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This report covers the period from September 2000 through August 2001. We now limit the research descriptions in this report to brief summary phrases or project titles, along with specific internet addresses, and selected publications. For more information on facilities, personnel, and research programs, see the astronomy and astrophysics group web site:

<http://www.public.iastate.edu/~astro>.

1. PERSONNEL AND EDUCATION

Faculty and staff active during this period were P. N. Appleton, G. H. Bowen (emeritus), D. A. Carter-Lewis, J. J. Eitter (Observatory Manager), S. Kawaler, F. Krennrich, R. C. Lamb (emeritus, resident in Pasadena, CA), R. Lavery C. Struck & L. A. Willson. At the end of this period, Lavery left to take a position at Northern Arizona State. Also at the end of the period G. Gonzalez joined the faculty as an Asst. Professor.

Graduate students in astronomy included R. Benson, A. Bischoff Kim, T. Fanetti, S. Hostler, M. Reed, D. C. Smith, & G. W. Turner. During this period, the M.S. degree was awarded to R. Benson & T. Fanetti. The Ph.D. degree was awarded to D. C. Smith.

Undergraduates involved in astronomical research during this period were J. Drake, A. Fox, K. Marasinghe, and several students working on summer projects under the NSF funded REU program.

Appleton continued his term as AURA member representative for ISU, and also served on the AURA Space Telescope Institute Council (STIC). Kawaler continues as Director of the Whole Earth Telescope (WET) collaboration. Willson continues to serve on the AURA Board of Directors. She is also the current President of the AAVSO.

Dr. Reed Riddle continued as Associate Director of Whole Earth Telescope Operations. Drs. Stephane Le Bohec and Dirk Petry are postdoctoral fellows working in the TeV gamma-ray program here.

Visitors included Simon O'Toole (University of Sydney) as well as many others during participation in WET runs. A WET planning meeting was also held at Iowa State in August 2001.

2. FACILITIES

In Oct. of 2000 a new PC-based computer was installed in the DFM control system of the 0.6m Mather telescope. This system is now much more "user friendly" and modifications in the software for the control of the telescope have been made. In Feb. of 2001 a new CCD camera from Andor Technology replaced the present detector system. This is a 1024 by 1024, 13-micron pixel, black illuminated detector that can be cooled to -70 C with thermoelectric cooling. At the Newtonian focus of the 0.6m telescope, the field of view is about

18'. With the addition of a remote control of a x,y,z positioner for the SBIG ST5 guider CCD and a new eight position filter wheel, the Newtonian imaging system can now be operated from the control room. This is a good deal more efficient and safer.

Of the 290 nights scheduled for observations, about 20 were used for photometry. Radial velocity measurements were obtained on about 15 nights (900 observations) and 47 nights were used for CCD imaging (1360 images).

3. ASTRONOMY EDUCATION RESEARCH

Willson, with several students, is developing a series of web-based astronomy modules, collectively known as "the Polaris Project." These cover basic concepts that often prove difficult to teach, such as diurnal motion, seasonal variations, and coordinate systems. Aimed at the freshman non-scientist, the first module has been tested by students with backgrounds ranging from none to senior in physics/astronomy. The presentation material is open for use by anyone: <http://www.polaris.iastate.edu>.

T. Fanetti completed an MS in Astronomy with an emphasis on astronomy education. Her project concerned whether misconceptions about the scale of the Earth-Moon system support misconceptions about the causes of the lunar phases. Her result showed that teaching about the scale of the system had measurable influence on students responses about the scale of the system but did not produce appreciable gains in the number of students showing evidence for understanding the causes of lunar phases.

4. RESEARCH PROGRAMS

4.1 Galaxies & ISM

P. N. Appleton: Observational studies of interacting and colliding galaxies in the optical, IR and radio. With V. Charmandaris (Cornell) and Y. Gao (Caltech) he continued to explore the mid-IR and sub-mm imaging of ring galaxies. In particular, work continues on the unusual Seyfert ring NGC 985. ISO observations show an inner shell of dust which may be part of a shock front lying at the interface between an outflowing wind from the AGN and the infall gas caused by the collision. CO observations with BIMA help to further refine this hypothesis, as described in a paper nearing completion. Appleton and Struck continue to explore the properties of the COLA (Compact Objects in Low-luminosity AGNs) North sample through CO line, radio continuum and optical V and I-band imaging of the galaxies. This work is in collaboration with V. Charmandaris (Cornell), T. Marston (Caltech), A. Zezas (CfA), R. Norris (ATNF), M. Dopita and L. Kewley (MSSSO). For recent publications see www.public.iastate.edu/~pnapplet.

R. J. Lavery: Observational studies of distant collisional ring galaxies investigating the evolution of the galaxy merger

rate (various aspects with graduate student A. Remijan, Illinois and S. Odewahn, Arizona State). Initial results of this program, involving the analysis of HST observations, indicate a very steeply increasing merger rate with redshift. See “Research Programs” at www.public.iastate.edu/~lavery.

C. Struck: Dynamical models of star and gas dynamics of early stages of galaxy collisions. This includes work on a bridge-plus-ring sample (with B. J. Smith, Eastern Tenn.), and ocular galaxies (with an extensive collaboration). A paper summarizing results on extra-disk molecular gas in interacting systems was published this period, as were several papers on the ocular sample (see Publications). Other projects include numerical and simple analytic models of quasi-steady thermal and dynamical states of the gas disks of isolated galaxies and their secular evolution, with grad. student D. C. Smith, who completed his thesis work this period. Numerical hydrodynamical models of ram pressure sweeping and induced spiral instabilities in cluster galaxies, done with former student S. Schulz, are in press. See www.public.iastate.edu/~curt.

4.2 Stars

Kawaler: Evolution and pulsation properties of evolved stars. The Whole Earth Telescope (which Kawaler directs) obtained data on the rapidly oscillating Ap star HR 1217 in November 2000. The data from this run, with Dr. Don Kurtz (SAAO) as PI, are currently being reduced and analyzed. This run was coordinated, in part, at Iowa State University. The pulsating subdwarf B star PG 1336 was the next WET target, observed in May 2001. This run was also coordinated at Iowa State University. Graduate student M. Reed was the principal investigator for this run. Graduate student M. Reed neared completion of his Ph.D. dissertation work on pulsating subdwarf B stars. For more details about work in these areas, as well as links to the Whole Earth Telescope project and teaching activities, see <http://www.public.iastate.edu/~sdk>.

Willson, Struck and Bowen have been looking at the fates of planets caught in the final outflow from a star like the Sun. Building on the understanding of the environment surrounding Mira variables built up over many years of work, they have identified some observable quantities that could be used to trace such an interaction. Bowen’s calculations show that unless at least 20% of the Sun’s mass is lost before the AGB, the Earth will spiral into the Sun, and this appears the most likely outcome. Modeling and the sifting of archival data continue in the effort to find unambiguous signatures of this process. Related material appeared in print during this interval (see refs below and <http://www.public.iastate.edu/~lwillson>).

4.3 TeV Gamma-ray Astronomy

D.A. Carter-Lewis and F. Krennrich: Ground-based gamma-ray astronomy has opened up a new observational window for observing TeV (10^{12} eV) photons from active galactic nuclei (AGNs), supernova remnants and pulsars. Our group, as part of the Whipple collaboration has pioneered the technique of detecting gamma-rays from using

large (Whipple 10 m), ground-based optical telescopes. We have designed and are presently constructing the focus box and focal plane instrumentation for the first of the VERITAS array to be located at Whipple Observatory, but down the mountain from the present 10 meter Cherenkov telescope. The VERITAS array (Very Energetic Radiation Imaging Telescope Array System) will have dramatically improved sensitivity, energy threshold, and angular and energy resolution, taking Cherenkov telescopes a generation forward. The science issues currently being addressed here include the measurement of energy spectra of AGNs and the study of particle acceleration in the vicinity of a supermassive black hole. We are also concerned with the detection of short bursts of gamma rays.

PUBLICATIONS

P. N. Appleton, *et al.* 2000, “Smoke in the “Smoke Rings”: ISO Observations of Dust in Collisional Ring Galaxies,” in Lecture Notes in Physics, v. 548, eds. (Berlin: Springer Verlag) p. 231

P. N. Appleton, J. J. Eitter, *et al.* 2001 “The Structure and Kinematics of Eitter’s Globule in Cygnus: Evidence for sub-stellar dust condensations in a collapsing Bok Globule?,” MNRAS, (In preparation).

W. G. Bagnuolo Jr., *et al.* (including **R. L. Riddle**) 2001, “ ι Orionis-Evidence for a Capture Origin Binary,” ApJ, 554, 362

D. J. Barry, W. G. Bagnuolo, & **R. L. Riddle** 2001, “An Improved “Newtonian” Version of the Ebert-Fastie Spectrograph,” PASP, in press

E. Brinks, *et al.* (including **C. Struck**) 2001, “A Bird’s Eye View of Ocular Galaxies,” in “Cosmic Evolution and Galaxy Formation, etc.,” ASP Conf. Vol. 215, eds. J. Franco, L. Terlevich, O. Lopez-Cruz, & I. Aretxaga (San Francisco: ASP), p. 197.

B. G. Elmegreen, *et al.* (including **C. Struck** 2001, “Hubble Space Telescope Observations of the Interacting Galaxies NGC 2207 and IC 2163,” AJ, 120, 630 (also see erratum AJ, 120, 3371)

D. M. Elmegreen, *et al.* (including **C. Struck** 2001, “Hubble Space Telescope Observations of Dust and Star-forming Regions in the Ocular Galaxy IC2163 and its Spiral Companion NGC 2207,” AJ, 121, 182

D. R. Gies, *et al.* (including **R. L. Riddle**) 2001, “The spectral components of SS 433,” submitted

S. D. Kawaler & M. Dahlstrom 2000, “White Dwarf Stars,” American Scientist, 88, 498

S. D. Kawaler 2001, “The Whole Earth Telescope: An International Asteroseismological Adventure,” in IAU Colloquium 183: Small-Telescope Astronomy on Global Scales, ed. W.P. Chen (San Francisco: ASP)

F. Krennrich, *et al.* (including **D. A. Carter-Lewis & S. LeBohec**) 2000, “VERITAS: Very Energetic Radiation Imaging Telescope Array System,” in Towards a Major Atmospheric Cherenkov Detector VI (Snowbird), AIP Conf. Proceed. 515, 515

F. Krennrich, S. Le Bohec, & T. C. Weekes 2000, “Detection Techniques of Microsecond Gamma-Ray Bursts using Ground-Based Telescopes,” ApJ, 529, 506

F. Krennrich, et al. (including **D. A. Carter-Lewis & S. LeBohec & D. Petry**) 2001, "Cutoff in the TeV Spectrum of Markarian 421 During Strong Flares in 2001," *ApJL*, 560, L45

S. Le Bohec, et al. (including **D. A. Carter-Lewis & F. Krennrich**) 2000, "Gamma Ray Observations of the Galactic Plane at Energies $E > 500$ GeV," *ApJ*, 539, 209

R. W. Lessard, *et al.* (including **D. A. Carter-Lewis & F. Krennrich**) 2000, "Search for Pulsed TeV Gamma-ray Emission from the Crab Pulsar," *ApJ*, 531, 942

R. W. Lessard, J. H. Buckley, V. Connaughton and **S. Le Bohec**, 2001, "A new analysis method for reconstructing the arrival direction of TeV gamma rays using a single imaging atmospheric Cherenkov telescope," *Astroparticle Physics*, 15, 1

R. J. Lavery & A. J. Remijan 2000, "Probing the Evolution of the Galaxy Interaction/Merger Rate Using Distant Collisional Ring Galaxies." In *A.S.P. Conference Series, "Galaxy Dynamics from the Early Universe to the Present,"* eds. F. Combes, G. A. Mamon & V. Charmandaris (San Francisco: ASP), p. 327

M. V. McSwain, *et al.* (including **R. L. Riddle**) 2001, "The Orbit of the Massive X-Ray Binary LS 5039," *ApJ*, 558L, 43

M. Sean O'Brien and **S. D. Kawaler** 2000, "The Pre-

dicted Signature of Neutrino Emission in Observations of Pulsating" Pre-White Dwarf Stars," *ApJ*, 539, 372

M.D. Reed, S. D. Kawaler, & M. S. O'Brien 2000, "PG2131+066: A Test of Pre-White Dwarf Asteroseismology," *ApJ*, 545, 785

R. L. Riddle & W. G. Bagnuolo 2001, "The Multiple Telescope Telescope," *IAU 183: Small telescope astronomy on global scales*, Eds. B. Paczynski, W. Ip & W.-P. Chen, in press

S. Schulz & C. Struck 2001, "Multi-Stage Three Dimensional Sweeping and Annealing of Disc Galaxies in Clusters," *MNRAS*, in press

B. J. Smith & **Struck, C.** 2001, "New Observations of Extra-Disk Gas in Interacting Galaxy Systems, Including a Two-Component System in Stephan's Quintet," *AJ*, 121, 710

T.C. Weekes, et al. (including **D. A. Carter-Lewis & F. Krennrich & S. LeBohec & D. Petry**) 2001, "VERITAS: the Very Energetic Radiation Imaging Telescope Array System," *Astroparticle Physics*, in press

A. M. Williams, *et al.* (including **R. L. Riddle**) 2001, "Detection of the Faint Companion in the Massive Binary HD 199579," *ApJ*, 548, 425

C. Struck