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This report covers the interval October 1, 1998, through September 30, 1999.

The astrophysics program in the Center of Excellence at TSU continues to concentrate on understanding magnetic activity in cool stars, managing robotic telescopes, and applying automation to astronomy. Astronomy staff in 1998-99 were Geoffrey S. Burks, Michael R. Busby, Joel A. Eaton, Francis C. Fekel, and Gregory W. Henry. Burks came from the Louisiana State University in June to join the astronomy staff. Marino Alvarez (Coll. of Education), Sallie L. Baliunas (CfA), and Douglas S. Hall (Vanderbilt University) continued as adjunct staff. Fekel spent 10 weeks at the University of Canterbury, Christchurch, New Zealand as a visiting Erskine University Fellow. Henry was named Distinguished Researcher of the Year at TSU. Kim Gold, Stephen Henry, Carlos Hyde, Allen Keel, Kenneth McDavis, Shannon Miles, Fred Northern, and Paul Strong served as student assistants in the astrophysics program.

1. OBSERVING FACILITIES

The Center of Excellence currently operates four Automatic Photoelectric Telescopes (APTs) at Fairborn Observatory, including the Fairborn 0.25 m, the Vanderbilt/Tennessee State 0.40 m, which is run in collaboration with D. Hall, and the SAO/TSU 0.75 m and TSU/SAO 0.80 m telescopes, in collaboration with S. Baliunas. We have now completed the third year of operation at the new observatory site in the Patagonia Mountains near Washington Camp, AZ. From early 1986 to mid-1996, the automated observatory site was located at the Fred L. Whipple Observatory on Mount Hopkins, AZ. Further information about the APTs and their observing programs can be found on the Web at <http://schwab.tsuniv.edu/>.

Construction continues at Fairborn on three new 0.80 m APTs as well as a 0.60 m automatic imaging telescope (AIT), all mentioned in last year's report. Final assembly of the three APTs is taking place, and they are expected to begin operation soon with the AIT to follow in another 6 months. Construction also continues on the TSU 2-m automatic spectroscopic telescope. Please refer to our last three reports for a description of it, or see our web site (http://coe.tsuniv.edu/eaton/eng_t13_over.html) for more details. We have now assembled the telescope in a building in Nashville and are beginning tests of the drives and control system. Students working on telescope development/instrumentation over the past year were Gold, Miles, McDavis, and Northern (weather station), McDavis, Hyde, and Strong (telescope assembly), and Keel (calculations of mirror support).

During the past year (4Q98-3Q99), the Fairborn 0.25 m APT collected 8,380 new group observations during 257 nights, mostly of semi-regular variable stars. In its 13 years of operation, the 0.25 m APT has collected a total of 81,432

group observations. The Vanderbilt/Tennessee State 0.40 m collected 19,031 group observations of chromospherically active single and binary stars on 252 nights. In its 12 years of operation, it has collected 150,205 group observations. The SAO/TSU 0.75 m APT acquired 6,933 group observations of lower-main-sequence stars on 258 nights. It has collected a total of 36,403 group observations in 7 years of operation. Finally, the TSU/SAO 0.80 m APT made 6,854 group observations of solar analogs on 252 nights. In 4 years of operation, it has collected a total of 20,576 group observations.

2. RESEARCH

Henry continues to obtain high-precision photometric observations of approximately 170 Sun-like stars with the 0.75 m and 0.80 m APTs. The precision of a single, nightly observation averages 0.0012 mag for these telescopes, while the precision of seasonal means is 0.0001–0.0002 mag. At this level of precision, long-term luminosity changes in Sun-like stars of only 0.001 mag over many years are clearly resolved. Sample results from this program, as well as a detailed account of the techniques for automated, high-precision photometry were published in the 1999 July issue of the *Publications of the Astronomical Society of the Pacific*.

Henry continues to use the 0.75 m and 0.80 m APTs to observe Sun-like stars for which planetary candidates from precision radial-velocity surveys have been announced. These observations are important for eliminating alternative explanations, such as surface magnetic activity or pulsation, for the observed radial-velocity variations. Upper limits of 0.0001–0.0002 mag for photometric variations on the purported planetary periods of τ Boo, 51 Peg, ν And, ρ^1 Cnc, ρ Cnc, 70 Vir, and 47 UMa have provided strong support for the existence of extrasolar planets around those stars. Henry has also used the APTs to search for possible planetary transits of announced extrasolar planets. Results have been negative for eight short-period systems examined in detail so far, in spite of a probability of greater than 50% for finding at least one transit in the sample. The observation of such a transit would represent the first direct detection of an extrasolar planet and lead directly to its true mass, size, and mean density. A detailed paper with Baliunas, R. Donahue (CfA), Fekel, and W. Soon (CfA) discussing the results for 9 extrasolar planetary systems has been accepted for publication in the *Astrophysical Journal*. Followup papers on additional newly discovered systems are in preparation.

Henry, Fekel, and Hall are collaborating with A. Kaye (Los Alamos National Laboratory) on the analysis of time-series photometry and spectroscopy of several new γ Doradus stars. Variable stars of this newly recognized class have spectral classes near F0 and luminosity classes V or V-IV, typical periods of 0.4–3 days, and amplitudes of only a few percent or less. Many potential new γ Dor stars are being found masquerading as comparison stars in the precision

photometry programs discussed above. A paper on HR 8330 has been accepted in the Monthly Notices of the Royal Astronomical Society. A second paper on HD 62454 and HD 68192 has been accepted in the Astronomical Journal. Photometry on several additional γ Dor candidates is being obtained and analyzed since only about a dozen of these stars are currently recognized as true γ Dor stars.

Henry, Fekel, S. Henry, and Hall are completing a paper on photometric variations in a sample of 187 G, K, and M0 giants. These stars were also observed as comparison stars with the APTs, but roughly half of them have been shown to be low-amplitude variables. Spectroscopic and photometric observations have been combined to demonstrate that the brightness variations in these stars cannot be due to rotational modulation of surface magnetic features. The time scales of variability in the late-K and M0 giants are consistent with radial p-mode pulsations of the kind operating in M-giant semi-regular variables. The photometric variations in the early-K and G giants may require another explanation.

Henry and S. Henry are collaborating with W. Lockwood (Lowell Observatory) in a joint photometric analysis of approximately 30 Sun-like stars that are being monitored in both the TSU and Lowell programs. They are attempting to improve the precision of brightness-change measurements of these stars compared to that of their separate data sets.

Henry and S. Henry are collaborating with E. Gaidos (JPL) in a photometric and spectroscopic study of the properties of a sample of 38 nearby, young, solar analogs. The study of these stars should improve our understanding of conditions in the early solar system. APTs were used to obtain photometric rotation periods for 27 of these stars. A paper on the results is in preparation.

Henry began a collaboration with John Percy (U. of Toronto) and several of his students on the analysis of long-term photometric data sets obtained with the Fairborn 0.25 m APT over the past 13 years. Photometric analysis of the light curves of the yellow hypergiant ρ Cas and the F2 Ibe variable 89 Herculis have been completed and papers are in preparation. Analysis of the long-term light curves of approximately 30 M giant semi-regular variables to establish their pulsation modes is in progress.

S. Henry is developing techniques to search the growing APT photometric data bases for evidence of planetary transits of unknown short-period planets. He has also worked to improve the Web pages of the Automated Astronomy Group.

Eaton continued his program of monitoring about 100 G, K, and M stars with luminosity classes I, II, and III at H α to look for variations in the blueshifted cores of these lines, discussed in last year's report.

Fekel, in collaboration with C. Scarfe (Univ. of Victoria) and others, is continuing spectroscopic observation of about 25 close multiple systems and a half dozen speckle binaries to obtain fundamental parameters. For most of the systems speckle observations have been obtained by the CHARA group (Georgia State Univ.). Combined spectroscopic and visual orbits usually produce orbital parallaxes more accurate than the trigonometric parallaxes obtained by the Hipparcos satellite, providing an important independent check on the *Hipparcos* results.

For over a decade Fekel has monitored the radial velocities of about 30 slowly rotating B and A stars, which are candidates for early-type velocity standards. A bootstrap procedure has been used to tie the velocities of the early-type stars to the IAU late-type velocity system. Most of the early- and mid-B type stars have variable velocities. However, about two-thirds of the slowly rotating late-B and A-type stars appear to have constant velocities.

Fekel, in collaboration with K. Hinkle and R. Joyce (NOAO), has obtained infrared spectra of the 1.6 μ m region of over two dozen D- and S-type symbiotic stars. Infrared radial velocities have been used to improve orbital elements for the cool component of 6 symbiotic binaries: EG And, T CrB, CI Cyg, BX Mon, RS Oph, and AG Peg. Each of the orbital periods has been determined solely from radial-velocity data. With the addition of our new velocities, the orbital period of BX Mon has been revised to 1259 days, a 10% decrease from the previously reported result.

Henry and Fekel, in collaboration with S. Balachandran (Univ. of Maryland), have continued to observe HDE 233517, a rapidly rotating, chromospherically active, single K giant with a dust disk and evidence of mass loss. Photometric observations show low-amplitude light variability with a period of 47.9 days. An abundance analysis shows that this post-main-sequence giant is slightly metal poor and has a *super-meteoritic* lithium abundance.

Burks' main research interests center on studying the use of interactive electronic networks for improving astronomy education. He is collaborating with Alvarez in developing and extending the Explorers of the Universe Project. He is instituting two astronomy courses designed to develop student interest in working with the staff on astronomy research projects. He is also working on Galactic halo studies.

PUBLICATIONS

- Boden, A. F., Koresko, C. D., van Belle, G. T., Colavita, M. M., Dumont, P. J., Gubler, J., Kulkarni, S. R., Lane, B. F., Mobley, D., Shao, M., Wallace, J. K. (The PTI Collaboration), & Henry, G. W. 1999, "The Visual Orbit of Iota Pegasi," *ApJ*, 515, 356
- Burks, G. 1999, "Explorers of the Universe: Interactive Collaborations via the Internet," *BAAS*, 31, 940
- Fekel, F. C. 1999, "The Status of Early-Type Radial-Velocity Standards," in *Precise Stellar Radial Velocities*, ASP Conf. Ser. 185, eds. J. B. Hearnshaw & C. D. Scarfe (Provo: ASP), p. 378
- Fekel, F. C., Strassmeier, K. G., Weber, M., & Washuttl, A. 1999, "Orbital Elements and Physical Parameters of Ten Chromospherically Active Binary Stars," *A&A*, 137, 369
- Fekel, F. C., & Watson, L. C. 1998, "A Search for Lithium-Rich Giants Among Stars with Infrared Excesses," *AJ*, 116, 2466
- Henry, G. W. 1999, "Techniques for Automated High-Precision Photometry of Sun-Like Stars," *PASP*, 111, 845

Henry, G. W., Henry, S. M., & Kaye, A. B. 1999, "Tau 1
Hydrae: Not a γ Doradus Variable," IBVS, No. 4688
Henry, G. W. & Kaye, A. B. 1999, "HD 74425: A New
Ellipsoidal Variable Star," IBVS, No. 4684

Strassmeier, K. G., Stepien, K., Henry, G. W., & Hall, D. S.
1999, "Evolved, Single, Slowly Rotating... but Magneti-
cally Active: The G8-giant HR 1362 = EK Eridani Re-
visited," A&A, 343, 175

