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The following report covers activities from September 2001 through August 2002.

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. Personnel include: (1) Space Sciences Center: Dr. Darrell L. Judge, Professor and Director of the Space Sciences Center, Dr. Geraldine J. Peters & Dr. C. Y. Robert Wu, Research Professors, Dr. Pradip Gangopadhyay & Dr. Howard S. Ogawa, Research Scientists, Dr. Fang-Zhong Chen, Postdoctoral Fellow, Jeffrey S. Nuttall, & Beau O'Shay, graduate students, and Donald McMullin, Project Manager, and (2) Department of Physics & Astronomy: Dr. Werner Däppen & Dr. Edward J. Rhodes, Jr., Professors, Dr. Vladimir Baturin, Postdoctoral Fellow, Dr. Zhigang Gong, Lecturer, Aihua Liang, Chia-Hsien Lin, Katie Mussack, & Perry Rose, graduate students, and Dr. Melvin Daybell & Dr. Gibson Reaves, Professors Emeritus. Judge, Peters, and Wu are also affiliated with the Department of Physics & Astronomy.

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. One of his activities 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. By using alternative astrophysical constraint on the chemical composition, this method can give information about the microphysics of the solar plasma. This work is now being extended from hydrogen and helium only to include heavy elements.

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 reduced if there is a thin layer of hot electrons in the upper atmosphere of Jupiter.

Gangopadhyay, V. Izmodenov, M. Gruntman (Dept. of Aerospace Engineering), J. Holberg (University of Arizona), and D. L. Judge continued 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 these difficulties have been significantly reduced. The current work uses 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.

D. L. Judge, H. S. Ogawa, D. R. McMullin, P. Gangopadhyay, and M. Daybell continued their studies of solar EUV irradiance observations from sounding rockets and satellites including SOHO. Various instruments are being utilized to obtain absolute solar EUV flux data. These include Rare Gas Ionization Cells to obtain absolute integral irradiance in a wavelength region shortward of the ionization limit of the working gas used, Double Ionization Cells 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 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 EUV irradiance that has been securing high quality data aboard the SOHO spacecraft.

D. L. Judge and D. R. McMullin have begun work on NASA's Solar Dynamics Observatory (SDO). The USC Space Sciences Center is providing two solar EUV irradiance instruments for the Extreme Ultraviolet Variability Experiment (EVE). USC will provide an OFS instrument as well as an EUV irradiance monitor similar to the Solar EUV Monitor currently operating on SOHO.

Judge, McMullin, and B. O'Shay (Electro-Physics Dept.) completed the 4th successful SOHO calibration rocket mission during the summer of 2002. The calibration payload consisted of solar EUV irradiance instruments and a duplicate of the SOHO/SEM instrument. The objective of this series of missions is to provide periodic calibration points during the SOHO mission for comparisons with SOHO EUV irradiance measurements. Over time, these successful rocket missions have been able to validate the calibration of the SOHO/SEM data.

J. S. Nuttall and D. L. Judge continue an analysis of spectral data from the Solar EUV Monitor and the Solar EUV Hitchhiker. Particular attention is devoted to a solar flare that occurred during the SEH-3 mission. The goal is to locate where there are significant differences in the spectra during, before, and after the flare, identify the spectral lines that are

responsible for these differences, and try to determine what these changes in these spectral lines reveal about the flare. From an analysis of these spectra and a comparison with theoretical predictions from different models, information will be obtained on the origin and the process of the flare.

G. J. Peters continued her study of Be Stars with emphasis on the Be stars that have been confirmed to be interacting binaries. The investigation reveals information on the evolution of massive stars with binary companions that undergo mass transfer. The circumstellar material in HR 2142 ($P = 80.86^d$) was investigated (with D. R. Gies, Georgia State University) using HIRES images from the *IUE* database that were accumulated from 1979-95 and CCD spectra taken with the Coudé Feed Telescope at KPNO between 1985-2001. Analysis of the He I 6678 Å emission suggests that it is formed in the plasma responsible for the *secondary* shell phase. HR 2142 appears to still be in the Algol phase of mass transfer but may represent an earlier evolutionary stage of ϕ Per and 59 Cyg that have O subdwarf companions. Peters continued to serve as Editor-in-Chief of the *Be Star Newsletter*, a periodical published in both paper (D. R. Gies, GSU, technical editor) and electronic (`http://www.astro.virginia.edu/dam3ma/benews/`, D. McDavid, Univ. of Virginia, technical editor) editions for the Working Group on Active B Stars of the IAU Divisions IV (Stars) and V (Variable Stars).

Peters continued a collaboration with R. S. Polidan (GSFC) on the interpretation of *FUSE* data on the Algol binaries V356 Sgr and TT Hya. Observations taken during totality reveal emission from O VI in both objects. The high temperature plasma ($\sim$300,000 K) that produces these lines appears to exist above/below the orbital plane and may be a bipolar jet. Such structures could be commonplace in Algol systems. Analysis of emission line data from O VI, Fe III, and C III is in progress. Peters presented talks on various aspects of her work on interacting binaries at IAU Colloquium No. 187 in Miami (March 2002), the 2002 *FUSE* Workshop at Johns Hopkins University (March), and the Brussels Workshop on stellar variability (July 2002).

Peters has continued a study of the abundances of the heavy elements in early B stars that reside both in our galaxy and the Small Magellanic Cloud. She embarked upon a project with S. J. Adelman (The Citadel) and C. R. Proffitt (CSC/STScI) to determine the abundances of the Fe group and s-process species in 17 cluster and field O9-B6 main sequence band objects using coadded HIRES images from the *IUE* archives. The coadded data will eventually be delivered to the MAST archive at STScI along with overplots of the best fitting synthetic spectra. Analysis of HST/STIS spectra of AV 304, a sharp-lined B0.5V star in the SMC, was completed (with J. A. Grigsby, Ball Aerospace Corp.) The abundance of Ti and Fe agrees with that from ISM lines, but the abundances of Cr and Mn appear to be 0.3 dex lower. The study of the abundances of heavy elements in the SMC continues in collaboration with S. J. Adelman using new *FUSE* observations of AV 304 and NGC346-637 that were acquired in 2002 August. The abundance 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 used in stellar evolution calculations.

G. Reaves continues his volunteer service to various organizations on the USC campus and elsewhere. He is still trying to develop–so far without success–an approximate and relatively simple method for calculating general perturbations.

E. J. Rhodes continues to run the 60-Foot-Solar-Tower at the Mt. Wilson Observatory as P.I. for the high-resolution helioseismology project that has been in operation since 1985. The telescope is operated by A. Grubb and S. Irish on every clear day collecting a series of mega-pixel sodium filtergrams obtained with the Magneto-Optical-Filter taken at a cadence of two per minute. The team continues to process the filtergrams to dopplergrams and subsequently to a reduced data product on a daily basis, adding to the growing archive of nearly 8 Terrabytes. The group will soon have a complete set of dopplergrams covering the entire observing history of the project and will send them to the Solar Oscillation Investigation group at Stanford University to be archived and analyzed and ultimately made available through the WWW.

Rhodes and J. Reiter, Technical University of Munich, Germany, are continuing their collaboration in developing techniques for fitting power spectra to obtain the high-degree p-mode frequencies that are trapped within the outer radius of the sun. Much work has already been done in correlating the frequency shifts of the p-modes with the changing levels of solar activity by utilizing dopplergrams collected by the 60-Foot-Solar-Tower and the Michelson-Doppler-Imager (MDI) on board the SOHO spacecraft. Recently, P. Rose has extended the data set by utilizing data collected by the Global Oscillation Network Group. The helioseismology group continues to collaborate with the Crimean Astrophysical Observatory and maintains another helioseismic instrument at the 60-Foot-Solar-Tower for the Birmingham Solar Oscillation Network (BiSON) in the UK.

C. Y. Robert Wu continued his work with F. Z. Chen, T. Hung, D. L. Judge, T. Matsui, and K. Ito in the measurements of (1) high pressure-induced effects of H_2, N_2, and Ar on the absorption cross sections of C_2H_2 in the VUV region (2) temperature-dependent cross sections of methane, ethane, propane, and acetylene in the VUV region, and (3) ultrahigh resolution (FWHM = 0.0003 nm) absorption cross sections of N_2 and O_2 in the 83.4, 91.7 and 108.5 nm regions under high temperature conditions (up to 650 K). The above data will be made available to the planetary and aeronomy communities in application to various models of planetary atmospheres such as Earth, Saturn, Mars, Io, Titan, Jupiter, Saturn, 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 a study of EUV-VUV photon-induced chemical reactions in pure, binary, and tertiary mixed ices at temperatures as low as 10 K. The recent studied samples include CH_4+H_2O, $C_2H_2+H_2O$, and CO_2+H_2O mixed icy systems. The results obtained in this project are important to our understanding of chemical syntheses in ice analogs, e.g., the cometary-type ices and icy satellites of giant planets.

PUBLICATIONS

The publication list includes papers published or submitted between 2001 September 1 and 2002 August 31 by permanent staff. Selected published abstracts of presentations at scientific meetings are also included.

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