

Vanderbilt University
Dyer Observatory
Nashville, Tennessee 37235

[S0002-7537(98)03101-1]

This report covers the period 1 October 1996 through 30 September 1997.

1. PERSONNEL

Teaching faculty were Douglas S. Hall, Arnold M. Heiser, David A. Weintraub, Didier Saumon, Timothy H. Farris, and Richard F. Gelderman. Farris joined us in September 1996 and Gelderman in September 1997, as Adjoint Professors. Charles H. McGruder continued as Adjunct Professor. Research Associates were John H. DeWitt, Joel A. Eaton, Francis C. Fekel, and Gregory W. Henry. André M. Hedrick continued as Observatory Superintendent, Betty L. Thurston as Observatory Secretary, and Jami C. Awalt as Observatory Librarian.

Observatory Assistants were (Vanderbilt students) Jeffrey S. Bary, Lionel J. Crews, Michael J. Dorris, Carlos G. Hernandez, Tracy L. Huard, Manuel Morales, Laszlo Sturmann, (members of the Barnard-Seyfert Astronomical Society) Mike Benson, Michael Crist, Powell Hall, Jason Holley, Warren Kirbo, Hank and Mariana Levine, Waylena McCully, Tom Murdic, Dudley Pitts, Bill Rodriguez, Lloyd and Kathy Watkins, Lee Wood, and (others) Valerie Hedrick, Tony Kaye, Syd Phillips, Linda Sparks, and Branson Thurston.

The Ph.D. degree in Physics was awarded to Sturmann.

2. RESEARCH

Crews continues his work on mapping the surfaces of heavily spotted stars using the technique of Matrix Light Curve Inversion, in collaboration with R.O. Harmon (Randolph-Macon College).

Crews, Bary, and Sam Knapper (high school student from Nashville) have been using the Dyer Observatory 24-inch for photoelectric photometry to determine times of minimum for several RS CVn-type eclipsing binaries.

Crews and Hall are coordinating the photometric campaign, described in the Crews *et al.* (1996) paper listed in Section VI of this Annual Report, to obtain a complete light curve of the RS CVn-type binary BE Piscium recently discovered to be eclipsing.

Crews and Hall are analyzing all existing photoelectric photometry of another recently discovered RS CVn-type eclipsing binary HD 223971. After correcting for the distortion by starspots, they will use the Wilson-Devinney model to solve the light curve.

Dorris interned at the S.A.O. during the summer, as part of their R.E.U. program, doing research with Brian McNamara and Alexey Vikhlinin on the problem of finding a photometric magnitude vs. redshift relation for distant clusters of galaxies.

Hall and Henry collaborated with A.B. Kaye (G.S.U.) on photometry of several newly discovered and already known variables of the gamma Doradus-type, with Vanderbilt's 16-inch APT in Arizona.

Heiser used the 24-inch Reflector-Corrector at Dyer Observatory to obtain photographic plates of Comet Hale-Bopp on ten nights in April and May of 1997.

Huard had an observing run at Cerro Tololo on the 1.5-meter with the CTIO infrared imager CIRIM, on December 26 through 29, 1996.

Huard and Weintraub were awarded observing time on the James Clerk Maxwell telescope with the SCUBA detector, for sub-millimeter observation of cold IRAS sources associated with Bok globules.

With graduate student D.J. Wagner, Saumon has fitted the interaction potentials of his model for the equation of state of hydrogen to recent measurements of the temperature of shock-compressed deuterium (Holmes *et al.* 1995). The conditions achieved in these experiments are representative of the envelope of Jupiter and thus represent useful constraints on astrophysical equations of state. Work on reproducing the pressure-density measurements of Da Silva (1997) on shocked deuterium at pressures up to 2 Mbar is in progress. By adjusting the thermodynamic model of hydrogen to reproduce these two recent and important data sets, Saumon plans to derive a much better description of the pressure ionization of this element.

Saumon has used the evolutionary sequences of very low-mass stars that he has calculated with his collaborators at the University of Arizona and at New Mexico State University to analyze the new determinations of masses and radii for the two stars in the lowest mass eclipsing binary known, CM Dra (McCook *et al.* 1997). He finds a significant discrepancy (at the 2% level) between the slope of the mass-radius relation implied by the two stars (roughly 0.22 solar mass each) and that of the models. This is also true of other published models of very low-mass stars and may open a new avenue of investigation into the physics of stars of very low mass.

This collaboration has also pursued their work on the atmospheres of extra-solar giant planets and brown dwarfs (Burrows *et al.* 1997). The first grid of models from 100 K to 1100 K has been completed and used to compute high-resolution spectra and evolutionary models for these new astrophysical objects. Fluxes in different bandpasses are compared to the sensitivity of several current and planned space and ground-based instrumentation and reveal that such objects will be significantly easier to detect in the near infrared than had previously been thought.

Sturmann completed his Ph.D. Dissertation, with the title "A New Method for Observations of Lunar Occultations," and began a post-doctoral position with the C.H.A.R.A. group at Georgia State University.

Weintraub has written a paper examining the astronomical accuracy in the dramatic play about the trial of Galileo called "Lamp at Midnight" by Barrie Stavis. This play, considered one of the best plays by an American playwright of the 20th century, is the basis for a course on science and religion taught by Weintraub.

Weintraub, with Kastner, Zuckerman, and Forveille, used the X-ray fluxes in the ROSAT All-Sky Survey Catalogue to demonstrate that a small group of stars known as the TW Hya Association is a cluster of T Tauri stars located only 39-to-60 parsecs from the Sun.

Weintraub, Tegler, and Romanishin, using near-infrared colors, found that the Centaur 1995 GO is one of the reddest objects in the solar system.

Weintraub, with Kastner and Gatley, has begun work using the high-resolution near-infrared spectrometer Phoenix to carry out a detailed study of planetary nebulae, protoplanetary nebulae, T Tauri stars, and protostars in the 2.122 micron line of molecular hydrogen.

Weintraub continues his work with the Hubble Space Telescope. Work with the Faint Object Camera on the supergiant VY CMa, done with Kastner, reveals that the high mass loss rate of this dying star is in part controlled by a massive circumstellar disk. Work, with Huard and Kastner, on modelling the polarization data obtained for HL Tauri with WFPC2 continues. In addition, this team is scheduled to obtain polarimetric and near-infrared imaging data with NICMOS for the star T Tauri during HST Cycle 7.

The 24-inch at Dyer Observatory was used for research by science teachers, with their students, from three local high schools: Bill Rodriguez (University School of Nashville), Carrie Thornthwaite (Glenclyff High School), and Terry King (Hunters Lane High School).

3. TELESCOPES AND INSTRUMENTATION

We acquired, from the College of Arts and Science, ten additional 8-inch Celestron telescopes, for use with the evening labs that are part of our introductory astronomy classes at Vanderbilt, which are experiencing increased enrollments. The total number of 8-inch Celestron telescopes is now twenty.

Myron Manker (a Vanderbilt alumnus) kindly donated a Meade 2080/LX3 telescope plus many accessories, including several Telvue, Plossl, and Nagler eyepieces.

Thanks to major donations from three of the individuals mentioned in Section V of this Annual Report (E.F. Bergquist, M.F. Bergquist, G.N.B. Trommald) and additional donations from many members of the Barnard-Seyfert Astronomical Society, we acquired a Celestron 14-inch telescope and a 12-foot Ash dome. Once permanently situated at Dyer Observatory, this will be for use primarily by local amateur astronomers of the B.S.A.S.

A complete refurbishment of the DeWitt 12-inch telescope and its dome, which were donated in 1975 and dedicated in 1983, is underway.

The Linux device driver for our SpectraSource HPC-1 CCD camera has been completed under developmental Kernels 2.1.xx, except for fine tuning.

The Precision Clock System (PCS, patent in process) has started commercial production for sale. The PCS is a millisecond precision time base separate from the main board RTC. Combining the HPC-1 and the PCS has yielded interrupt-timed and memory-limited extended image exposures.

TDI drift scanning has been implemented successfully with a non-TDI camera. Extended field exposures have provided a possible new or enhanced method of CCD photometry.

The instrument control and data reduction work station has been upgraded from a 486 PC to an SMP Dual 200 Pentium P5. Using CPU task assignment should make it possible to do "on the fly" data reduction under IRAF.

Power management problems for all Linux work stations have been solved finally with American Power Conversion UPS's and writing "apcupsd," which is daemon for Linux, for managing the UPS's.

4. MEETINGS

The "Carl K. Seyfert Lecture in Astronomy," established in and first given in 1983, was given again in September 1997 by Geoffrey W. Marcy of San Francisco State University, who talked about "First Reconnaissance of Planets Orbiting Other Suns."

Dyer Observatory offered a "Photometry Summer School," held at Dyer Observatory and lasting seven days in June of 1997. Instructors were Rodriguez (University School of Nashville), Hall, Hedrick, Heiser, and Henry.

Dyer Observatory also hosted its Second Annual I.A.P.P.P. Symposium at Dyer Observatory (June 1997). Talks were given by Weintraub, Sturman, Henry, Eaton, Heiser, Hedrick, and Hall, and two by Crews.

At the Fourth Midwest I.A.P.P.P. Symposium in Williams Bay, Wisconsin (October 1996) a talk was given by Heiser.

At the 28th Annual Meeting of the A.A.S. Division of Planetary Sciences in Tucson, AZ (October 1996) three papers were given by Saumon and one by Weintraub.

At the 28th Annual Lunar and Planetary Science Conference in Houston, TX (March 1997) a paper was given by Weintraub.

At the joint APS/AAPT meeting in Washington, DC (April 1997) an invited review talk was given by Saumon.

At the Gordon Conference on "Origins of Solar Systems" in Henniker, NH (June 1997) talks were given by Huard and Weintraub and by Saumon.

At the 190th meeting of the A.A.S. in Winston-Salem, NC (June 1997) papers were given by Huard, by Saumon, and two by Weintraub. Bary and Crews attended.

At the 10th Cambridge Workshop on Cool Stars, Stellar Systems and the Sun in Cambridge, MA (July 1997) papers were given by Hall and Kaye, by Saumon, and by Weintraub. Dorris attended.

At the 29th Annual Meeting of the A.A.S. Division of Planetary Sciences in Cambridge, MA (July 1997) two papers were given by Saumon and one by Weintraub.

At the 191st meeting of the A.A.S. in Washington, DC (January 1998) papers will be given by Crews and by Huard.

5. MISCELLANEOUS

Heiser was one of the instructors at the Dyer Observatory Photometry Summer School, participated in the Vanderbilt Summer Science Collaborative program for high school students and their science teachers from Tennessee, participated

in the Tennessee Visiting Scientist program, and continued as Subscriptions Editor of the I.A.P.P.P. Communications.

Hall continued serving on the Board of Trust of Fairborn Observatory, as an Assistant Editor of the I.A.P.P.P. Communications, on the Editorial Board and the Education Advisory Board of the A.A.V.S.O., as a Member at Large on the Board of Directors of S.A.R.A., and on the Editorial Board of the I.B.V.S. He also was an instructor at the Dyer Observatory Photometry Summer School.

Weintraub again participated in the Vanderbilt Summer Science Collaborative program for high school students and their science teachers from Tennessee and, for the first time, taught an entire elementary school (K-4) about comets.

The monthly open house nights at Dyer Observatory for the general public and the extra open house nights for special groups of young people have continued. We now have added extra open house nights for high school students. And in the Spring of 1997 we opened the observatory on about a dozen nights for the public to view comet Hale-Bopp.

Visiting astronomers during the period of this report were Peter Biermann, John C. Brandt, Rick Chappel, David J. Jeffery, Anthony B. Kaye, Geoffrey W. Marcy, Paul Richards, William Schopf, and James C. White.

The entire staff of Dyer Observatory is very grateful to all who have generously supported its research and other activities. These include the College of Arts and Science, the Vanderbilt University Research Council, the NSF, NASA, the Theodore H. Dunham Fund for Astrophysical Research, Timothy Amstutz, Weaver Barksdale, Mike Benson, E. F. Bergquist, M. Fráncille Bergquist, Herbert Crowder, Scott Degenhardt, Thomas Duncan, Mimi K. Hall, Jason Holley, Daniel Jared, James Kelley, Santos Lopez, Myron Manker, Kristine McCall, Mary McClure, Mitchell Moody, Stephanie Anne Gannaway Osborn, Bradley Overton, Dudley Pitts, Curt Porter, Bill Rodriguez, Michael Schmerling, Isaac Silver, Michael Snowden, Giuseppe Sosta, Gae Nelle Trommald, Arthur Ward, Lloyd Watkins, and Calvin Young.

PUBLICATIONS

- Burrows, A., Hubbard, W.B., Lunine, J.I., Guillot, T., Saumon, D., Freedman, R.S. (1996) "Evolutionary Models of Extra-solar Giant Planets and Brown Dwarfs," *BAAS*, 28, 1113.
- Crews, L.J., Hall, D.S., Henry, G.W., Fekel, F.C. (1996) "BE Piscium - A Perfect Eclipsing Variable Needing Observation," *I.A.P.P.P. Communication*, 65, 43.
- Hall, D.S. (1996) "A New Venture at Vanderbilt University's Arthur J. Dyer Observatory," *I.A.P.P.P. Communication* no. 63, 78.
- Hall, D.S. (1996) "Ellipsoidal Variables" in *Light Curves of Variable Stars*, edited by C. Sterken & C. Jäschek (Cambridge: Cambridge Univ. Press), p.117.
- Hall, D.S. (1996) "BY Draconis Variables" in *Light Curves of Variable Stars*, edited by C. Sterken & C. Jäschek (Cambridge: Cambridge Univ. Press), p.120.
- Hall, D.S. (1996) "FK Comae Variables" in *Light Curves of Variable Stars*, edited by C. Sterken & C. Jäschek (Cambridge: Cambridge Univ. Press), p.123.
- Hall, D.S. (1996) "Algol-Type Eclipsing Binaries" in *Light Curves of Variable Stars*, edited by C. Sterken & C. Jäschek (Cambridge: Cambridge Univ. Press), p.168.
- Hall, D.S. (1996) "Beta Lyrae-Type Eclipsing Binaries" in *Light Curves of Variable Stars*, edited by C. Sterken & C. Jäschek (Cambridge: Cambridge Univ. Press), p.173.
- Hall, D.S. (1996) "RS Canum Venaticorum-Type Eclipsing Binaries" in *Light Curves of Variable Stars*, edited by C. Sterken & C. Jäschek (Cambridge: Cambridge Univ. Press), p.178.
- Hall, D.S. (1996) "The 1996 I.A.P.P.P. Symposium at Dyer Observatory," *I.A.P.P.P. Communication* no. 65, 50.
- Heiser, A.M. (1996) "Photometry of the RR Lyrae Variable U Comae," *AJ*, 112, 2142.
- Heiser, A.M. (1997) review of "Nebulous Earth: The Origin of the Solar System and the Core of the Earth from Laplace to Jeffreys" by S. Brush, *Science Books and Films*, 33, 38.
- Heiser, A.M. (1997) review of "The Nature of Time and Space: Stephen Hawking and Roger Penrose," *Science Books and Films*, 33, 183.
- Huard, T., Weintraub, D.A., Kastner, J.H. (1997) "Bipolar Outflow Sources in the Serpens Core: SVS 2 and SVS 20," *MNRAS*, 290, 598.
- Huard, T., Weintraub, D.A., Kastner, J.H. (1997) "Polarization Modelling of Protostellar Environments with Large Dust Grain Distributions," *BAAS*, 29, 833.
- Kastner, J.H., Zuckerman, B., Weintraub, D.A., Forveille, T. (1997) "X-Ray and Molecular Emission from the Nearest Region of Recent Star Formation," *Science* 277, 67.
- Lunine, J.I., Hubbard, W.B., Burrows, A., Sharp, C., Sudarski, D., Marley, M.S., Guillot, T., Saumon, D., Freedman, R.S. (1997) "Cloud Formation in Extra-Solar Giant Planets," *BAAS*, 29, 1024.
- Marley, M.S., Guillot, T., Saumon, D., Freedman, R.S. (1996) "Model Atmospheres and Spectra of Extra-solar Giant Planets," *BAAS*, 28, 1114.
- Marley, M., Gelino, C., Loeber, D., Stephens, D., Lunine, J., Burrows, A., Hubbard, W., Guillot, T., Freedman, R., Saumon, D. (1997) "Model Visible and Near-Infrared Spectra of Extrasolar Giant Planets" *BAAS*, 29, 1024.
- McCook, G.P., Guinan, E.F., Saumon, D., Kang, Y.W. (1997) "Eclipsing Binaries as Astrophysical Laboratories: CM Draconis - Absolute Physical Properties of Low Mass Stars and an Independent Estimate of the Primordial Helium Abundance," *BAAS*, 29, 810.
- Olah, K., Kvari, Z., Bartus, J., Strassmeier, K.G., Hall, D.S., Henry, G.W. (1997) "Time-Series Photometric Spot Modelling. III. Thirty Years in the Life of HK Lacertae," *A&A*, 321, 811.
- Parker, J.W., Stern, S.A., Festou, M.C., A'Hearn, M.F., Weintraub, D.A. (1997) "Ultraviolet Observations of 2060-Chiron with the HST/FOS: Probing a Centaur's Grey Matter," *AJ*, 113, 1899.
- Parker, J.W., Stern, S.A., Festou, M.C., A'Hearn, M.F., Weintraub, D.A. (1997) "The First HST UV Spectroscopic Observation of Chiron in Outburst," *28th Annual Lunar & Planetary Science Conference*, p.1075.
- Saumon, D., Marley, M.S., Guillot, T., Freedman, R.S.

- (1996) "The Remarkable Spectrum of the Brown Dwarf Gliese 229 B," BAAS, 28, 1114.
- Tegler, S., Romanishin, W., Weintraub, D.A., Fink, U., Fevig, R. (1997) "A Photometric Survey of Centaur and Trans-Neptunian Objects," BAAS, 29, 1021.
- Weintraub, D.A., Tegler, S.C., Romanishin, W.J. (1997) "Visible and Near-Infrared Photometry of the Centaur Objects 1995 GO and 5145 Pholus," BAAS, 29, 783.
- Weintraub, D.A., Tegler, S.C., Romanishin, W.J. (1997) "Visible and Near-Infrared Photometry of the Centaur Object 1995 GO," Icarus, 128, 456.

Douglas S. Hall