution from the electric current wedge on the night side.

A statistical study was performed of the response of the magnetotail magnetic field to the conditions in the solar wind, based on data of *ISEE-2*, *AMPTE/IRM*, and *GEOTAIL* spacecraft.

M. Reiner (RITSS) collaborated with M.L. Kaiser, J. Fainberg, and R.G. Stone (GSFC), used these techniques to demonstrate that low-frequency solar type II radio emissions are generated in the upstream region of an interplanetary shock and that the radio emissions originate from various locations along the shock front. These techniques have so far revealed no evidence for deceleration of CMEs propagating through the interplanetary medium.

Working in collaboration with scientists at Berkeley (S.D. Bale, S. Krucker, D.E. Larson, and R.P. Lin), at GSFC (M.L. Kaiser) and at the Paris Observatory (J.-L. Bougeret), M. Reiner (RITSS) made the first *in situ* detection of the type II radio source in the upstream region of an interplanetary shock.

M. Reiner (RITSS) and M. Kaiser (GSFC) analyzed a number of events where the type II radio emissions in the frequency range from 1-14 MHz were temporally well separated from the metric type II radio emissions observed by ground-based radio observatories. These results suggest that two distinct coronal shocks are involved in the generation of the solar type II radio emissions.

Reiner discovered a unique coronal and interplanetary type II radio event that tracked very well an observed *SOHO/LASCO* CME. Working with S. Plunkett (NRL) and N. Prestage (Culgoora Obs., Australia), Reiner and M. Kaiser (GSFC) were able to use this radio event to demonstrate conclusively that both blast-wave flare-associated and CME-driven shocks occur simultaneously in the solar corona.

### 3.3 Solar Physics

J. Brosius (RITSS) used spectra from GSFC's Solar EUV Research Telescope and Spectrograph (SERTS) to measure relative wavelength shifts of coronal emission lines as functions of position in solar active regions (Brosius, Thomas, & Davila 1999; Brosius, Thomas, Davila, & Thompson 2000). Although most of the coronal EUV lines observed from the active regions were predominantly redshifted (relative to the regions' quiet surroundings), some of the lines exhibited significant blueshifts as well.

As part of a *SOHO* Guest Investigator program, Brosius and collaborators obtained coordinated *SOHO*, *Yohkoh*, *TRACE*, and VLA observations of solar active regions and sunspots on four dates in April and May 1999. These observations were designed to provide the data needed to perform solar active region coronal magnetography. Brosius also provided support for the 1999 June 24 SERTS flight, which was coordinated with *SOHO/CDS* and *SOHO/EIT* for cross-calibration.

Brosius proceeded with the analysis of *SOHO*/CDS and coordinated SERTS data from the 1997 November 18 rocket flight. The EUV spectral data will be used to obtain the two-dimensional differential emission measure distribution and plasma densities. When combined with the VLA observations at four different microwave frequencies, these data will be used to derive solar active region coronal magnetograms.

Brosius collaborated with J. Schmelz (U. Memphis), J. Saba, K. Strong (Lockheed-Martin), and T. Winter (U. Memphis) in an analysis of the emission measure distribution for a solar active region using coordinated SERTS and *Yohkoh*/SXT observations. This analysis reveals that the SXT response functions are sensitive to the assumed elemental abundances and ionization fractions, and indicates that using broadband SXT data (or comparable high-temperature constraints) in conjunction with high-resolution spectra covering a wide lower-temperature range significantly improves the information derived from either data *set al.*one (Schmelz *et al.* 1999).

Brosius, Davila, & Thomas (1998) completed the absolute radiometric calibration for the SERTS-95 active region and quiet-sun spectral line catalogs. Andretta, Jordan, Brosius, *et al.* (2000) used SERTS He II 304 Å spectral line data to present observational evidence for the effect of small scale microturbulent velocities in enhancing the intensity of the He II 304 Å line with respect to other transition region emission lines.

R. Cebula and M. DeLand (RITSS) continued their studies of solar UV irradiance variability. Recent efforts have focused on the *Nimbus-7* SBUV spectral irradiance data set, which covers the period from November 1978 to October 1986. The current archived data set has significant instrument drift problems which preclude its use for estimation of solar cycle variations. An improved instrument characterization was derived and implemented. These reprocessed *Nimbus-7* SBUV data indicate that 2050 Å solar irradiance, which is important for stratospheric photochemistry, varied by approximately 8% during solar cycle 21. This result is in good agreement with overlapping data from the SME instrument, and with predictions from the Mg II index proxy model. Cebula and E. Hilsenrath (GSFC) continue to work with national and international colleagues in an intercomparison of absolute solar spectral irradiance measurements for selected dates during solar cycle 22.

L. Ofman (RITSS) collaborated with V. Nakariakov (St. Andrews U.) and C.E. Deforest (Stanford) on the study of slow magnetosonic waves in plumes detected by the *SOHO* Extreme ultraviolet Imaging Telescope (EIT). They identified the observed propagating disturbances as slow magnetosonic waves by using numerical 1-D and 2-D model of waves in coronal plumes. They showed that the outward propagating slow magnetosonic waves are trapped and nonlinearly steepen in the polar plumes. The nonlinear steepening of the magnetosonic waves may contribute significantly to the heating of the lower corona by compressive dissipation (Ofman, Nakariakov, and Deforest 1999).

Ofman collaborated with V. Nakariakov (St. Andrews U.), E. DeLuca (CfA), B. Roberts (St. Andrews U.), and J. Davila (GSFC) on the analysis of *TRACE* spacecraft. Their recent

results indicate that the viscosity in the corona is significantly larger than previously thought (Nakariakov *et al.* 1999). The high viscosity may help explain why the solar corona is so much hotter than the photosphere. Waves and disturbances in the corona dissipate into heat more rapidly and effectively than previously believed.

Ofman collaborated with V. Nakariakov and T. Arber (St. Andrews U.) on the study of nonlinear dissipation of Alfvén waves in solar coronal holes. They found that the waves can be described by a spherical scalar Cohen-Kulsrud-Burgers equation. Solutions of the equation show that the dissipation is dramatically enhanced by nonlinear effects (Nakariakov, Ofman, and Arber, 1999).

Ofman collaborated with V. Nakariakov, and N. Sehgal (NASA/CUA) on the theoretical study of the dissipation of slow magnetosonic waves in plumes. The results of their study show that slow waves may dissipate very effectively by compressive viscosity, and may contribute significantly to the heating of coronal holes (Ofman, Nakariakov, Sehgal 1999).

Ofman collaborated with Romoli, M., Noci G. (U. of Florence), G. Poletto (Arcetri Obs., Italy) on the study of signatures of compressional waves in the solar coronal holes. They found considerable evidence of the presence of these waves in the solar corona high above the limb (about one solar radius) using the White Light Channel (WLC) of the Ultraviolet Coronagraph Spectrometer (UVCS) on *SOHO* (Ofman *et al.* 2000).

Ofman and J. Davila (GSFC) continued their collaboration on the study of the fast solar wind. They investigated the effective proton temperature using 2.5-D two-fluid MHD model of the coronal hole plasma. They found that the effective proton temperature dependence on heliocentric distance agrees with the *SOHO* UVCS observations of Ly- $\alpha$  line width broadening with the heliocentric distance. This result supports the Alfvén waves solar wind acceleration model (Ofman & Davila, 1999; Davila & Ofman 1999).

Ofman collaborated with M. Ruderman (St. Andrews U.), M. Goldstein, D. Roberts (GSFC), and A. Deane (UMD) on the study of Alfvén wave phase mixing driven by velocity shear in two-dimensional open magnetic configurations (Ruderman *et al.* 1999). This process may be responsible for the heating of open magnetic structures in the solar corona. They found that nonlinear and geometric effects are important in determining the saturation level of the phase mixing process.

M. Reiner (RITSS) has developed new methods of analysis for solar (type II) radio emissions that inherently reveals the underlying dynamics of the coronal mass ejection (CME), which generates the radio emissions. These techniques have been used to track CMEs through the solar corona and interplanetary space and have led to new insights into the relationship between coronal and interplanetary shocks and their associated solar radio emissions observed by the *WIND* spacecraft.

The morphology of complex solar type III-like bursts, observed for the first time by the high-frequency receivers on the *Wind* spacecraft, was described by M. Reiner (RITSS) and M. Kaiser (GSFC). Their relationship to previously observed kilometric shock associated (SA) events was also ex-

pored. These bursts were previously thought to originate from electrons accelerated at interplanetary shocks. In order to establish the true origin of these complex radio bursts, Reiner working with M. Karlicky and K. Jiricka (Ondrejov Obs., Czech Republic), H. Aurass and G. Mann (Potsdam) and M. Kaiser (GSFC) compared a number of WAVES radio events to simultaneously observed decimeter and metric radio emissions. The results of these analyses have reveal that, contrary to popular conception, these complex radio events must originate from electrons accelerated at the flare site.

### 3.4 Planetary Physics

L. Mayo was the second recipient of a Sabbatical Research Leave award from the Center for Astronomy and Space Physice (CASP) at Raytheon ITSS. He spent his 6 month sabbatical leave at GSFC, Laboratory for Extraterrestrial Physics. During this time, Mayo investigated the thermal infrared properties of Titan's north polar hood aerosol haze and stratospheric condensate cloud which is inferred to exist from analysis of *Voyager* IRIS datasets. The research involved enhancement of a radiative transfer modeling program developed by Mayo which incorporates a curved atmosphere, absorption, emission, and scattering properties, collisionally induced absorption, and a spatially convolved instrument field-of-view. He used this software for intensive modeling of particulate opacity sources in Titan's lower stratosphere as well as collisionally induced absorption in the troposphere. The results of this study (as presented at the 1999 DPS conference in Padua, Italy) indicate: A derived particle size for the stratospheric condensate of between 2 and 5  $\mu\text{m}$ , a condensate material probably not ethane, and a mole fraction for the stratospheric condensate between  $5 \times 10^{-7}$  and  $5 \times 10^{-8}$ . They also indicate a lower stratosphere which is depleted of aerosol particulates and a Tropospheric methane degree of supersaturation around unity. One explanation for these results would be a build up of stratospheric hydrocarbon or nitrile condensates due to the lower polar temperatures, the winter season, and protection of volatiles from photodissociation by Titan's polar shadow. This build up would quickly precipitate out leaving a "clean" stratosphere below the point of condensation. The precipitating particles would also act as seed nuclei for tropospheric methane resulting in the lower retrieved supersaturation value as compared with lower latitudes.

Inspired by recent results obtained by *Galileo* which showed long-term periodicities in the Jovian radio emissions, M. Reiner (RITSS) and M. Kaiser (GSFC) have analyzed the long-term behavior of Jovian bKOM and nKOM emissions observed during the *Ulysses*-Jupiter encounter in the latter part of 1991 and early 1992. It was found that at the time of the *Ulysses*-Jupiter encounter the solar wind had a simple two-sector structure and that the long-term behaviors of the Jovian nKOM and bKOM radio emissions were clearly directly correlated to the interplanetary sector structure.

### 3.5 Stars and Stellar Clusters

Brosius (RITSS) & Woodgate (GSFC) calculated the theoretical time dependence of the nonthermal redshifted Ly-

$\alpha$  radiation from a proton beam injected into a model stellar atmosphere. The nonthermal redshifted Ly- $\alpha$  radiation varies with time because the beam ionizes and heats the atmosphere. Measurements of temporal variations of this radiation in actual solar or stellar flare spectra could be used to deduce properties of injected proton beams.

W. Landsman (RITSS) continued his study of hot stars in globular clusters. With F. Grundahl (DAO) and M. Catelan (GSFC), he investigated the "jump" observed in Strömgen  $u$  magnitudes at around 11,500 K in the horizontal branches of many globular clusters. They deduced that the most likely cause of the jump was the sudden onset of supersolar photospheric iron abundances at this temperature, due to radiative levitation. Together with S. Moehler and U. Heber (Bamberg), Landsman was able to directly observe the transition to supersolar iron abundances in NGC 6752 (Moehler *et al.* 1999). The presence of radiative levitation must be taken into account in the determination of the fundamental properties of horizontal branch stars, including their luminosities, gravities, and masses (Landsman 1999). Landsman also assisted M. Chavez (INOAE) and J. Holberg (LPL) in summarizing the *Voyager* detections of globular clusters below 1200 Å (Chavez *et al.* 1999).

P. Leonard (RITSS) contributed an article to the *Encyclopedia of Astronomy and Astrophysics* on "Multiple Stellar Systems: Types and Stability."

D. Massa (RITSS) continued his collaboration with N. Evans (CfA) on Cepheid research. During this last year, they used the FOC on *HST* and a novel observing approach to determine the angular separation of the binary 6.4 day classical Cepheid AW Per. Since the star is also a spectroscopic binary with a period of 40 years, this measurement opens the possibility of determining the inclination of the system if the measurements are repeated at additional epochs and this would provide the distance to the system and the masses of the components from fundamental measurements. He also collaborated with Evans and several other investigators to obtain new orbital velocities of the hot component of the long-period Cepheid binary T Mon using *HST* and *IUE*. Although the observations do not cover a full orbit, both the maximum and minimum orbital velocities have now been obtained and a preliminary orbit calculated. The velocities for the companion appear to be inconsistent with binary orbital motion, and it is likely that the companion is itself a binary in a short-period orbit.

Massa and E. Fitzpartick (Villanova) continued their collaboration on hot star research. They have begun a program to : 1) to test quantitatively the level of agreement between model atmosphere and observed UV/optical energy distributions of main sequence B stars; and 2) to determine how precisely and accurately the stellar properties (temperature, gravity, metallicity, and microturbulence velocity) can be determined from analyses of the stellar continua. They have demonstrated that the models can reproduce the observed continua of unreddened main sequence B stars to a level consistent with the uncertainties in currently available spectrophotometric data. This success is due to a number of factors, including 1) the quality of the new models; 2) the excellent absolute UV/Optical flux calibration of the FOS; 3)

the expansion of the original model grid to a wide range of parameters; and 4) the use of non-linear fitting techniques to optimize all of the model parameters simultaneously. They also showed that both the model atmosphere parameters *and* the shape of the UV/optical interstellar extinction curve can be extracted from the analysis of reddened stars. This is possible because the spectral “signature” of interstellar extinction is very different from those of temperature, surface gravity, metallicity, and microturbulence.

Massa also collaborated with Grady (AURA) in the analysis of the Herbig Ae star, AB Aur. Recent millimeter interferometry of the star indicate that it is viewed slightly above the disk midplane ( $i = 76^\circ$ ). The wealth of archival spectroscopic data for this star makes it an ideal test of the geometry for infalling or accreting gas in these stars. They review the extant *IUE* and *HST* GHRS spectral data for AB Aur and find, in contrast to previous studies of this star, which focused on Mg II, that infalling gas is detected at all epochs with covering factors similar to those reported for HD 100546 and that an episode of enhanced infall was serendipitously detected during a 1990 *IUE* monitoring run.

In collaboration with R. Prinja and others at UCL, Massa presented the results of a 28-day *IUE* time-series campaign monitoring the stellar wind of the normal O5 giant HD 93843. The principal aim was to study wind variability in a star with a normal projected rotation velocity. Systematic changes were identified, amidst continuous line-profile variability, in the absorption troughs of the Si IV and N V resonance lines. The patterns observed have characteristic time-scales of several days and are mimicked by fluctuations (of several  $100 \text{ km s}^{-1}$ ) in the blue wings of the saturated C IV P Cygni profile. Fourier analysis provides support for the repeatability of wind structures in HD 93843 on a 7.1-d ‘period’. The long modulation time-scale suggests that changes in the star itself probably trigger the wind structure. The study demonstrates that the incidence of cyclic, possibly regular, stellar-wind variability is not restricted to rapid rotators, and that its period increases with decreasing rotational velocity, suggesting surface features of some sort drive the variability.

### 3.6 Nebulae, Interstellar Medium and Galactic Structure

R. Cornett (RITSS) began work on a publication presenting and analyzing results of UIT, ground-based, and X-ray images of the Cygnus Loop supernova remnant, in collaboration with JHU personnel C. Danforth, B. Blair, N. Levenson and UIT PI T. Stecher (GSFC).

A. Danks has continued to study the ISM in the Vela region, using the Coudé Auxiliary Telescope at ESO with the Coudé echelle spectrograph, and recently the data from Na I and Ca II lines was used to determine a new distance to the Vela SNR (Cha *et al.* 1999). Danks has also been studying STIS observations of the star CPD -59° 2603 in the Craina nebula in collaboration with N. Walborn (STScI), and they are currently analyzing echelle spectra for 4 stars in the  $\eta$  Carina region, measuring different components in the interstellar line profiles and deriving their abundances and details of their velocity fields. In CPD -59° 2603, dramatic variations are observed in the high velocity components. Compo-

nents  $\sim 300 \text{ km s}^{-1}$  are seen on a time scale of 22 months. These measurements are being used to arrive at estimates of the homogeneity of the medium cloud sizes and details on the gas behavior at high shock speeds. Similar data is being obtained for two stars in the Vela nebula which will be used for comparison. Ground based observation of the Carina region have been obtained with the telescope “El Leonsito” in Argentina in collaboration with B. Garcia, and the Ca II and Na I lines have been introduced into a “kriging” model, adapted from geodesic applications to arrive at plausible 3 dimensional model of the gaseous regions.

With M. Sahu (NOAO/GSFC) and others, Landsman (RITSS) investigated the interstellar deuterium abundance toward white dwarf G191-B2B using both new STIS observations and archival GHRS spectra (Sahu *et al.* 1999). Their analysis of the GHRS data showed different D/H abundance values in the two interstellar components, in agreement with the previous study of Vidal-Madjar *et al.* (1998, A&A, 338, 694). However, this result was not confirmed by their analysis of the STIS data. The origin of the discrepancy between the STIS data and the GHRS data is likely due to the better correction for echelle scattered light available for STIS.

### 3.7 Galaxies and Extragalactic Astronomy

K. Borne (RITSS) was the first recipient of a Sabbatical Research Leave award from CASP at Raytheon ITSS. He spent his 6-month Sabbatical Leave at the STScI in Baltimore and worked on several research projects during that period, a subset of which are described below.

Borne and his colleagues H. Bushouse (STScI), L. Colina (CSIC-UC, Spain), R. Lucas (STScI), A. Baker (Cardiff), D. Clements (Cardiff), A. Lawrence (Edinburgh), S. Oliver (Imperial College), and M. Rowan-Robinson (Imperial College) continued their intensive *HST* imaging study of a nearly complete sample of ultraluminous IR galaxies (ULIRGs), the most luminous galaxies in the universe. Several papers are now in press, under peer review, or in final preparation. They published a morphological classification scheme for ULIRGs. The classes include: strongly disturbed single galaxy, dominant AGN/QSO nucleus, strongly interacting multiple-galaxy system, and weakly interacting compact groupings of galaxies. They find that there is equal likelihood for a ULIRG to be in a single system (first two classes) as in a multiple system (last two classes). They also find that the classes have essentially the same mean IRAS 60- $\mu\text{m}$  luminosity.

Borne, Colina, Bushouse, and Lucas have used *HST* images to study Mrk 273X, the serendipitous X-ray companion to the ULIRG Mrk 273. This companion is not associated with the nearby Mrk 273; it is at redshift  $z = 0.46$ . They find that Mrk 273X is a relatively featureless elliptical-like galaxy in a moderately rich environment and appears to be the brightest member of a poor cluster. Its emission-line properties are AGN-like, but are atypical: it is most similar to the IC 5063 class of active galaxies – a hybrid Seyfert 2 and powerful radio galaxy.

Borne, Colina, Bushouse, and Lucas have studied *HST* images of the ULIRG IRAS 10026+4347. They have measured the photometric properties of the galaxy and its environment. IRAS 10026+4347 is an IR ultraluminous Fe II

emitting QSO. They have modeled the QSO with an *HST* PSF, subtracted the model PSF, and have measured the properties of the underlying host galaxy. They find the host to be an  $0.5-L^*$  galaxy with an exponential disk-like surface brightness profile, with a very low surface brightness tidal tail, and with a pair of very faint nearby disrupted companions. The surrounding field has a higher than average galaxy density. IRAS 10026+4347 may thus be the remnant of a merger within a small group. An unusual arc-like object is seen in the same *HST* field. Additional observations of this object could prove interesting.

Borne, Bushouse, Lucas, and Colina have analyzed a sample of 99 ULIRGs in the redshift range  $z=0.05-0.20$  with *HST* images. They find that a significant fraction of them (at least 30%) show signs of multiple ( $> 1$ ) mergers. These signs include (1) those with multiple nuclei, sometimes accompanied by a complex system of tidal tails; and (2) those that are in fact dense groupings of interacting (soon-to-merge) galaxies. Using space-density and other arguments, they hypothesize that the most likely progenitors for these (and maybe all) ULIRGs are the evolved descendants of compact groups of galaxies (similar to the Hickson compact groups).

Borne, Colina, and Arribas (IAC, Spain) obtained multi-fiber spectroscopic observations for several of the brightest ULIRGs using the new multi-fiber system at the William Herschel Telescope. They have completed a study of the emission-line gas in the bright ULIRG Mrk 273. The results show: (1) the presence of highly disturbed gas in the regions around the LINER nucleus, (2) a high velocity gas flow with a peak-to-peak amplitude in excess of  $2000 \text{ km s}^{-1}$ , and (3) quiescent gas in the outer (3 kpc) regions. They hypothesize that the high-velocity flow is the starburst-driven superwind generated in an optically obscured nuclear starburst, and that the quiescent gas is directly ionized by the nuclear source, like the ionization cones typically seen in Seyfert galaxies.

Borne and colleagues D. Patton, R. Carlberg (U. Toronto), R. Marzke (OCIW), and C. Pritchett (U. Victoria) are obtaining *HST* images for a large sample of galaxy pairs at intermediate redshift. They are attempting to identify those pairs that show evidence for interaction. The pairs were identified in the CNOC2 Field Galaxy Redshift Survey, and thus the pairs are known in advance to be at the same redshift and dynamically close. The goal is to derive a firmer estimate of the redshift dependence of the galaxy interaction and merger rates. Several pairs have now been imaged and results will be derived in the coming year.

Borne and W. Keel (U. Alabama) have obtained and are now analyzing *HST* images of two pairs of nearby interacting galaxies: Arp 297 and NGC 6621/22. They are analyzing variations in numerous interaction-induced properties (particularly, the frequency of young blue super star clusters). These two collisions are believed to delimit the range of galaxy-galaxy interactions: from weak, old interactions (Arp 297) to strong, young interactions (NGC 6621/22).

E. Malumuth, N. Collins, and R.S. Hill (all RITSS) continued their collaboration with a group led by S. Heap (GSFC/LASP) investigating the photometry and morphology of galaxies in several groups at a redshift of  $\sim 0.1$ , using

STIS FUV and optical imagery. The same personnel also continued collaborating in a group led by J.P. Gardner (GSFC) investigating star-forming galaxies found in the STIS Parallel Survey imagery and slitless spectra. Malumuth contributed photometric redshift analysis and Collins contributed galaxy photometry for investigation of galaxies in a  $0.6$  by  $0.6$  degree field surrounding the HDF-South, led by H. Teplitz (GSFC/LASP/NOAO). Hill contributed two-point correlation function analysis to the same effort (Teplitz *et al.* 1998).

Landsman (RITSS) assisted S. Yi, T. Brown, S. Heap, I. Hubeny, T. Lanz, and A. Sweigart in using spectral synthesis in determining an age for the  $z = 1.55$  galaxy LBDS53W091. Yi *et al.* (1999) concluded that the galaxy was less than 2.0 Gyr old, and thus does not set useful constraints on cosmological parameters.

W. Waller (RITSS) has been investigating the anatomy and powering of starburst regions, as well as the dynamical orchestration of starburst activity in galaxies. A multi-wavelength imaging study of the emission-line bubble nebula N70 in the Large Magellanic Cloud (with U. Washington doctoral candidate B. Skelton) yielded an energy budget dominated by photoionization and winds from the hot stars inside, but also requiring additional powering from 1 or 2 supernovae. The need for mechanical powering of the bubble nebula was especially pronounced at the shell boundary, where the [S II] emission is highly elevated relative to that at H- $\alpha$  and [N II]. Comparison with the Orion nebula showed N70 to have considerably greater energetics of mechanical origin. These results provide a basis for interpreting the line emission from more distant and powerful starbursting systems.

Waller has continued collaborations with members of the Ultraviolet Imaging Telescope (UIT) Science Team, led by T. Stecher at GSFC. Ultraviolet imaging of the face-on ringed spiral galaxy M94 (NGC 4736) and of the edge-on disk galaxy NGC 4631 has revealed hitherto unseen patterns of starburst activity, which when compared with observations at H- $\alpha$  and other visible bands, has provided diagnostic constraints on the star-forming structures, histories, and underlying dynamics in these two nearby galaxies. Their analyses indicate that the UV morphology of M94 is resonance driven – suggesting similar dynamics in the ring-like “Pretzel galaxy” observed at high redshift; and that the UV structure of the edge-on disk galaxy NGC 4631 is remarkably similar to those of the so-called “chain galaxies” evident at high- $z$  – suggesting a similar interpretation for at least some of these distant and primeval objects.

Ongoing research efforts by Waller include the development of a UV-Optical atlas of nearby galaxies in collaboration with P. Marcum (TCU) and M. Fanelli (Univ. of N. Texas), spectroscopy and subsequent kinematic analysis of the cores of spiral galaxies (in collaboration with J. Kenney at Yale), and stellar photometry of the giant H II regions in M33 (in collaboration with P. Hodge at U. Washington).

N. Collins (RITSS), with GSFC and other co-workers, has completed and submitted a study of UIT imagery of the edge-on spiral NGC4631. The study included analysis of FUV, broad-band optical, H  $\alpha$ , H  $\beta$ , and H I and H II

position-velocity data. It has resulted in photometry of 48 star-forming regions, modeling of the regions, and a detailed recent star formation history for the galaxy. A 3-kpc ring of star-forming regions located concentrically with an expanding H I shell is explained as originating 20 Myr ago from supernova in a massive star forming region, with current FUV emission arising from second-generation stars.

In April 1999, RITSS staff provided logistical, LOC, and SOC support, for the ‘‘Annapolis Conference on Spectrophotometric Dating of Stars and Galaxies,’’ held at the Charles Carroll House in historic Annapolis, MD. The conference was sponsored by GSFC’s LASP and in part by RITSS and was attended by 52 astronomers from throughout the world. It facilitated a confrontation of models with observations related to the critical question of the ages of stars, clusters, and galaxies. RITSS staff is also providing editorial support for the Proceedings which will appear in November 1999.

### 3.8 Cosmology

S. Odenwald (RITSS) has continued his research collaborations with J. Mather and S. Kashlinsky, which has led to the detection of fluctuations in the cosmological infrared background between 1-5 microns using *COBE*/DIRBE all-sky data. They are continuing this research using 2-MASS data in collaboration with M. Skrutsky at the Univ. of Massachusetts.

R. Arendt, D. Fixsen, J. Weiland and N. Odegard (all RITSS) collaborated with a groups lead by E. Dwek and including T. Kelsall, D. Leisawitz, J. Mather, S. Moseley, R. Shafer, R. Silverberg (all GSFC) and M. Hauser (STScI) in attempting to determine a direct measurement of the extragalactic background light (EBL). Such a detection could provide important constraints on the integrated cosmological history of star formation, metal and dust production, and the conversion of starlight into infrared emission by dust. They examined the cosmological implications of the recent detection of the EBL in the 125 to 5000  $\mu\text{m}$  wavelength region by the DIRBE and FIRAS instruments on board *COBE*. They demonstrated that the 140 and 240  $\mu\text{m}$  isotropic residual emission found in the DIRBE data cannot be produced by foreground emission sources in the solar system or the Galaxy. The DIRBE 140 and 240  $\mu\text{m}$  isotropic residuals, and by inference the FIRAS residuals as well, are therefore extragalactic. Assuming that most of the 140 and 240  $\mu\text{m}$  emission is from dust yields a  $2\sigma$  lower limit of  $\nu I(\nu) \sim 5 \text{ nW m}^{-2} \text{ sr}^{-1}$  for the EBL at 100  $\mu\text{m}$ . The integrated EBL detected by the *COBE* between 140 and 5000  $\mu\text{m}$  is  $\sim 16 \text{ nW m}^{-2} \text{ sr}^{-1}$ , roughly 20%-50% of the integrated EBL intensity expected from energy release by nucleosynthesis throughout cosmic history. This also implies that at least  $\sim 5\%$ -15% of the baryonic mass density implied by big bang nucleosynthesis has been processed through stars. The *COBE* observations provide important constraints on the cosmic star formation rate, and we calculate the EBL spectrum for various star formation histories. The results show that the UV and optically determined cosmic star formation rates fall short in producing the observed 140 to 5000  $\mu\text{m}$  background. The *COBE* observations require the star formation rate at redshifts of  $z$

$\sim 1.5$  to be larger than that inferred from UV-optical observations by at least a factor of 2. This excess stellar energy must be mainly generated by massive stars, since it otherwise would result in a local K-band luminosity density that is larger than observed. The energy sources could either be yet undetected dust-enshrouded galaxies, or extremely dusty star-forming regions in observed galaxies, and they may be responsible for the observed iron enrichment in the intracluster medium. The exact star formation history or scenarios required to produce the EBL at far-IR wavelengths cannot be unambiguously resolved by the *COBE* observations and must await future observations (Dewk *et al.* 1998).

RITSS scientist D. Fixsen is involved in the development of the TopHat balloon payload. This is being prepared at GSFC for a December 2000 flight in Antarctica. HopHat will measure the small scale structure in the cosmic microwave background. RITSS support includes design and development of a cryostat which will rest atop this long-duration balloon and must meet stringent specification (a mass of 10 kg with a 2-week hold time at milli-Kelvin temperatures). Systems, detector, and telescope engineering and development support is also provided by RITSS.

### 4. EDUCATION AND PUBLIC OUTREACH

RITSS scientists regularly give talks and demonstrations at local schools and frequently act as judges at regional science fairs, and they also help to maintain the outreach and education WEB resources associated with several of the projects discussed in § 2. In addition to these activities, the following contributions are aimed specifically at education and outreach.

J. Brosius mentored a public middle school teacher from the District of Columbia during summer 1999 as part of the SUNBEAMS (Students United with NASA Becoming Enthusiastic About Math and Science) program at GSFC. He helped develop lesson plans, participated in Parents’ Night activities, and interacted with students visiting GSFC.

E. Bell, J. Cooper, and D. Williams (RITSS) are collaborating with E. Myhill (Marymount Univ.) in developing an educational outreach effort related to the Jovian magnetic field and satellites. The effort is called Interactive Magnetospheric Particles Applied to Classroom Teaching, or IMPACT, and is geared towards undergraduate and upper level high school students.

S. Odenwald (RITSS) has been the *IMAGE* Education and Public Outreach manager during 1996-1999. In February 1999, he was awarded the NASA Excellence in Outreach award at GSFC for his many popularizations of astronomy in such venues as Sky and Telescope, Astronomy, and the Washington Post. His well-known web site The Astronomy Cafe,

<http://www2.ari.net/home/odenwald/cafe.html> has been in operation since 1995, and the success of his Ask the Astronomer resource led to the publication of his book *The Astronomy Cafe; 365 questions and answers from Ask the Astronomer* by W.H. Freeman. His CDROM was also featured in the recent edition of *Discovering Astronomy* by S. Shawl, R. Robbins and W. Jeffereys.

L. Mayo coordinated GSFC SEC participation in development of a Space Weather traveling museum exhibit. This effort, led by the Space Sciences Institute, is developing a traveling 200 square foot exhibit to teach the public about the sun earth connection and it's impact here on Earth. Expected launch date is early spring 2000.

Mayo pioneered (and currently leads) a new educational concept: The "Parent Science Advisory Council" (PSAC) for a local Montgomery County elementary school. The PSAC concept pulls parents with science and math expertise into the education process as partners with educators, school administration, and community groups and encourages their participation through: community/family science nights, after school science clubs and activities, science fairs, in-classroom speakers, science consulting for teachers, and coordination of other community science and technology resources. This program, currently in a pilot phase, has the participation and support of both the school and county science coordinators and will serve as a model for a county-wide program.

Mayo worked with SECEF management to develop an E&PO workshop for SEC scientists, mission EP&O leads, and educators. The workshop will be held just before the fall AGU meeting at the Exploratorium in the S.F. Bay Area.

J. Gass (RITSS) has contributed to the new educational outreach project called Radio JOVE, created by J. Thieman (GSFC) and C. Higgins (Penn State). This project is being conducted with partners from the Univ. of Florida, the Florida Space Grant Consortium and others. Radio JOVE involves students in basic planetary and solar radio astronomy. The focus of this project is to observe Jupiter's decametric radio emissions and Solar bursts in the shortwave radio spectrum near 20 MHz. The goals of Radio JOVE are to:

Educate people about planetary and solar radio astronomy space physics and the scientific method

Provide teachers and students with a hands-on radio astronomy exercise as a science curriculum support activity by building and using a simple radio telescope receiver/antenna kit

Create an on-line radio observatory that provides real-time data for those with Internet access

Allow interactions among participating schools by facilitating exchanges of ideas data and observing experiences

Kits for version 1.1 of the JOVE radio telescope have been available since Spring of 1999. Since that time, more than 90 middle schools, high schools, and colleges have ordered and received the kits. The kits feature a simple radio receiver, materials for constructing a dual-dipole HF antenna array, and a CD-ROM containing chart recorder and audio spectral display software for PCs. The kit costs is \$100. A number of schools have successfully built their kits, and some of these groups have made their first observations. More information is available at the Radio JOVE Web site <http://radiojove.gsfc.nasa.gov/>

Finally, A. Danks and D. Massa (RITSS) contributed an article entitled "Astronomers in the Commercial Sector" to the AAS Newsletter. This article outlined the activities of astronomers in the business world and was intended to provide graduate students with a better picture of what such

scientists do. Graduate students are at a point in their lives where they must decide which direction their career should take. Unfortunately, they have typically had very little contact with astronomers in the private sector and know very little about their skill mix or activities. This article was intended to give them a first hand account of the lives of scientists in the business world.

## PUBLICATIONS

- Airapetian, V.S., **Ofman, L.**, Robinson, R.D., Carpenter, K.G. & Davila, J.M. 1999, "Two-Component Winds from Luminous Late-type Stars," *ApJ*, in press
- Andretta, V., Jordan, S.D., **Brosius, J.W.**, Davila, J.M., Thomas, R.J., Behring, W.E., Thompson, W.T., & Garcia, A. 2000, "The Role of Velocity Redistribution in Enhancing the Intensity of the He II 304 Line in the Quiet Sun Spectrum," *ApJ*, submitted (Sept. 1999).
- Arendt, R.G.**, Dwek, E., & Moseley, S.H. 1999, "Newly Synthesized Elements and Pristine Dust in the Cassiopeia A Supernova Remnant," *ApJ*, 521, 234
- Arendt, R.G.**, **Fixsen, D.J.**, & Moseley, S.H. 1999, "Dithering Strategies for Efficient Self-Calibration of Imaging Arrays," *ApJ*, submitted
- Bale, S.D., **Reiner, M.J.**, Bougeret, J.-L., Kaiser, M.L., Krucker, S. Larson, D.E. & Lin, R.P. 1999, "The source region of an interplanetary type II radio burst," *Geoph. Res. Lett.*, 26, 1573
- Berdichevsky, D.**, Bougeret, J.-L., Delaboudiniere, J.-P., Fox, N., Kaiser, M., Lepping, R., Michels, D., Plunkett, S., Reames, D., **Reiner, M.**, Richardson, I., Rostoker, G., Steinberg, J., Thompson, B. & von Rosenvinge, T. 1998, "Evidence for Multiple Ejecta; April 7-11, 1997 ISTP Sun-Earth Connection Event," *Geo. Res. Lett.* V. 25, 2473
- Berdichevsky, D.**, Richardson, I.G., Thompson, B.J., Reames, D.V., MacDowall, R., Plunkett, S.P., Michels, D.J., Kaiser, M.L., Lepping, R.P., Ogilvie, K.W. & Stone, R.G. 1999, "Examples of fast solar wind transients, their sources and the forecast of possible geomagnetic impact", *Geof. Inter.*, in press
- Berdichevsky, D.**, Szabo, A., Lepping, R.P., Viñas, A.F. & Mariani, F. 1999, "Inter-planetary fast shocks and associated drivers observed through the 23rd. solar minimum by Wind over its first 2.5 years," *JGR*, submitted
- Berdichevsky, D.**, Thejappa, G., Fitzenreiter, R., Lepping, R., Yamamoto, T., Kokubun, S., McEntire, R., Williams, D. & Lin, R.P. 1999, "Widely spaced wave-particle observations during *GEOTAIL* and *WIND* magnetic conjunctions in the Earth's ion foreshock," *JGR*, V. 104, 463
- Bilitza, D.** 1999, "Science tools on the internet - access to information, data, and models," *J. Atmos. Solar-Terr. Phys.* 61, 167
- Bilitza, D.**, Hernandez-Pajares, M., Juan, J. & Sanz, J. 1999, "Comparison between IRI and GPS-IGS derived electron content during 1991-97, *Phys. Chem Earth C0*, 24, No. 4, 311-319
- Bilitza, D.**, Radicella, S., Reinisch, B., Adeniyi, J., Mosert Gonzalez, M., Zhang, S. & Obrou, O. 1999 "New B0 and B1 models for IRI," *Adv. Sp. Res.*, in press

- Bilitza, D.** & Williamson, R. 1999, "Towards a better representation of the IRI topside based on ISIS and Alouette data," *Adv. Sp. Res.*, in press
- Borne, K.D., Blackwell, J.H., Gass, J. E., Kargatis, V.E., Schneider, G.L., Shaya, E.J., Weiland, J.L.,** Cheung, C.Y., & White, R.A., 1998, "New and Improved Catalog Services at the ADC," *BAAS*, 193, No. 13.05
- Borne, K.D.,** Bushouse, H., Colina, L., Lucas, R.A., Baker, A., Clements, D., Lawrence, A., Oliver, S., & Rowan-Robinson, M., 1998, "NICMOS and WFPC2 Imaging of Ultraluminous Galaxies," in "Astrophysics with Infrared Surveys: A Prelude to *SIRTf*," in press
- Borne, K.D.,** Bushouse, H., Colina, L., Lucas, R.A., Baker, A., Clements, D., Lawrence, A., Oliver, S., & Rowan-Robinson, M., 1998, "Dynamics of Ultraluminous Galaxies," in "Galaxy Dynamics," p. 461
- Borne, K.D.,** Bushouse, H., Colina, L., Lucas, R.A., Baker, A., Clements, D., Lawrence, A., Oliver, S., & Rowan-Robinson, M., 1998, "A Morphological Classification Scheme for Ultraluminous Galaxies: Evidence for Multiple Mergers," *Ap & SS*, in press
- Borne, K.D.,** Bushouse, H., Colina, L., & Lucas, R.A., 1998, "Evidence for Multiple Mergers Among Ultraluminous IR Galaxies," in *After the Dark Ages: When Galaxies Were Young*, eds. S. Holt & E. Smith (Woodbury: AIP), p220
- Borne, K.D.,** Bushouse, H., Colina, L., & Lucas, R.A. 1999, "Evidence for Multiple Mergers Among Ultraluminous IR Galaxies," *AAS/DDA*, 31, 13.04
- Borne, K.D.,** Bushouse, H., Colina, L., & Lucas, R.A. 1999, "Evidence for Multiple Mergers among Ultraluminous IR Galaxies (ULIRGs): Remnants of Compact Groups?," *ApJ Letters*, submitted
- Borne, K.D.,** Colina, L., Bushouse, H., & Lucas, R.A. 1999, "*HST* Observations of the Serendipitous X-ray Companion to Mrk 273: Cluster at  $z = 0.46?$ ," *ApJ*, in press
- Borne, K.D.,** Colina, L., Bushouse, H., & Lucas, R.A., 1999, "*HST* Observations of the Ultraluminous IR Galaxy IRAS 10026+4347: The QSO, its Host Galaxy, and its Rich Environment," *AJ*, submitted
- Borne, K.D., Shaya, E.J.,** White, R.A., & Cheung, C.Y., 1998, "An Archival Survey of the HDF-South," in *After the Dark Ages: When Galaxies Were Young*, eds. S. Holt & E. Smith (Woodbury: AIP), p438
- Borne, K.D.,** White, R.A., Cheung, C.Y., & Shaya, E.J., 1999, "An Archival Survey of the HDF-South," *AAS/DDA*, 31, 05.01
- Brosius, J.W.,** Davila, J.M., & Thomas R.J. 1998, "Solar Active Region and Quiet-Sun EUV Spectra from SERTS-95," *ApJS*, 119, 255
- Brosius, J.W.,** Thomas, R.J., & Davila, J.M. 1999, "SERTS-95 Measurements of Wavelength Shifts in Coronal Emission Lines Across a Solar Active Region," *BAAS*, 31, 997
- Brosius, J.W.,** Thomas, R.J., & Davila, J.M. 1999, "SERTS-95 Measurements of Wavelength Shifts in Coronal Emission Lines Across a Solar Active Region," *ApJ*, 526, in press
- Brosius, J.W.,** Thomas, R.J., Davila, J.M., & Thompson, W.T. 1999, "SERTS-97 Measurements of Relative Wavelength Shifts in Coronal Emission Lines Across a Solar Active Region," *Sol. Phys.*, submitted
- Brosius, J.W.** & Woodgate, B.E. 1999, "Using Temporal Variations of the Nonthermal Redshifted Ly- $\alpha$  Emission to Deduce Properties of Proton Beams Injected into a Stellar Atmosphere," *ApJ*, 514, 430
- Bushouse, H.A., **Borne, K.D.,** Colina, L., & Lucas, R.A. 1998, "*HST* Reveals the Core Properties of Ultraluminous IR Galaxies," *BAAS*, 193, 76.09
- Cebula, R.P., & DeLand, M.T.** 1999, "*Nimbus-7* SBUV solar spectral UV measurements: 1979-1987," presented at the XXIIth General Assembly of IUGG, Birmingham, England.
- Cebula, R.P., DeLand, M.T.,** Schlesinger, B.M. & Heath, D.F. 1999, "*Nimbus-7* SBUV and the birth of long-term UV solar studies," *EOS Trans. AGU*, 79, Fall Meeting Suppl., F78.
- Cha, A.N., Sembach, K.R., **Danks, A.C.** 1999, "The Distance to the Vela Supernova Remnant," *ApJ*, 515
- Chavez, M., Holberg, J.B., & **Landsman, W.B.** 1999, *AJ*, 117, 962
- Colina, L., Arribas, S., & **Borne, K.D.** 1999, "Two-dimensional Spectroscopy of Mrk 273: Mapping  $10^3 \text{ km s}^{-1}$  Gas Flows and an Off-Nucleus Seyfert 2 Nebula," *ApJ Letters*, in press
- Davila, J.M., & **Ofman, L.** 1999, "Two-fluid 2.5D MHD Simulations of the Fast Solar Wind in Coronal Holes and the Relation to UVCS Observations," *SSR*, 87, 287
- DeLand, M.T., & Cebula, R.P.** 1999 "Nimbus-7 SBUV and NOAA-11 SBUV/2 middle UV solar irradiance data," *EOS Trans. AGU*, 79, Fall Meeting Suppl., F10.
- Dunham, D.W., Faust, D., **Warren, W.H.,** Sato, I., Goffin, E., & Soma, M. 1998, "Catalogs of Asteroidal Occultation Observations and Stars," *BAAS*, 30, 1042
- Dwek, E. & **Arendt, R.G.** 1999, "A Tentative Detection of the Cosmic Infrared Background at  $3.5 \mu\text{m}$  from *COBE/DIRBE* Observations," in *After the Dark Ages: When Galaxies Were Young*, eds. S. Holt & E. Smith, (AIP: Woodbury, NY), 354
- Dwek, E., **Arendt, R.G.** & Moseley, S.H. 1999, "Newly-Synthesized Elements and Pristine Dust in the Cassiopeia A Supernova Remnant as Observed by *ISO*," in *The Universe as Seen by ISO*, eds. P. Cox & M.F. Kessler, (ESA SP-427), 237
- Dwek, E., **Arendt, R.G.,** Hauser, M.G., **Fixsen, D.,** Kelsall, T., Leisawitz, D., Pei, Y.C., Wright, E.L., Mather, J.C., Moseley, S.H., **Odegard, N.,** Shafer, R., Silverberg, R.F., & **Weiland, J.L.** 1998, "The *COBE* Diffuse Infrared Background Experiment Search for the Cosmic Infrared Background. IV. Cosmological Implications" *ApJ*, 508, 106
- Evans, N.R., Carpenter, K., Robinson, R, **Massa, D.,** Wahlgren, G.M., Vinko, J., & Szabados, L. 1999, "Toward an Orbit for the High-Luminosity Cepheid T Monocerotis," *ApJ*, 524, 379
- Fanelli, M.N., Marcum, P.M., O'Connell, R.W., **Waller, W.H., Cornett, R.H.** & Stecher, T.P. 1998, "Global and

- Differential Far-UV Photometric Properties of Galaxies,” BAAS, 30, 1260
- Fettig, R.**, Moseley, S.H., Kutyrav, A.S., Orloff, J., Kuhn, J.L. & Shude, L. 1999 “Some aspects on the mechanical analysis of micro-shutters,” in Proc. SPIE, 3875, 1999
- Fitzpatrick, E.L. & **Massa, D.** 1999, “The UV/Optical Energy Distributions of the A Stars” BAAS, 194.10503
- Fitzpatrick, E.L. & **Massa, D.** 1998, “Modeling the UV/Optical Energy Distributions of the B Stars,” BAAS, 193.4403
- Fixsen, D. J.**, Moseley, S. H., & **Arendt, R.G.** 1999, “Calibrating Array Detectors,” ApJ, submitted
- Francis, P.J., Woodgate, B.E., **Danks, A.C.** 1999, “On the Nature of Red Galaxies in the Early Universe,” in *Looking Deep in the Southern Sky, Proceedings of the ESO/Australia Workshop*, eds. R. Morganti & W.J. Couch, Springer-Verlag, 309
- Grady, C.A., Pérez, M.R., Bjorkman, K.S. & **Massa, D.** 1999, “Transient Infall Events in the Disk of AB Aurigae: The beta Pictoris Phenomenon at 2-4 Megayears,” ApJ, 511, 925
- Grundahl, F., Catelan, M., **Landsman, W.B.**, Stetson, P.B., & Anderson, M.I. 1999, ApJ, 524, 242
- Hesse M., Birn, J. & **Kuznetsova, M.** 1999, “Collisionless magnetic reconnection: Electron processes and transport modeling,” JGR, in press
- Hesse, M., Schindler, K., Birn, J., **Kuznetsova, M.** 1999, “The diffusion region in collisionless magnetic reconnection,” Phys. Plasmas 6, 1781
- Jordan, S.D., Andretta, V., **Brosius, J.W.**, Behring, W.E., & Garcia, A. 1999, “Velocity Redistribution as a He II Intensity Enhancement Mechanism,” BAAS, 31, 990
- Jordan, S.D., Andretta, V., Garcia, A., **Brosius, J.W.** & Behring, W.E. 1999, “Does Velocity Redistribution Really Enhance the He 304 A Line to Observed Intensities?,” in Proc. of the 9th European Meeting on Solar Physics
- Kargatis, V.E., **Shaya, E.J.**, **Blackwell, J.H.**, **Borne, K.D.**, White, R.A., & Cheung, C.Y., “Web-Based Tools For Exploration Of ADC Data Holdings And NASA Data Archives,” BAAS, 193, No. 13.04 (1998).
- Kargatis, V.E., **Shaya, E.J.**, **Blackwell, J.H.**, **Borne, K.D.**, White, R.A., & Cheung, C.Y., 1999, “Web-Based Tools For Exploration of ADC Data Holdings and NASA Data Archives,” ADASS VIII, (ASP Conf. Ser., 172, eds. D.M. Mehringer, R.L. Plante & D.A. Roberts), 217
- Keenan, F.P., O’Shea, E., Thomas, R.J., **Brosius, J.W.**, Foster-Woods, V.J., Ryans, R.S.I., Reid, R.H.G., Pradhan, A K., & Zhang, H.L. 1999, “Si X Emission Lines in Spectra Obtained with the Solar EUV Rocket Telescope and Spectrograph (SERTS),” MNRAS, in press
- Kuznetsova, M.**, Hesse, M. & Winske, D. 1999, “Toward a transport model of collisionless magnetic reconnection,” JGR, in press
- Kuznetsova, M.**, Hesse, M. & Winske, D. 1999, “Collisionless reconnection supported by nongyrotropic pressure effects in hybrid and particle simulations,” JGR, submitted
- Landsman, W.** 1999, in ASP Conf. Proc. series *Workshop on “Spectrophotometric Dating of Stars and Galaxies,* Annapolis, Maryland (USA), eds. I. Hubeny, S. Heap, & R. Cornett, in press
- Leonard, P.J.T.** 1999 “Multiple Stellar Systems: Types and Stability,” in “Encyclopedia of Astronomy and Astrophysics,” in press
- Lu, G., **Tsyganenko, N.A.**, Lui, A.T.Y., Singer, H.J., Nagai, T. & Kokubun, S. 1999, “Modeling of time-evolving magnetic fields during substorms,” JGR, 104, 12327
- Lucas, R.A., Bushouse, H., Colina, L., & **Borne, K.D.**, 1999, “The Archival Study of Extragalactic Tidal Tails in NGST Observations,” BAAS, 194, 91.03
- Malumuth, E.M.**, **Hill, R.S.**, Gardner, J.P., Heap, S.R. & Smith, E.P. 1999, “STIS Far UV Images and Broadband Colors of Galaxies at  $z = 0.1$ ,” BAAS, 198, No. 8.15
- Massa, D.** & Fitzpatrick, E.L. 1998, “A recalibration of IUE NEWSIPS low dispersion data” AAS, 193, 1122
- Massa, D.**, Evans, N.R. & Endal, A.S. 1999, “Cross-dispersion imaging of the classical Cepheid binary AW Per,” BAAS, 194, 900
- Mayo, L.A.** & Samuelson, R.E. 1999, “Properties of Condensed Ethane in Titan’s Stratosphere,” BAAS, 31, 1143
- Mayo, L.A.** 1998, “MarsQuest: Bringing the Excitement of Mars Exploration to the Public,” EOS Transactions, AGU 1998 Fall Meeting, 79, No 18, Suppl
- Moehler, S., Sweigart, A.V., **Landsman, W.B.**, Heber, U., & Catelan, M. 1999, A&A, 346, L1
- Moseley, S.H., **Fettig, R.K.**, **Kutyrev, A.S.**, Bowers, C.W., Kimble, R.A., Orloff, J. & Woodgate, B.E., “Programmable 2-Dimensional Microshutter Arrays,” in Proc. SPIE, 3878, Sept
- Nakariakov, V.M.**, **Ofman, L.** & Arber, T.D. 1999, “Non-linear Dissipative Spherical Alfvén Waves in Solar Coronal Holes,” A&A, in press
- Nakariakov, V.M., **Ofman, L.**, DeLuca, E., Roberts, B., Davila, J.M. 1999, “TRACE Observation of Damped Coronal Loop Oscillations: Implications for Coronal Heating,” Science, 285, 862
- Nieto-Santisteban, M.A., **Fixsen, D.J.**, **Offenberg, J.D.**, Hanisch, R.J., & Stockman, H.S. 1999, “Data Compression for NGST” ADASS, VIII, (ASP Conf. Ser., 172, eds. D.M. Mehringer, R.L. Plante & D.A. Roberts), 137
- Offenberg, J.D.**, **Fixsen, D.J.**, Nieto-Santisteban, M. A.; Sengupta, R., Stallcup, S., Stockman, H.S., Hanisch, R.J. & Mather, J.C. 1998, “Science Data Processing with the Next Generation Space Telescope” BAAS, 193.3503
- Offenberg, J.D.**, **Fixsen, D.J.**, Sengupta, R., Nieto-Santisteban, M.A., Stockman, H.S. & Hanisch, R.J. 1999, “Cosmic Ray Rejection and the Next Generation Space Telescope,” AAS, 194.4401
- Offenberg, J.D.**, **Fixsen, D.J.**, Sengupta, R., Nieto-Santisteban, M.A., Stallcup, S., Hanisch, R.J. & Mather, J.C. 1999, “Cosmic Ray Rejection with NGST” ADASS, VIII (ASP Conf. Ser., 172, eds. D.M. Mehringer, R.L. Plante & D.A. Roberts), 141
- Ofman, L.**, & Davila, J.M., 1999, “Two-fluid 2.5D MHD Model of the Fast Solar Wind and the Effective Proton Temperature,” in Solar Wind Nine, S. Habbal *et al.* (eds), AIP Conf. Proc., 471, p405
- Ofman, L.**, & DeForest, C.E. 1999, “Numerical Simulations

- of Trapped Sound Waves in Solar Coronal Plumes,” 32nd COSPAR Scientific Assembly, Advances in Sp. Res., in press
- Ofman, L.**, Nakariakov, V. & DeForest, C.E. 1999, “Slow Magnetosonic Waves in Coronal Plumes,” *ApJ*, 514, 441
- Ofman, L.**, Nakariakov, V.M., & Sehgal, N. 1999, “Dissipation of Slow Magnetosonic Waves in Coronal Plumes,” *ApJ*, submitted
- Ofman, L.**, Romoli, M., Noci, G., Poletto, G., Kohl, J.L., Howard, R.A., & St. Cyr, C. 1999, “*SOHO* Observations of Density Fluctuations in Coronal Holes,” *SSR*, 87, 165
- Ofman, L.**, Romoli, M., Poletto, G., Noci G. & Kohl, J.L. 1999, “UVCS WLC Observations of Compressional Waves in the South Polar Coronal Hole,” *ApJ*, in press
- Prinja, R.K., **Massa, D.**, Howarth, I.D. & Fullerton, A.W. 1998, “Repetitive structure in the stellar wind of HD 93843: a normal O-type star *MNRAS*, 301, 926
- Reiner, M.J.** 1999 “Interplanetary type II radio emissions associated with CMEs,” in *Chapman Conference on Space based radio observation at long wavelengths*, invited review, in press
- Reiner, M.J.** & Kaiser, M.L. 1999, “Complex Type III-like Radio Emissions Observed from 1 to 14 MHz,” *Geoph. Res. Let.*, 26, 397
- Reiner, M.J.** & Kaiser, M.L. 1999, “High-frequency type II radio emissions associated with shocks driven by CMEs,” *JGR*, 104, 16979
- Reiner, M.J.**, Kaiser, M.L., Fainberg, J. & Stone, R.G. 1998, “A new method for studying remote type II radio emissions from coronal mass ejection-driven shocks,” *JGR*, 103, 29651
- Reiner, M.J.**, Kaiser, M.L., Fainberg, J. & Stone, R.G. 1999, “Remote Radio Tracking of CMEs in the Solar Corona and Interplanetary Medium,” *Proc. of the Ninth International Solar Wind Conference, AIP Conf. Proc.*, 471, 653
- Reiner, M.J.**, Karlicky, M., Jiricka, K., Aurass, H., Mann, G. & Kaiser, M.L. 1999, “On the solar origin of complex type III-like radio bursts observed at and below 1 MHz,” *ApJ*, in press
- Reiner, M.J.** & Kaiser, M.L. 1999, “Long-term behavior of Jovian bKOM and nKOM radio emissions observed during the Ulysses-Juptier encounter,” in preparation.
- Reiner, M.J.**, Kaiser, M.L., Plunkett, S.P., Prestage, N.P. & R. Manning, 1999 “Radio Tracking of a White-light CME from Solar Corona to Interplanetary Medium,” *ApJ Letters*, submitted
- Ruderman, M.S., Goldstein, M.L., Roberts, D.A., Deane, A. & **Ofman, L.** 1999, “Alfvén Wave Phase Mixing Driven by Velocity Shear in Two-Dimensional Open Magnetic Configurations,” *JGR - Space Physics*, 104, 17057
- Ruderman, M.S., Goldstein, M.L., Roberts, D.A., **Ofman, L.**, & Deane, A.E., 1999, “Alfvén Wave Phase Mixing Driven by Velocity Shear in Two-Dimensional Open Magnetic Configurations” in *Solar Wind Nine*, S. Habbal *et al.* (eds), AIP Conf. Proc., 471, pp. 337
- Sahu, M.S., **Landsman, W.**, Bruhweiler, F.C., Gull, T.R., Bowers, C.A., Lindler, D., Feggans, K., Barstow, M.A., Hubeny, I., & Holberg, J.B. 1999, *ApJ*, 523, L159
- Sande, C.B., Brasoveanu, D., Miller, A.C., Home, A., Tracewell, D.A., & **Warren, W.H. Jr.** 1998, “Improved Instrumental Magnitude Prediction Expected from Version 2 of the NASA SKY2000 Master Star Catalog,” in *Spaceflight Dynamics 1998*, ed. T.H. Stengle, Advances in the Astronautical Sciences, Vol. 100, part II, pp. 765-778
- Schmelz, J.T., Saba, J.L.R., Strong, K.T., Winter, H.D., & **Brosius, J.W.** 1999, “Emission Measure Distribution for an Active Region Using Coordinated SERTS and Yohkoh/SXT Observations,” *ApJ*, 523, in press
- Shaya, E.J.**, **Blackwell, J.H.**, **Gass, J.E.**, Kargatis, V.E., **Schneider, G.L.**, **Weiland, J.L.**, **Borne, K.D.**, White, R.A., & Cheung, C.Y., 1998, “Application of XML to Journal Table Archiving,” *BAAS*, 193, 13.06
- Shaya, E.**, **Blackwell, J.**, **Gass, J.**, Kargatis, V., **Schneider, G.**, **Borne, K.**, Cheung, C., & White, R., 1999, “Formatting Journal Tables in XML at the ADC,” *ADASS VIII*, (ASP Conf. Ser., 172, eds. D.M. Mehringer, R.L. Plante & D.A. Roberts), 274
- Smith, A.M., **Collins, N.R.**, **Waller, W.H.**, Roberts, M.S., Smith, D.A., Bohlin, R.C., Cheng, K.-P., Neff, S.G., O’Connell, R.W., Parise, R.A., Smith, E.P. & Stecher, T.P. 1999 “Far ultraviolet imagery of the edge-on spiral galaxy NGC4631” *ApJ Submitted*
- Smith, A.M., **Collins, N.R.**, **Waller, W.H.**, Roberts, M.S., Smith, D.A., Bohlin, R.C., Cheng, K.-P., Fanelli, M.N., Neff, S.G., O’Connell, R.W., Parise, R.A., Smith, E.P. & Stecher, T.P. 1999 “Far Ultraviolet Imagery of the Edge-On Spiral Galaxy NGC 4631,” *ApJ*, in press
- Swartz, M., Condor, C.E., Davila, J.M., Haas, J.P., Jordan, S.D., Linard, D.L., Miko, J.J., Nash, I.C., Novello, J., Payne, L.J., Plummer, T.B., Thomas, R.J., White, L.A., **Brosius, J.W.** & Thompson, W.T. 1999, “The SERTS-97 Rocket Experiment to Study Activity on the Sun: Flight 36.167-GS on 1997 November 18,” *NASA/TP-1999-208640*
- Teplitz, H.I., Gardner, J.P., Palunas, P., Sahu, M.S., **Malumuth, E.M.**, Woodgate, B.E., Heap, S.R., Williger, G.M., Danks, A.C., Smette, A., Brown, T.M., Kaiser, M.E., & Gull, T.R. 1998, “The Hubble Deep Field South: Deep uBVRI Imaging of 1/2 Square Degree,” *BAAS*, 193, No 75.07
- Tsyganenko, N.A.** 1998, “Modeling of twisted/warped magnetospheric configurations using the general deformation method,” *JGR*, 102, 23551
- Tsyganenko, N.A.** 1999, “Recent progress in the data-based modeling of magnetospheric currents,” *AGU Monograph on Magnetospheric Current Systems*, in press
- Tsyganenko, N.A.** 1999, “Solar wind control of the tail lobe magnetic field as deduced from *GEOTAIL*, *AMPTE/IRM*, and *ISEE-2* data,” *JGR*, submitted
- Tsyganenko, N.A.** & Russell, C.T. 1999, “Magnetic signatures of the distant polar cusp: Observations by *POLAR* and quantitative modeling,” *JGR*, in press
- Tsyganenko, N.A.**, Le, G., Russell, C.T. & Iyemori, T. 1999, “A study of the inner magnetosphere, based on data of *POLAR*,” *JGR*, 104, 10275
- Waller, R.F.** Gelderman, L.W. Brown, B.E. Woodgate, A. Caulet, & R.A. Schommer 1999, “Emission-Line Proper-

- ties of the LMC Bubble N70,” *PASP*, 111, 465
- Waller, W.H.**, Winslow, C.M., Fanelli, M.N. & Stecher, T.P. 1999, “UV Signposts of Resonant Dynamics in Disk Galaxies,” in *Galaxy Dynamics*, eds. D. Merritt, J.A. Sellwood, M. Valluri, ASP Conf. Ser., 182, p. 239
- Warren, W.H. Jr.**, and Dickel, H.R. 1998, “Nomenclature for Extrasolar Planets: A New Challenge,” in *Brown Dwarfs and Extrasolar Planets*, ed. R. Rebolo, E.L. Martin, & M.R. Zapatero Osorio, ASP Conf. Ser., 134, p327
- Warren, W.H. Jr.**, Sande, C.B., Miller, A.C., Myers, J.R., Home, A. T., & Tracewell, D.A. 1998, “Version 2 of the NASA SKY2000 Master Star Catalog,” *BAAS*, 30, 765
- White, R.A., **Borne, K.D.**, Cheung, C.Y., Kargatis, V.E., Leisawitz, D.T., & **Shaya, E.J.**, 1998, “An Archival Survey Around the HDF-South Region,” *BAAS*, 193, 75.10
- Woodgate, B.E., Kimble, R.A., Bowers, C.W., Kraemer, S., Kaiser, M.E., **Danks, A.C.**, *et al.* 1998, “The Space Telescope Imaging Spectrograph Design,” *PASP*, 110, 1183
- Yi, S., Brown, T.M., Heap, S., Hubeny I., **Landsman, W.**, Lanz, T., & Sweigart, A. 1999, *ApJ*, in press

D. Massa

