

**Florida Institute of Technology**  
**Department of Physics and Space Sciences**  
*Melbourne, Florida 32901-6988*

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The following report covers the Department activities from 1 November 1997 to 31 October 1998. Additional information about Florida Tech, the Department, and its activities can be found on our homepage at: <http://pss.fit.edu/>.

## 1. PERSONNEL

J. D. Patterson serves as Department Head, who reports to the Dean of the College of Science and Liberal Arts, G. Nelson. Faculty with instructional and research activities in areas related to Astronomy and/or Space Sciences include Professors J. Blatt, T. Oswalt, and J.D. Patterson; Associate Professors R. Jin, M. Moldwin, R. Raffaele, H. Rassoul, and M. Wood; Assistant Professor J. Mantovani; and Visiting Assistant Professor F.A. Ringwald. Graduate students in Space Sciences (or in Physics and pursuing astrophysical research projects) during this report period include T.J. Ahrens, B. Bailey, M. Bentley, B. Gilbert, M. Kaplan, P. Martin, M. Montgomery-Bobertz, T. Potdevin, B. Sheeley, and N. Silvestri. Full time post-doctoral research staff during this period included O. Giovannini, Jr. and J. Z. Li.

## 2. ACADEMIC PROGRAMS

The Department offers complete bachelors, masters, and doctoral programs in Space Sciences as well as Physics. Currently, the enrollment in Space Sciences and Astronomy/Astrophysics includes 83 undergraduates and 5 graduate students, with 2 in the doctoral track. Enrollments in Physics include 6 undergraduates and 6 graduate students, with 4 in the doctoral track.

## 3. FACILITIES AND EQUIPMENT

Florida Tech is the lead and financial institution for the Southeastern Association for Research and Astronomy (SARA), and enjoys a roughly 30% share of the available observing time on the SARA 0.9-m Telescope on Kitt Peak, near Tucson, Arizona. Other consortium members include East Tennessee State University, Florida International University, University of Georgia at Athens, and Valdosta State University. During the reporting period, Florida Tech astronomers conducted their first successful remote observations, controlling the telescope and CCD camera from the Astronomy Lab in Crawford Science Tower on campus. The SARA telescope has a fully computerized telescope and observatory control system, weather sensors, four-port instrument selector, and filter wheel. Our primary instrument is a 2Kx2K Axiom/Apogee CCD camera. Plans are underway to construct an instructional observatory on the main campus.

SARA continues its NSF-funded Research Experiences for Undergraduates (REU) Summer Intern Program. During the Summer of 1998, Florida Tech hosted four of the 12 SARA REU Interns, supplemented by two Florida Tech participants funded by other grants.

Florida Tech also is a founding member of the Florida Space Institute. FSI is a consortium of institutions interested in Space Science education and research. It is made up of Florida Tech, University of Central Florida, Embry-Riddle Aeronautical University, Brevard County Community College, NASA Kennedy Space Center, Cape Canaveral Air Station, and the Boeing Corporation. The FSI conducts “hands-on” undergraduate classes at KSC and CCAS and operates a clean room facility for student-built payload integration and testing.

The Geospace Physics Laboratory coordinates the space and atmospheric research efforts of the department and university. The GPL currently has 12 students active in research and provides office space, computational facilities, and lab space for instrument development.

The Department currently supports a cluster of Sun SPARCstation and a large number of PCs and Macs, almost all of which are linked to the Internet. The University provides a well-equipped machine shop and electronic repair facility, as well as laboratory space at the Applied Research Laboratory off campus.

## 4. RESEARCH

### 4.1 Astronomy and Astrophysics

Oswalt, J.A. Smith (Michigan), and Wood continued an NSF- and NASA-sponsored a study of wide binaries known to have white dwarf (WD) components. The sample includes over 1000 binaries and is among the deepest surveys of its type. The project’s current goal is to derive a precise luminosity function for WD components, which can be used to set important independent constraints on the age of the Galactic disk and the Universe. The results help resolve the current discrepancy between ages derived from globular clusters isochrone fits and observational determinations of the Hubble constant. The observed WD luminosity functions derived are being fit to new theoretical models computed by Wood. Preliminary results, using a carefully chosen completeness-corrected sample of 50 WDs, indicate that the age since star formation commenced in the solar neighborhood is  $\sim 10$  Gyr. Using a much larger observational sample, Smith, advised by Oswalt, verified these results in his doctoral thesis, which was completed during this reporting period.

Accounting for the time span between the Big Bang and the formation of the Galaxy and any delay between the onset of star formation in the halo and the local disk, Oswalt, Smith and Wood derived a firm minimum age of  $\sim 12$  Gyr for the Universe. New estimates for the age of the Universe, based on recent revisions to the extra-Galactic distance scale and ages of old globular clusters, are now within  $1\sigma$  of the age derived from the WDLF. Also, the integrated WDLF suggests that stellar remnants in the Solar neighborhood con-

stitute no more than a few percent of the dark matter in the Galaxy.

Oswalt and Silvestri are studying the kinematics of wide binary sample, based on observations made with the 4.0-m telescopes at Kitt Peak and Cerro Tololo. In a collaboration with N. Reid (Caltech) this work has been extended to the fainter wide binaries using the Keck 10-m telescope. Silvestri, advised by Oswalt, spearheaded this work and completed her M.S. thesis during this reporting period. Ahrens is helping Oswalt to prepare an atlas of  $\sim 1200$  wide binary spectra for publication.

Ringwald, funded by NASA/Space Telescope Science Institute, is carrying out a snapshot survey of nova shells with *Hubble Space Telescope*. This project is obtaining narrow-band images in the  $H\alpha$  and  $[O\ III] \lambda 5007 \text{ \AA}$  emission lines of the 52 Galactic novae known to have erupted since 1980. Several previously unknown shells have been discovered, and hydrodynamic modeling of the shells' expansion and morphologies is planned. Ringwald also has at least seven undergraduates involved in research projects, including compiling statistics of dwarf nova outbursts and coordinating small telescope science.

Wood, funded by the NASA Astrophysics Theory Program, continued his research studying white dwarf evolution, and the use of these numerical model results to explore the age and star-formation history of the local Galactic disk. Wood and Oswalt (1998) published a preliminary Monte Carlo study of the kinematics and luminosity function of white dwarf stars.

Wood, collaborators M. Bolte (UC/Lick Obs.) and C. Claver (NOAO), and Florida Tech graduate student T.J. Ahrens are analyzing data the old open cluster M67 with the Keck telescope searching for the complete white dwarf cooling track. The cumulative luminosity function of these stars will provide an age estimate for M67 which is essentially independent of uncertainties in main-sequence evolutionary calculations. The white dwarf age will be compared with the age obtained through isochrone fits, thus cross-calibrating the two techniques. Wood and a large team of US and Canadian astronomers were granted *Hubble Space Telescope* Cycle 7 time for a similar project to observe white dwarfs in the open cluster NGC 188.

Wood and J.C. Simpson are continuing their simulations of the accretion disk dynamics in cataclysmic variable (CV) systems using the method of smoothed particle hydrodynamics (SPH). Simpson and Wood (1998) recently published a study of the superhump instabilities in low-mass-ratio CVs. They found that the viscous energy dissipation time series of the purely hydrodynamic accretion disk simulations display remarkable similarities with the observed light curves of dwarf novae superhumps in general, and the AM CVn subclass of dwarf novae specifically. The amplitudes and relative phases of the harmonics in the power spectrum during both the superhump growth phase and when the resonance is saturated agree well with the observations. The morphology of the mean pulse profile at saturation appears to be a useful predictor of system mass ratio.

Wood continues his collaboration with the Whole Earth Telescope (WET) and Delta Scuti Network (DSN) of observ-

ers, and uses the SARA Observatory as a node in these networks.

## 4.2 Planetary and Space Physics

Jin is continuing his research on the time-series analysis of geomagnetic reversal records. This is to ascertain whether the process is a deterministic chaos or a random process.

Moldwin and Rassoul are active in a variety of atmospheric and magnetospheric plasma physics topics including: (1) the structure and dynamics of the Earth's plasmasphere; (2) propagation of ULF waves within the Earth's magnetosphere, and (3) observing upper atmospheric lightning from space and the ground.

The first project is supported by a NASA Space Research and Technology grant and Los Alamos National Laboratory's Space and Atmospheric Sciences Group. It involves analysis of a suite of geosynchronous and geosynchronous-transfer orbit satellites to study the behavior of the low-energy plasma environment. Several undergraduate and graduate students are currently participating in this research.

The second project is supported by a NSF CAREER award and involves developing a meridional ground array of 5 closely spaced pairs of magnetometers from Florida to Canada. The data will be used to better understand the mechanism by which magnetic wave energy propagates throughout the magnetospheric system. The project is being developed in collaboration with the University of California-Los Angeles, Boston University, Newcastle University in Australia, the Johns Hopkins University's Applied Physics Lab, the US Geological Survey and the Canadian Geological Survey.

The third project is being supported by a Research Corporation Cottrell Scholar Award, the Florida Space Grant Consortium, and the Florida Space Institute and involves developing a student built payload to be flown on the space shuttle. The Radio, Optical, Gamma ray, Undergraduate Experiment (ROGUE) project will look for the correlation of Sprites with lightning activity, terrestrial gamma ray bursts, and radio noise. Also, a collaboration with NASA Kennedy Space Center's Lightning Detection and Ranging Facility helps to understand upward propagating lightning phenomena in terms of well studied tropospheric lightning processes.

## 4.3 Space Sciences

Patterson is finishing a program funded by NASA and Universities Space Research Association (USRA) on the electron properties of narrow gap semiconductors. Assisting in this work are Mantovani and Li. Patterson and Li have done an extensive set of calculations on Mercury Cadmium Telluride (MCT) and Mercury Zinc Telluride (MZT). This research is focusing on using scanning tunneling optical spectroscopy to characterize the material. These materials are important components of infrared detectors used in astronomy. This work concentrates on the theory of the STM when the sample is illuminated.

Raffaella and Mantovani are interested in synthesizing and characterizing thin film materials that can be used in photovoltaic solar cells for space applications. Multilayered

thin films of copper indium diselenide (CIS) are being synthesized by means of the cost-effective method of electrochemical deposition. CIS is a leading alternative to silicon for use in solar cells due to its optical absorption and electrical properties. After fabrication, the multilayered thin film structures are characterized using x-ray diffraction (XRD), energy dispersive spectroscopy (EDS) in a scanning electron microscope (SEM), optical spectroscopy, and scanning tunneling microscopy (STM). This project has been supported in recent years by funding from the Florida Solar Energy Center, Florida Space Grant Consortium, Oak Ridge Associated Universities, and the Southeastern Universities Research Association. Raffaele is currently collaborating on a related project with researchers at the NASA Lewis Research Center in Cleveland. There are three graduate students currently involved in the project, as well as several undergraduate students who are involved on a part-time basis. Raffaele is also currently involved in an undergraduate SEDS project in which the undergraduate students are designing a microgravity experiment intended to fly on a future space shuttle mission as part of a "get-away-special" canister.

#### 4.4 Instrumentation

Blatt continues his work on Moiré Profilometry on structures and has developed optical non-contact methods to measure the shape of a surface or to compare its shape to a finished shape. The technique has applications to robot assembly and space alignment, ranging and docking and automated assembly. He has developed a real time optical processor to do real time 3-D object recognition. Another optical processor can produce real time spectra of an image with military, industrial and pollution control applications. Neural-net image processing has been used to automatically locate damage in structures. Blatt has received several grants from Holmes Regional Medical Center to study imaging and reconstruction of limbs, to develop eye testing software, to design instrumentation to aid in the diagnosis of temporomandibular joint disorder (TMJ), and to develop statistical methods to analyze measures of disability.

Blatt is working on new designs of visible and near IR hyperspectral imaging spectrometers which would allow the simultaneous acquisition of one or two spatial and one spectral dimensions with one or two CCD sensors. These instruments obtain  $\sim 102$ - $103$  spectral channels for  $\sim 102$ - $103$  spatial channels simultaneously.

Moldwin is currently developing a low-cost and low-noise induction coil magnetometer. This instrument is supported by a grant from the National Oceanographic and Atmospheric Administration Space Environment Center. He is also faculty advisor for Florida Tech's Space Shuttle Get-Away Special Canister (GAS-CAN) project. A GAS-CAN is a small self-contained experiment that flies in the space shuttles cargo bay. Florida Tech has proposed to fly two experiments: a materials science experiment led by Raffaele, and an upward propagating lightning detector led by Moldwin and Rassoul. Currently over 12 undergraduate students are active in developing this GAS-CAN project.

#### 5. OTHER ACTIVITIES

Blatt served as an Associate Editor for the *Journal of Manufacturing Engineering*, and a reviewer for *Applied Optics*, *Optical Engineering*, and the *Journal of Manufacturing Engineering*. He also served as a Program Committee Member for the Three-Dimensional Imaging and Laser-Based Systems for Metrology and Inspection session at the SPIE Intelligent Systems and Advanced Manufacturing Conference, Boston, November 1998.

Jin is completing the final phase of a two-year NSF Grant for laboratory improvement. The title of the project is "Implementation of Virtual Instrumentation in a Senior Physics Laboratory."

Moldwin was a reviewer for the *Journal of Geophysical Research*, *Geophysical Research Letters*, *Journal of Geophysics and Geomagnetism*, the NSF, and NASA's Space Research & Technology program.

Oswalt served on peer review panels for the NSF and for NASA during this reporting period. He continued as Editor of the I.A.P.P.P. Communications and worked on behalf of the American Astronomical Society as a Harlow Shapley speaker as well as a Special Awards Judge for the AAS Bart and Priscilla Bok Awards at the annual Intel International Science and Engineering Fair (ISEF). He was active in public outreach activities, such as "Science Mentor" for National Public Radio, and "Ask the Expert" for Scientific American. Oswalt served as the Chair of SARA, and as the SARA-REU Program Director until August 1998, when he assumed the position of Program Director for Stellar Astronomy and Astrophysics at the National Science Foundation. He will be on leave from Florida Tech for this 1 - 2 year appointment.

Patterson, Rassoul, and S. Billings (Univ. Idaho) are developing a book with the working title "Problems in the Space Sciences: Fundamental Physics of the Space Sciences (with Solutions)."

Rassoul was a peer reviewer for the U.S. Environmental Protection Agency for grants, cooperative agreements and applications for Graduate Education Fellowships in environmental fields of study. Rassoul was a reviewer for the *Journal of Geophysical Research* and NASA's Space Research & Technology program.

Ringwald has taken over as Coordinator of the North American Small Telescope Cooperative.

Wood is currently serving as the Chair of SARA, and is the SARA-REU Program Director. He was a referee for the journal *SCIENCE* and proposal reviewer for NASA's *Extreme Ultraviolet Explorer* satellite.

Wood and Mantovani received funding from the NSF Instrumentation and Laboratory Improvement (ILI) program for a Computational Physics Laboratory.

#### PUBLICATIONS

*The publication list includes papers published or submitted between November 1997 and October 1998 by the Department staff.*

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- Moldwin, M.B. 1997, “Outer Plasmaspheric Plasma Properties: What We Know from Satellite Data,” *Space Science Rev.* 80, 181.
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