Northern Arizona University
Department of Physics and Astronomy
Flagstaff, Arizona 86011-6010

1. PERSONNEL

1.1 Department of Physics and Astronomy

Astronomers on the faculty of the Department of Physics and Astronomy at Northern Arizona University were K. DeGioia-Eastwood, C. A. Griffith, R. C. Hall, B. L. Lutz, A. P. Odell, and R. L. Wildey. Lutz has served his third year as department chair during this period. Adjunct research professors included J. S. Gallagher, D. Hunter, T. Kreidl, C. Shoemaker, E. Shoemaker, and M. Womack. P. Massey and W. Romanishin supplemented the faculty during the summer as visiting faculty.

During the 1994/1995 period covered in this report S.C. Tegler joined the faculty. Tegler obtained his B.S. and Ph.D. Degrees in Physics from the State University of New York at Stony Brook and Arizona State University, respectively. After completion of graduate work, Tegler held post-doctoral and faculty fellow appointments at the University of Florida and the University of Notre Dame, respectively.

The summer of 1995 marks the fifth year of the Research Experiences for Undergraduates program held at NAU, funded by NSF and directed by K. DeGioia-Eastwood with W. Romanishin, University of Oklahoma, acting as chief mentor. Eight undergraduates selected nationally worked with NAU, NURO, and Lowell Observatory astronomers. The students were M. Agner, A. Coil, E. Fierce, M. Hoffman, C. O. Johnson, J. Plummer, D. Soliz, and M. Schwartz.

1.2 The National Undergraduate Research Observatory

The members of the National Undergraduate Research Observatory (NURO) Consortium were Alma College, Ball State University, Benedictine College, Central Michigan University, Denison University, Dickinson College, Franklin and Marshall College, Gettysburg College, the University of Nevada at Las Vegas, the University of Oklahoma, Lowell Observatory, Maria Mitchell Observatory, Northern Arizona University, and Western Connecticut State University. During the 1994/1995 period covered in this report, Colorado College withdrew from the Consortium and Widener University became the newest member. B. W. Taylor, employed by NAU, continued as astronomical instrument specialist and K. DeGioia-Eastwood continued as Director of NURO.

2. FACILITIES

2.1 Deparment of Physics and Astronomy

NAU maintains a 0.6-m telescope on campus, which is primarily for undergraduate classwork and the public program. Two small CCD camera are currently being utilized for both imaging and spectroscopy by undergraduate students in the department. In tandem with the main campus observatory, a roll-off roof protected observing platform with six ten-inch Meade Schmitt-Cassigrain telescopes are available for labs at all scholastic levels.

The department has continued its participation in the operation of the Lowell 0.8-m telescope on Anderson Mesa and, with Lowell Observatory, is a co-sponsor of NURO which uses this facility.

The Northern Arizona University facility known as Robot Lunar Observer became operational under the direction of Robert Wildey in collaboration with Hugh Kieffer of the U. S. Geological Survey Astrogeology Team. Though only the spectral region covered by 23 narrow-band filters from 350 to 1000 nm is presently functional, arrangements are under way in cooperation with George Rieke of the Steward Observatory to provide a NICMOS array that will utilize about seven bands from 1 to 2.6 microns. It will be a 256 x 256 array in a LN2 dewar with cooled filters, mounted on a separate bore-sighted Ritchey-Cretien telescope of 20 cm aperture. Delivery is expected in approximately nine months. The present system uses a 512 x 512 CCD on the same size telescope. Data collection has been hampered by weather and mechanical debugging, but stands at about two lunations. A four year NASA contract to observe at every opportunity for the next four years, which will provide a comprehensive photometric model of the Moon, including selenographic variegation, for the purpose of radiometric calibration of EARTH OBSERVING SYSTEM, is pending. All in-dome absolute calibration sources are in place and will be periodically recalibrated by the EOS traveling radiometer. A by-product will be a revised absolute calibration of the system of stellar magnitudes and colors.

2.2 The National Undergraduate Research Observatory

NURO uses the Lowell 0.8-m telescope on Anderson Mesa outside of Flagstaff. The primary instrumentation is a Photometrics camera with nitrogen cryogenics using a Tektronix back-illuminated 512 x 512 CCD with a Metachrome coating. In addition to the Photometics CCD, JPL donated the TI 800 x 800 CCD that had previously been on long term loan to NURO.

3. RESEARCH

3.1 Department of Physics and Astronomy

DeGioia-Eastwood was a member of the AASTRA (American Astronomical Society Teacher Resource Agents) team. The summer of 1995 was the second of three years in which a group of twenty-five K-12 teachers, nationally recruited and selected, came to Flagstaff to become resource agents for the AAS. The teachers learned to use the best available hands-on educational materials available in astronomy, and also trained to give workshops on these materials to other teachers in their home states. DeGioia-

Eastwood was site director for Flagstaff; the other two sites were the University of Maryland and Loyola University in Chicago. During the school year she attended workshops given by the participants in their home states.

Griffith has focused initially on several related studies of the atmosphere of Titan, Saturn's largest moon. The techniques developed in these studies will later be used to investigate the history of other planetary atmospheres. Titan's atmosphere offers a unique opportunity to study the evolution of an atmosphere that is similar to Urey-Miller models of the Earth's early atmosphere. It is nitrogen-based, has a complex organic chemistry, has a complicated surface and atmosphere interdependence and a surface pressure similar to that of the Earth. Titan also distinguishes itself by being the only moon in the outer solar system with a substantial atmosphere.

Griffith has pursued infrared observations to address questions on the composition of atmospheres and surfaces that relate to their formation and subsequent evolution. Titan's surface may be regarded as the largest frontier in the Solar System, since its surface has only recently been ''seen.'' Griffith (and several colleagues) have discovered several narrow spectral regions in which Titan's atmosphere is transparent enough to allow visibility of its surface. Investigation of these spectral regions have been carried out on the CGS4 on UKIRT in an effort to determine the composition of Titan's surface, which is the most likely source of the organic material in Titan's atmosphere, and which is important to the understanding of how this atmosphere evolved. Also, infrared observations of airless saturnian satellites to study the organic and volatile composition of these ices. Lastly, at present, Griffith is working most vigorously to understand, from observations of the SL9 impact with Jupiter, the dynamics and the shock chemistry of cometary impacts in atmospheres.

Lutz continued his research on comets in collaboration with M. Womack. Their current effort centered on the analysis of gas and dust in comet Brorsen-Metcalf.

In addition, Lutz and collaborators T. Snow (U. Colorado), R. Crutcher (U. Illinois), J. Black (U. Arizona), and E. Van Dishoeck (Netherlands) completed a paper on the analysis of Hubble Space Telescope spectra of HD154368, analyzing the interstellar atomic abundances along the line of sight towards it.

Odell finished the analysis of photometry of the close-eclipsing binary W Corvi, and found that even though the two stars are in contact, they have substantially different temperatures (by over 20/mitigate this seeming impossibility is to put a cool spot on the end of the secondary star opposite the neck. This has the added effect of not requiring the stars to be in contact. In order to distinguish between these two possibilities, Odell and Ferbiak (an undergraduate student at NAU) obtained high resolution spectra with the Perkins 72-inch telescope.

Odell also finished an analysis of the apsidal motion and pulsation characteristics of Alpha Virginis (Spica), with W. D. Pesnell, (Nomad Research) using the 1993 Opal Opacities tables. It was found that all of the binary star properties could be fit by models in the overall contraction phase (after core hydrogen depletion of the primary), but that the pulsation characteristics could not be accommodated by such models. Recent spectroscopic measurements of this star indicate that the primary might be overly enriched in Helium abundance by about a factor of two, perhaps by non- convective mixing. The effects of this on the structure and pulsation are now being investigated.

Odell and K. Rakos (U. Vienna) continued observing high-redshift clusters of galaxies with Stroemgren filters matched to the redshift of the cluster, using the CCD at the Steward Observatory 90-inch telescope. This is a sensitive method for identifying galaxies with star formation, and will be used to correlate star formation with environmental factors in the clusters.

During the last year, Tegler and collaborators have been carrying out astronomical research supported by the NASA Origins of Solar Systems Research Program. In one program, Tegler and D.A. Weintraub (Vanderbilt U.) have provided tantalizing evidence for the existence of solid organic material in the mantles of pre-cometary icy grains located in circumstellar environments around young stars. Also, they have suggested a possible mechanism for the synthesis of the organic material. A similar mechanism may have occurred in pre-cometary material early in the history of the Solar System. The delivery of organic rich material to the surface of the Earth through comet impacts may have played a key role in prebiotic chemistry.

Tegler and W.J. Romanishin (U. Oklahoma) have been carrying out physical and chemical studies of recently discovered Trans-Neptunian Objects (TNOs). The discovery of TNOs represents one of the most exciting advances of planetary astronomy during the 20th century. Visible and infrared imaging of these objects will establish whether or not solar wind and cosmic ray impacts of TNO surfaces synthesizes complex organic molecules.

In a third program, Tegler and F. Salama (NASA Ames) have been testing the hypothesis that ionized polycyclic aromatic hydrocarbons are the carriers of the diffuse interstellar bands. These programs make use of observations obtained at the Lowell Observatory 31-inch Telescope, Steward Observatory 90-inch Telescope, NASA Infrared Telescope Facility, United Kingdom Infrared Telescope, and the Kitt Peak National Observatory Coude Feed Telescope.

Brian W. Taylor