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The following report covers activities from September 2000 through August 2001.

1. INTRODUCTION & PERSONNEL

Research in astronomy and the space sciences at USC is carried through in the Space Sciences Center and Department of Physics and Astronomy. Scientists whose research is reported below include: 1) Space Science Center: Dr. Darrell L. Judge, Professor and Director of the Space Sciences Center, Dr. C. Y. Robert Wu, Research Professor, Dr. Pradip Gangopadhyay, Dr. Howard S. Ogawa, & Dr. Geraldine J. Peters, Research Scientists, Dr. Fang-Zhong Chen, Postdoctoral Fellow, Jeffrey S. Nuttall, & Beau O'Shay, graduate students, & Donald McMullin, Project Manager, and 2) Department of Physics & Astronomy: Dr. Werner Däppen & Dr. Melvin Daybell, Professors, Dr. Vladimir Baturin, Dr. Alan Nayfonov, Postdoctoral Fellows, Zhigang Gong, Aihua Liang, Chia-Hsien Lin, & Ladislav Zejda, graduate students, and Dr. Gibson Reaves, Professor Emeritus.

John A. Russell, Professor of Astronomy, Emeritus, founder of the USC Department of Astronomy and pioneer meteor spectroscopist, passed away on 2001 November 2.

2. RESEARCH

W. Däppen continued his research on using the sun as a plasma physics laboratory. To pursue this goal, he participates in state-of-the art solar modeling and the analysis of helioseismic data. Helioseismology is the first accurate ''experiment'' that puts strong constraints on the thermodynamic quantities of the plasma of stellar interiors. 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. His most recent attention is devoted to the subtle thermodynamic effects of excited states in atoms and ions of the solar interior. Such effects have been detected by helioseismology, and they have to be taken into account in the determination of the helium abundance of the solar convection zone.

P. Gangopadhyay and D. E. Shemansky (Dept. of Aerospace Engineering) continue their work on calculating the outer planetary upper atmosphere Lyα, Lyβ, Lyγ, and Lyδ glow. The work is being carried out to resolve the discrepancy between the 15000 Rayleighs observed by the *Voyager* spacecraft from the Jovian upper atmosphere and the maximum of 5000 Rayleighs that solar Lyα flux can generate. Preliminary calculations suggest that the discrepancy can be resolved if there is a thin layer of hot electrons in the upper atmosphere of Jupiter. The results of their calculation will be presented in a forthcoming DPS meeting.

P. Gangopadhyay, V. Izmodenov, M. Gruntman (Dept. of Aerospace Engineering), J. Holberg (Univ. of Arizona), and D. L. Judge continue work on the interpretation of *Pioneer* 10 and *Voyager* Lyα data. The EUV data interpretation has suffered because of inadequate neutral hydrogen plasma models, difficulty of calculating the multiple scattered Lyα glow and calibration uncertainties. Recently all these difficulties have been significantly reduced. In our work we have used the latest state of the art supersonic VLISM neutral hydrogen plasma and a Monte Carlo radiative transfer model, incorporating neutral hydrogen density, temperature, and velocity variations, actual solar line shape, a Mihalas Case II redistribution function, Doppler, and aberration effects. The Monte Carlo simulations for a number of neutral hydrogen models and the comparison with *Pioneer* 10 data will be discussed in a future paper.

D. L. Judge, H. S. Ogawa, D. R. McMullin, P. Gangopadhyay, and M. Daybell have continued their studies of solar EUV irradiance observations from sounding rockets, the Shuttle, and satellites including SOHO. 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, Double Ionization Cells (HDIC) to obtain photoionization rates of He and Ne, Free Standing and Film Deposited Photodiodes to obtain absolute flux within the wavelength band pass of the metal filter used, an Optics Free Spectrometer (OFS) to obtain spectral irradiance data in the EUV and soft X-ray region, a low resolution ($\sim$10 Å) normal incidence spectrometer, and a solar EUV Monitor (SEM) to obtain absolute solar EUV irradiance that has been securing high quality data for four years aboard the SOHO spacecraft.

Judge, McMullin, and Ogawa participated in a coordinated observation of the gravitational focusing cone of interstellar He during the rise to solar maximum. This was a Joint Observation Project for SOHO together with ACE, *EUVE*, and *Ulysses* lead by the scientific team coordinator Eberhard Moebius, and was the first comprehensive study of the interstellar parameters and the ionization of helium in the heliosphere. The campaign took place in 2000 November-December when the Earth and all earth bound spacecraft passed through the interstellar focusing cone.

Judge, Ogawa, McMullin, Gangopadhyay and J. M. Pap have presented the entire SOHO CELIAS/SEM EUV database from January 1, 1996 (near SC23 minimum) to December 31, 1999. The SOHO CELIAS/SEM is a transmission grating spectrometer. The spectrometer continously measures the full solar disk absolute solar flux within an 8 nm bandpass centered at the prominent and scientifically important He II 30.4 nm line (first order channel) as well as the absolute solar flux between 0.1 and 50 nm (central order channel). The central channel data also contain solar soft X-ray data. The 30.4 nm flux, the 0.1 to 50 nm flux and the extracted soft X-ray flux (0.1 to 5 nm) flux were presented and compared with the behavior of solar proxies.

Judge, McMullin, Gangopadhyay, Ogawa, F. M. Ipavich, A. B. Galvin, E. Moebius, P. Bochsler, P. Wurz, M. Hilchenbach, H. Gruenwaldt, D. Hovestadt, B. Klecker, and F. Gliem have published a paper on space weather observations using the SOHO CELIAS complement of instruments. The CELIAS particle and soft X-ray measurements have been used to examine examples of precursor information of CME events. They also discuss the usefulness of the CELIAS/SEM data for studying long term weather trends as well as short term storm data.

J. Nuttall and D. L. Judge continue an analysis of spectral data from the Solar EUV Monitor and the Solar EUV Hitchhiker. Particular attention is on a solar flare that occurred during the SEH-3 mission. From an analysis of the spectra recorded before, during, and after the flare, and comparison of these observations with theoretical predictions from different models, information will be obtained on the origin and the process of the flare.

B. O'Shay (Electro-Physics Department) and D. L. Judge continue to analyze the X-Ray and EUV characteristics of solar flares. The long term goal of this project is to correlate solar flares and coronal mass ejections (CME) to geomagnetic storms. This information will help protect astronauts, satellite communications systems, and the electric power grid from potentially destructive solar energetic particle events.

G. J. Peters continued her study of Be Stars and the circumstellar material in interacting binaries with early B primaries. A new study of the long-period (80.86^{d} interacting binary Be star HR 2142 was initiated in collaboration with D. R. Gies (Georgia State Univ.) using data from the *IUE* archives acquired over the 18 year lifetime of this spacecraft and ground-based Hα CCD images from the Coudé Feed Telescope at KPNO. The investigation will provide information on the evolution of massive stars with binary companions that undergo mass transfer. G. Peters investigated short-term photospheric activity in Hα and He I 6678 Å in the Be star π Aqr that lost its emission-line disk in the mid-1990s. Evidence for nonradial pulsation in a high-order sectorial mode ($\ell \sim 6$) was found as well as micro-emission activity. Peters continued to serve as Editor-in-Chief of the *Be Star Newsletter*, a periodical published in both paper (D. R. Gies, Georgia State University, technical editor) and electronic (http://www.limber.org/benews/, D. McDavid, Limber Observatory, technical editor) editions for the Working Group on Active B Stars of the IAU Divisions IV (Stars) and V (Variable Stars). In 2001 March, Peters presented a series of Harlow Shapley lectures on ''The Hot Active Stars of the Night Sky'' and ''Circumstellar Material About Massive Algol Binary Star Systems'' in Cranbrook, Kelowna, and Penticton, British Columbia, Canada.

Peters collaborated with R. S. Polidan (GSFC) and D. E. Lynch (Global Science & Tech.) in an investigation of the apparent bipolar jets in the Algol binaries V356 Sgr & TT Hya. Observations with the *FUSE* spacecraft throughout totality reveal emission from O VI in both objects that implies the presence of a high temperature plasma ($\sim$300,000 K) plasma above/below the orbital plane. Such structures may be commonplace in Algol systems. As the flux from the B star is insufficient to power this ionization or drive a polar flow of material, the energy must come from the mass accretion process itself. Analysis of emission line data from O VI, Fe III, and C III is currently in progress.

Peters has continued a study of the abundances of the Fe group elements in early B stars that reside in our galaxy and the Small Magellanic Cloud. In a project with J. A. Grigsby (Ball Aerospace), the abundances of Ti, Cr, Mn, and Fe were determined in AV 304, a sharp-lined B0.5V star in the SMC, directly from photospheric lines in the FUV observed with HST/STIS. The abundances range from 0.6–1.0 dex below those observed in the sun. An average [Fe/H] of -0.61 $\pm$0.30 agrees well with the Fe abundance in the SMC determined from ISM lines. Peters & Grigsby also completed an investigation of the abundances of the Fe group elements in the ultrasharp-lined early B star ι Her using coadded high resolution *IUE* data, the Kurucz SYNTHE code, and Kurucz model atmospheres. Fe group abundances are also being determined for other sharp-lined early B stars in our galaxy. These studies provide information on the chemical evolution of our galaxy and the SMC as well as important data for determining the opacities in stellar interiors that are used in stellar evolution calculations.

G. Reaves continued a study of planetary orbital dynamics, concentrating on a novel method of short-term approximate calculations of general perturbations. He is also preparing a table of astronomical data useful for astroarchaeology. Reaves continues his voluntary activities at USC and elsewhere, including service on the Lowell Observatory Advisory Board.

C. Y. Robert Wu has continued his work with F. Z. Chen, T. Hung (Celectron International), and D. L. Judge and collaborators to obtain (1) temperature dependent cross sections of acetylene, methane, and ethylene in the UV region, (2) temperature-dependent cross sections of gaseous and liquid water and benzene in 160-180 nm region, and (3) ultrahigh resolution (FWHM = 0.0003 nm), high (650, 555, and 455 K), and room (295 K) temperature absorption cross sections of N_2 and O_2 in the 83.4, 91.7, and 108.5 nm regions. Much of the above data have been analyzed and will be made available to the planetary and aeronomy communities. The data have been applied in modeling various planetary atmospheres such as Earth, Saturn, Mars, Io, Titan, Jupiter, and Neptune.

Wu has recently implemented a joint research project with collaborators from the National Central University and the Synchrotron Radiation Research Center, Taiwan, in the study of EUV-UV photon-induced chemical reactions in $C_2H_2-H_2O$ mixed ices and CO_2-H_2O mixed ices at low temperature conditions as low as 10 K. The results obtained in this project are essential to our understanding of chemical syntheses in ice analogues, e.g., the cometary-type ices and icy satellites of planetary systems.

Wu, F. Z. Chen, T. Hung, and D. L. Judge have continued their studies of fluorescence produced through photoexcitation of CO 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 tun-

able synchrotron radiation source available at the Photon Factory, Tsukuba, Japan, was employed in the experiment. The O I and C I fluorescence excitation functions are useful in the modeling of dayglow in atmospheres of 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.

PUBLICATIONS

The publication list includes all papers published or submitted between 2000 September 1 & 2001 August 31 by permanent staff.

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Geraldine J. Peters