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The following report covers activities from September 1996 through August 1997.

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. R. Wu, Research Professor, Drs. Geraldine J. Peters, Howard S. Ogawa, & Pradip Gangopadhyay, Research Scientists, Dr. Fang-Zhong Chen, Postdoctoral Fellow, & Donald McMullin, Project Manager, and 2) Department of Physics & Astronomy: Drs. Werner Däppen, Melvin Daybell, & Edward J. Rhodes, Professors, Andrew Jones, Postdoctoral Research Associate, Chia-Hsien Lin & Tom Hung, graduate students, and Dr. Gibson Reaves, Professor Emeritus.

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. Däppen has ongoing collaborations, supported by his NSF grant, with the leading groups that model the statistical mechanics of reacting Coulomb systems (such as in Livermore, Lyon, Strasbourg, Rostock/Greifswald). His own contribution to the field [the Mihalas-Hummer-Däppen (MHD) equation of state] is currently being used in collaboration with several international solar and stellar modeling groups.

P. Gangopadhyay, H. S. Ogawa, W. Däppen, G. Reaves, A. Jones, D. L. Judge and K. Scherer (Max-Planck Inst. für Aeronomie) have continued their work on designing a space-based light weight pinhole camera that will provide high precision measurement of the solar radius. Details of this work are given in a paper submitted to Solar Physics.

A. Jones, working with E. J. Rhodes and Chia-Hsien Lin continued to develop research in local helioseismology. These techniques allow us to explore the dynamic structure of the Sun just below the photosphere. We have embarked on a collaborative effort to reduce data from different groups, and using different techniques to explore the reliability of the results obtained by these new methods. We hope to use these local reductions to study the interaction of solar p-modes with sunspots and active regions and to learn about subsurface flows and the interaction of convection, flows and magnetic fields which give rise to the solar activity cycle.

H. S. Ogawa, M. Daybell, D. R. McMullin, and D. L. Judge have continued their work on solar EUV irradiance

observations from sounding rocket, Shuttle, and satellite. Various instruments have been and are being utilized to obtain absolute solar EUV flux data. These include Rare Gas Ionization Cells (RGIC) to obtain absolute integral irradiance in a wavelength region shortward of the ionization limit of the working gas used, Double Ionization Cells (HDIC) to obtain photoionization rates of helium and neon, Free Standing and Film Deposited Photodiodes to obtain absolute flux within the wavelength band pass of the metal filter used, Optic Free Spectrometer (OFS) to obtain spectral irradiance data in the EUV and soft X-ray region, low resolution ($<10\text{\AA}$) normal incidence spectrometer, and a Solar EUV Monitor (SEM) to obtain absolute solar EUV irradiance that has been obtaining high quality data for two years that are reliable. The SEM monitors a wavelength band pass of 8 nm centered at the prominent solar 30.4 nm emission line, with another channel that monitors a broad wavelength band pass between 0.1 and 77 nm. The data has been placed on the world wide web (http://www.usc.edu/dept/space_science/) in ten minute averaged intervals. The smallest time resolution is an integration time of 15 seconds. On August 11, 1997 a sounding rocket underflight containing an "identical" instrument as the CELIAS/SEM was flown to calibrate the instrument aboard SOHO. The SEH set of instrumentation aboard the space Shuttle (IEH mission) was launched on August 7, 1997 and remained in orbit until August 18, 1997. Successful simultaneous solar measurements were obtained on August 11, 1997 and are presently being analyzed. The SEM data aboard SOHO placed on the web are based on the June 26, 1996 calibration rocket underflight.

G. J. Peters continued a study of short-term (*daily*) photometric and spectroscopic variability in Be stars. Analysis of a large database of *IUE* data on 15 Be stars from 10 multiwavelength campaigns confirmed that the light variations are due to a modulation in the star's photospheric temperature and revealed 3 classes of behavior: 1) wind strength and FUV flux correlated, period less than the star's rotational period, and NRP modes identified from ground-based spectroscopy showing the hot crest in front when the star is bright, 2) wind strength cyclically varies but does not correlate with light variations, and 3) FUV flux varies cyclically but wind variability is minimal and does not correlate with the flux. For the latter two cases, the period is consistent with the rotation period. Analysis of long-term wind variations in λ Eri & 66 Oph confirms that most of the variability is in the DACs. Prior to an episode of wind enhancement, the DACs show the largest outflow velocities ($<-1000\text{ km s}^{-1}$) and this activity precedes the strengthening of the Balmer emission. The above results are to be presented at the ESO Workshop on "Cyclical Variability in Stellar Winds" in Garching bei München in 1997 October. Peters continued to serve as Editor-in-Chief of the *Be Star Newsletter*, which is published at Georgia State University (D. R. Gies, technical editor) in

both paper and electronic (<http://chara.gsu.edu/BeNews/intro.html>) versions for the IAU Working Group on Active B Stars.

G. J. Peters also continued to investigate the circumstellar material in Algol binary systems. In collaboration with R. S. Polidan (GSFC), she obtained FUV spectra in the 900–1220 Å region of six Algols (AU Mon, Z Vul, U CrB, TX UMa, TT Hya, and SX Cas) with the UC Berkeley spectrometer on the ORFEUS-SPAS 2 payload that was flown on STS-80 in November/December 1996. Evidence of O VI absorption was found in AU Mon ($\phi = 0.58$) and variable emission lines of numerous moderately-ionized species in SX Cas (observed during and just after totality). Using data from the *IUE* archives, Peters continued an analysis of the long-term disk & photospheric variability in AU Mon and investigated the circumstellar material in four systems (V393 Sco, FV Sco, Z Vul, and RS Vul) in which the gas stream strikes the gainer's surface at a shallow angle.

G. J. Peters and J. Grigsby (Wittenberg Univ.) completed a study of the abundances of the iron group elements in the ultrasharp-lined B3 IV star ι Her using coadded high resolution *IUE* data, the Kurucz SYNTH code, and Kurucz model atmospheres. The abundances of Ti, Cr, & Mn are slightly lower than the solar values but Co & Ni appear to be significantly depleted relative to those in the sun.

G. Reaves is continuing his studies of the orbits of Hirayama families of asteroids with a view to determining from them the nature of their formation. In August, he attended the International Astronomical Union General Assembly in Kyoto.

C. Y. Robert Wu has continued his work with F. Z. Chen, D. L. Judge, and collaborators to obtain (1) high (395 K), room (295 K) and low (150 K) temperature cross sections of CO in the 4PG A¹Π–X¹Σ⁺ (1,0) region and the temperature-dependent oscillator strengths of the A–X (1,0) and the d–X (5,0) bands, (2) temperature-dependent cross sections of NH₃ in UV region including the absorption strengths of the (0,1) and (0,2) hot bands, and (3) ultrahigh resolution (FWHM = 0.003 Å) high (555 K) and room (295 K) temperature absorption cross sections of N₂ in the 916 Å and 834 Å regions. Much of the above data have been analyzed and will be made available to the planetary community. Our data have been applied in modeling various planetary atmospheres such as those of Earth, Saturn, Mars, Io, Titan, Jupiter, and Neptune and in the evaluation and modeling of the effect of the recent Comet SL9 impact on Jupiter's atmosphere.

Wu, F. Z. Chen, Tom Hung, and D. L. Judge have continued their studies of fluorescence produced through photoexcitation of CO and CO₂ in the 28–100 eV region. They have observed, for the first time, fluorescence processes correlated with excited electronic states of doubly and triply charged molecules. This observation was possible because the newest, brightest tunable synchrotron radiation source available at the Advanced Light Source, Laboratory Lawrence Berkeley, Berkeley, was employed in the experiment. The 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 temperatures of the upper atmospheres of the mentioned planets are higher than the ambient temperature on the Earth's surface.

Wu, Chen, and P. Scoggins have continued their investigation of the solar photon sputtering/desorption of CH₄ clathrate hydrates, H₂O ices, D₂O ices, and CH₃OH ices in the inner valence and core electron regions using intense tunable VUV photon source provided by synchrotron radiation.

PUBLICATIONS

The publication list includes all papers published or submitted between 1996 September 1 & 1997 August 31 by permanent staff.

Arndt, S., **Däppen, W.** & Nayfonov, A., 1997, "On Density and Temperature-Dependent Ground-State and Continuum Effects in the Equation of State for Stellar Interiors," *ApJ*, in press.

Charbonnel, C., **Däppen, W.**, Bernasconi, P., Maeder, A., Meynet, G., Schaerer, D., & Mowlavi, N., 1997, "Grids of Stellar Models. VII. From 0.4 to 1.0 M_{sun} at Z=0.020 and Z=0.001, with the MHD Equation of State," *A&A*, submitted.

Däppen, W., 1997, "Atoms and Molecules," (invited book chapter) in *Astrophysical Quantities*, 4th ed., ed. A. Cox (American Institute of Physics), in press

Däppen, W. & Perez, A., 1997, "The Current Situation in the Solar Equation of State," in *Sounding Solar and Stellar Interiors (IAU Symp. 181)*, ed. G. Berthomieu, in press.

Gangopadhyay, P., Ogawa, H. S., Däppen, W., Reaves, G., Jones, A., Judge, D. L., & Scherer, K., 1997, "A Pinhole Camera Technique for Measurement of the Relative Solar Diameter and Solar Irradiance," 1997, *Sol. Phys.*, submitted.

Gies, D. R., Bagnuolo, W. G., Ferrara, E. C., Kaye, A. B., Thaller, M. L., Penny, L. R., & **Peters, G. J.**, 1998, "HST/GHRS Observations of the Be + sdO Binary Phi Persei," *ApJ*, in press.

Judge, D. L., McMullin, D. R., Ogawa, H. S., Hovestadt, D., Klecker, B., Hilchenbach, M., Moebius, E., Canfield, L. R., Vest, R. E., Tarrío, C., Kuehne, M., & Wurz, P., 1998, "The First Solar EUV Irradiances Obtained by the CELIAS/SEM, *Sol. Phys.*, in press.

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- Trampedach, R., **Däppen, W.**, Rogers, F. & Baturin, A., 1997, "A Comparative Study of the MHD and the OPAL Equations of State," A&A, submitted.
- Wu, C. Y. R.** & **Chen, F. Z.**, 1997, "Temperature-Dependent Photoabsorption Cross Sections of OCS in the 1600-2600 Å Region," jqsrt, in press.
- Wu, C. Y. R.**, **Chen, F. Z.**, & **Judge, D. L.**, 1997, "Temperature-Dependent Photoabsorption Cross Sections of H₂S in the 1600-2600 Å Region," jqsrt, in press.
- Wu, C. Y. R.**, **Chen, F. Z.**, **Judge, D. L.**, & Caldwell, J., 1997, "Low and Room Temperature Photoabsorption Cross Sections of NH₃ in the UV Region," Planet Space Sci., submitted.

Geraldine J. Peters