

**Iowa State University**  
**Department of Physics and Astronomy**  
**Erwin W. Fick Observatory**  
*Ames, Iowa 50011*

This report covers the period from September 2002 through August 2003. We limit the research descriptions in this report to brief summaries, along with specific internet addresses, and selected publications. For more information on facilities, personnel, and research programs, see our group website:

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

## 1. PERSONNEL AND EDUCATION

G. H. Bowen (emeritus), D. A. Carter-Lewis, J. J. Eitter (Observatory Manager), G. Gonzalez, S. Kawaler, F. Krennrich, R. C. Lamb (emeritus, resident in Pasadena, CA), C. Struck & L. A. Willson. At the end of this period, the term of service by visiting professor Dr. Sydney D'Silva ended. New faculty members Charles Kerton and Martin Pohl joined our faculty in August 2003.

Graduate students in astronomy included A. Bischoff Kim, J. Brown, S. Hostler, A. Imran, B. Behera, M. Vuckovic, & G. W. Turner. During this period, G.W. Turner earned the Ph.D. degree, and is an assistant professor at Morningside College in Sioux City, Iowa. A. Kim completed a Masters degree, and entered the Ph.D. program in Astronomy at the University of Texas.

Dr. Stephane Lebohec is a senior postdoctoral fellow working on SGARFACE and VERITAS. Dr. Michael Daniel arrived in November 2002, and is working on VERITAS and analysis of Whipple telescope data. Both are based in Ames, but make frequent trips to Arizona to observe or work on the VERITAS prototype telescope.

Undergraduates involved in astronomical research during this period included ISU students R. Hamper, C. Hansen, G. Knoke, K. Marasinghe, and E. Potter; I. Radtke (Minnesota State University, Mankato) joined us for summer research.

Kawaler continues as AURA member representative for ISU and Director of the Whole Earth Telescope (WET) collaboration. He also began serving a three-year term as vice-president of I.A.U. Commission #27. Dr. Reed Riddle continues as Associate Director of Whole Earth Telescope Operations. Pohl continues as NASA Interdisciplinary Scientist for the GLAST mission. Willson serves Ex-President of the American Association of Variable Star Observers (AAVSO).

Gonzalez and Willson, with several undergraduate and graduate students, continue developing a series of web-based astronomy modules, collectively known as the Polaris Project. Aimed at the freshman non-scientist, several modules have 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>

## 2. FACILITIES

We have continued construction of a precision radial-velocity spectrograph (m/s resolution). The spectrograph is based on the "Externally Dispersed Interferometer" design of Jian Ge and David Erskine. It will eventually be used with the Mather Telescope at Fick Observatory to obtain high-precision radial velocities to study giant planets around Sun-like stars.

CCD observations were obtained at Fick Observatory over this period except for about ten weeks in the Fall of 2002. During this time the movable roof of the observatory could not be moved due to a failure of a speed reducer used to open the roof. In late 2002, the mechanical drive for the roll-off roof of the observatory building was repaired, restoring the observatory to full-sky visibility. CCD imaging for the COLA project and general imaging were obtained on 50 nights over this period.

High-speed photometric observations of pulsating compact stars continued during this period. These observations have employed the Andor CCD camera; we are also developing a new system using a high-speed CCD photometer (based on the Apogee AP-7) with custom software (designed by Riddle and Radtke) to allow nearly real-time light curve analysis.

## 3. RESEARCH PROGRAMS

### 3.1 Galaxies & ISM

C. Struck continued work on detailed dynamical models of star/ gas dynamics and induced star formation in early stages of galaxy collisions. This work focuses on modeling specific well observed systems. For example, extensive modeling on the bridge-plus-ring Arp 284 system was published in this period (with B. J. Smith, Eastern Tenn.). Similar modeling work on the NGC 2207/IC 2163 ocular galaxy system (with an extensive collaboration) was completed in this period, and a journal paper is in preparation. Results from both these projects were described in a talk at the IAU meeting in July 2003.

Struck also continued work on numerical hydrodynamical models of ram pressure sweeping and induced spiral instabilities in cluster galaxies. This work was begun with former student S. Schulz, and continues with graduate student Jason Brown. Schulz explored the effects of different ram pressures and galaxy disk inclinations. Brown is exploring the effects of different disk mass fractions and other structural parameters. See

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

C. R. Kerton joined our faculty in August 2003. His research interests are in the area of observational studies of star

formation and Galactic structure. Kerton is currently involved with large-scale radio and infrared surveys of our Galaxy as part of the International Galactic Plane Survey (IGPS) and the Galactic Arecibo L-Band Feed Array (GALFA) consortia.

### 3.2 Stars and Planets

Gonzalez continues a long-term program, started in late 1995, to derive the basic properties of stars with planets. This is the Ph.D. thesis topic of C. Laws (U. Washington), which he expects to complete in June 2004. REU student Kyle Walker (Ohio State) assisted with measurement of the spectra during summer 2002. Work with G. Wallerstein (University of Washington) and S. Giridhar (Indian Institute of Astrophysics) on the abundances of very metal-poor cool giants continues; the work is based on observations obtained in 2000 and 2001 with the KPNO 4-m and Apache Point 3.5-m telescopes. In collaboration with J. Armstrong (Weber State), Gonzalez is continuing a study of the Moon as a source for evidence of early life on Earth, exploring the possibility of re-seeding the Earth following a sterilizing impact, and search strategies for Terran meteorites on the Moon.

Struck, Willson and Cohanin (undergrad. alum) have been modeling the effects of accretion onto giant planets and brown dwarfs orbiting in the extended atmospheres and winds of stars like the Sun in their late evolutionary stages (AGB, Mira phase). Preliminary work was followed up with a modest grid of two-dimensional numerical models to study the bow shock, wake and accretion hydrodynamics of such systems. This work is described in a paper for MNRAS (in press). Related material can be found at

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

Willson, with A. Kim, investigated the dependence of observable quantities on the character of the mass loss law, and discovered that all the standard core mass - luminosity relations give Mira core masses larger than the observed remnant masses (CSPN and WD). It appears most likely that convective penetration and mixing lead to increasing  $L$  without increasing  $M_{\text{core}}$  on the AGB. These results were reported at the Mt. Rainier meeting on Asymmetric Planetary Nebulae in July 2003.

Under Kawaler's direction, the Whole Earth Telescope obtained data on several targets during the 23rd extended coverage campaign, held in August 2003. The primary target was the pulsating sdB star KPD 1930, with S. Charpinet (Obs. Midi Pyr.) and M. Reed (SMSU) as the principal scientists.

Graduate students Hostler and Vuckovic, along with David Oesper, obtained several nights of data on pulsating white dwarfs, planetary nebula central stars, and pulsating sdB stars at Fick Observatory. M. Reed (SMSU) (along with Kawaler, Vuckovic, and Riddle) completed analysis of five years of time-series photometry of the pulsating sdB star Feige 48, placing (among other limits) strong constraints on any planetary system around this evolved star.

On the theoretical side, Kawaler and graduate student Hostler explored the evolution of angular momentum within stars as the evolved from the main sequence to the white dwarf (and hot subdwarf) phases. Results of these studies

suggest new ways of analyzing the pulsating members of those classes to look for evidence of rapid core rotation.

For WET operations, Riddle created XQED, a new light curve analysis package for the WET. A new mode of operations for controlling WET runs using a 'portable HQ' was used for Xcov23, and sets the stage for future WET operations. For more details about work in these areas, as well as links to the Whole Earth Telescope project and Kawaler's teaching activities, see

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

In addition to his work with the WET, Riddle continued his collaboration with the massive star group at Georgia State University. With W. G. Bagnuolo (GSU) he continued upgrading the Multiple Telescope Telescope, a novel 1 m spectroscopic telescope. Riddle assisted in development of the spectrograph for the CHARA Array and, with Bagnuolo, is pursuing a program to identify spectral types and orbit parameters for binaries in collaboration with CHARA observations. Riddle continues to pursue his studies of the Struve-Sahade Effect, a wind interaction phenomenon seen in short period massive binary systems.

### 3.3 TeV Gamma-ray Astronomy

Faculty members Frank Krennrich and David Carter-Lewis work entirely in this area. We have been joined by Martin Pohl in August, 2003 who will divide his time between GLAST (satellite/GeV energies) and VERITAS (ground-based/TeV energies).

Ground-based gamma-ray astronomy has opened up a new observational window for observing TeV ( $10^{12}$  eV) photons from active galactic nuclei (AGN), 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 constructed the focus box and focal plane instrumentation for the first telescope of the VERITAS array to be located at Fick Observatory. This prototype telescope is now functioning and being tested at the Whipple Observatory basecamp near Amado Arizona. 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. We are presently investigating analysis methods for best utilizing this array. The TeV science issues currently being addressed at ISU include the measurement of energy spectra of AGN, the implications for particle acceleration in the vicinity of supermassive black holes, and implications for extra-galactic background light.

In addition we have developed a unique trigger system (SGARFACE) now attached to the Whipple telescope to search for burst phenomena on timescales of 10 nanoseconds to 10 microseconds. Lebohec, is working on the first data and developing data analysis techniques. SGARFACE will eventually be expanded and moved to VERITAS.

## PUBLICATIONS

- J. Armstrong, L. Wells, & **G. Gonzalez**, 2002, “Rummaging through Earth’s Attic for Remains of Ancient Life,” *ICARUS*, 160, 183.
- Y.M. Butt, P. Benaglia, J.A. Combi, M. Corcoran, T.M. Dame, J. Drake, M. Kaufman Bernadó, P. Milne, F. Miniati, F., **M. Pohl**, O. Reimer, G.E. Romero, & M. Rupen, 2003, “CHANDRA/VLA Follow-up of TeV J2032+4131, the only unidentified TeV gamma-ray source,” *ApJin* press.
- K.R. Covey, G. Wallerstein, G., **G. Gonzalez**, A.D. Vanture, & N.B. Suntzeff, 2003, “A Reinvestigation of the Possible Metallicity Spread in NGC 3201,” *PASP*, 115, 819.
- P. Candia, *et al.* (including **G. Gonzalez**, 2003, “Optical and Infrared Photometry of the Unusual Type Ia Supernova 2000 cx,” *PASP*, 115, 277.
- D. Geisler, V.V. Smith, G. Wallerstein, **G. Gonzalez**, & C. Charbonnel, 2003, “The Chemistry of Giants in the Sculptor Dwarf Spheroidal Galaxy,” *AAS meeting 202*, Abstract 40.02.
- D. Geisler, V.V. Smith, G. Wallerstein, **G. Gonzalez**, & C. Charbonnel, 2003, “The Chemistry of Giants in the Sculptor Dwarf Galaxy,” 25th meeting of the IAU, Joint Discussion 15, July 23.
- D.R. Gies, *et al.* (including **R.L. Riddle**), 2003, “Wind Accretion and State Transitions in Cygnus X-1,” *ApJ*, 583, 424
- G. Gonzalez**, 2003, “Stars, Planets, and Metals,” *RMP*, 75, 101.
- G. Gonzalez**, 2002, “The Galactic Habitable Zone,” in *Astrophysics of Life* (Cambridge: Cambridge University Press), in press.
- G. Gonzalez**, 2002, “A Search for  ${}^6\text{Li}$  in Stars with Planets,” in *Scientific Frontiers in Research on Extrasolar Planets*, (San Francisco: ASP), in press.
- G. Gonzalez** & C. Laws, 2002, “Metallicity Trends among Stars with Planets – 2002,” in *Scientific Frontiers in Research on Extrasolar Planets* (San Francisco: ASP), in press.
- T. Hall, *et al.* (including **D.A. Carter-Lewis**, **F. Krennrich** & **S. LeBohec**), 2003, “Search for TeV Emissions from Pulsars in Binary Systems Authors,” *ApJ*, 583, 853.
- G. Handler, *et al.* (the WET collaboration, including **S.D. Kawaler** & **R. Riddle**), 2003, “Amplitude and frequency variability of the pulsating DB white dwarf stars KUV 05134+2605 and PG 1654+160 observed with the Whole Earth Telescope,” *MNRAS*, 340, 1031.
- T.C. Hillwig, E.W.G. Bagnuolo, E.& **R.L. Riddle**, 2002, “A Medium-Resolution Spectrograph for the CHARA Optical/IR Interferometer,” *BAAS*, 34, 1130
- J. Holder, *et al.* (including **D.A. Carter-Lewis**, **F. Krennrich** & **S. LeBohec**), 2003, “Detection of TeV Gamma Rays from the BL Lacertae Object IES 1959+650 with the Whipple 10 Meter Telescope,” *ApJL*, 583, L9.
- D. Horan, *et al.* (including **D.A. Carter-Lewis**, **F. Krennrich**, **S. LeBohec** & **Dirk Petry**), 2002, “Detection of the BL LAC Object 1H1426+428 at TeV Gamma Ray Energies,” *ApJ*, 571, 753.
- I.I. Ivans, G. Wallerstein, C. Sneden, R.P. Kraft, J.E. Norris, **G. Gonzalez**, & J.P. Fulbright, 2003, “On Question of a Metallicity Spread in GC M22,” 25th meeting of the IAU, Joint Discussion 4, July 16-17.
- S.D. Kawaler**, 2003, “Rotation of White Dwarfs: Observation and Theory,” in *I.A.U. Symposium 215: Stellar Rotation*, ed. P. Eenens & A. Maeder (San Francisco, ASP).
- S.D. Kawaler**, 2003, “Perspectives: Taking the Pulse of a Massive Star,” *Science*, 300, 1885.
- S.D. Kawaler**, 2003, “The Whole Earth Telescope: International Adventures in Asteroseismology,” in *The Future of Small Telescopes In The New Millennium. Volume III - Science in the Shadows of Giants*, ed. Terry Oswalt (Dordrecht, Kluwer), p. 245.
- S.D. Kawaler**, 2003, “Conference Summary,” in *I.A.U. Colloquium 193: Variable Stars in the Local Group*, ed. D. Kurtz & K. Pollard, in press.
- S.D. Kawaler**, **S. Hostler**, & J. Burkett, 2003, “The Origin of White Dwarf Rotation Velocities,” in *White Dwarfs: the Thirteenth European Workshop*, ed. D. de Martino, R. Silvotti, J.-E. Solheim, and R. Kalytis (Dordrecht, Kluwer), p. 27.
- S.D. Kawaler** & **S. Hostler**, 2003, “Pulsating sdB stars - a New Approach to Probing Their Interiors,” in *Extreme Horizontal Branch Stars and Related Objects*, ed. P. Maxstedt, in press.
- S.O. Kepler, *et al.* (the WET collaboration, including **S.D. Kawaler** & **R. Riddle**), 2003, “The Everchanging Pulsating White Dwarf GD358,” *A&A*, 401, 639.
- C.R. Kerton**, C.M Brunt, C.E. Jones, & S. Basu, 2003, “On the intrinsic shape of molecular clouds,” *A&A*, in press
- C.R. Kerton**, C.M. Brunt, & L.B.G. Knee, 2003, “High Spatial Dynamic Range HI Surveys of Nearby Molecular Cloud Complexes” in *Milky Way Surveys: The Structure and Evolution of Our Galaxy*, ASP Conf. Ser. in press
- C.R. Kerton**, C.M Brunt, & R. Kothes, 2003, “The overlooked HII Region DA 568,” *AJ*, in press
- F. Krennrich**, *et al.* (including **D.A. Carter-Lewis**, **S. LeBohec** & **D. Petry**), 2002, “Discovery of Spectral Variability of Markarian 421 at TeV Energies,” *ApJL*, 575, L9.
- C. Laws, **G. Gonzalez**, **K.M. Walker**, S. Tyagi, J. Dodsworth, K. Snider, & N.B. Suntzeff, 2003, “Parent Stars of Extrasolar Planets. VII. New Abundance Analyses of 30 Systems,” *AJ*, 125, 2664.
- C. Laws, & **G. Gonzalez**, 2003, “A Reevaluation of the Super Lithium-rich Star in NGC 6633,” *ApJ*, 595, 1148.
- S. LeBohec** & J. Holder, 2003, “The Cosmic Ray Background as a Tool for Relative Calibration of Atmospheric Cherenkov Telescopes,” *Astropart. Phys.*, 19, 221.
- T.S. Metcalfe, M.H. Montgomery, & **S.D. Kawaler**, 2003, “Probing the envelope structure of DBV white dwarfs,” *MNRAS*, in press.
- A. Mukudam, *et al.* (the WET collaboration, including **S.D. Kawaler** & **R. Riddle**), 2003, “Constraining the Evolution of ZZ Ceti,” *ApJ*, in press.
- D. Petry**, *et al.* (including **D.A. Carter-Lewis**, **F. Krennrich** & **S. LeBohec**), 2002, “The TeV Spectrum of H1426+428,” *ApJ*, 580, 104.
- M. Pohl**, 2003, “Particle acceleration in AGN jets,” in *High*

- energy blazar astronomy*, PASP Conference Series, eds. A. Sillanpää, L. Takalo, and E. Valtaoja, in press.
- M. Pohl**, C. Perrot, I. Grenier, I., & S. Digel, S., 2003, “The imprint of Gould’s Belt on the local cosmic-ray electron spectrum,” *A&A* in press.
- M.D. Reed, **S.D. Kawaler**, *et al.* (the WET collaboration, including **R. Riddle** & **M. Vuckovic**), 2003, “The long term pulsational stability of the pulsating sdB star Feige 48,” *MNRAS*, in press.
- M.D. Reed, **S.D. Kawaler** *et al.* (the WET collaboration), 2003, “Feige 48: A Model Match for the Coolest Pulsating Subdwarf B Star,” in *White Dwarfs: the Thirteenth European Workshop*, eds. D. de Martino, R. Silvotti, J.-E. Solheim, and R. Kalytis (Dordrecht, Kluwer), p. 81.
- R.L. Riddle**, 2003, “XQED: The Next Generation of WET Light Curve Reduction and Analysis Software,” *Balt. Astron.*, 12, 183.
- R. Schlickeiser, **M. Pohl**, & R. Vainio, 2003, “The influence of electron impact ionisation in the relativistic pick-up of interstellar neutrals,” *ApJ*, in press.
- S.L. Schuh, *et al.* (the WET collaboration, including **S. Kawaler** & **R. Riddle**), 2003, “Preliminary results of the WET Xcov22 campaign at Calar Alto Observatory,” in *White Dwarfs: the Thirteenth European Workshop*, eds. D. de Martino, R. Silvotti, J.-E. Solheim, and R. Kalytis (Dordrecht, Kluwer), p. 263.
- R. Silvotti, *et al.* (including **R.L. Riddle**), 2002, “The temporal spectrum of the sdB pulsating star HS 2201+2610 at 2 ms resolution,” *A&A*, 389, 180.
- C. Struck** 2004, “Case Studies of Mass Transfer and Star Formation in Galaxy Collisions,” in *Recycling Intergalactic and Interstellar Matter: IAU Symposium Series, Vol. 217*, eds. P.-A. Duc, J. Braine, & E. Brinks (San Francisco: ASP), in press.
- C. Struck** & **J.R. Brown** 2004, “Some Effects of Galaxy Collisions in a Cluster ICM,” in *Recycling Intergalactic and Interstellar Matter: IAU Symposium Series, Vol. 217*, eds. P.-A. Duc, J. Braine, & E. Brinks (San Francisco: ASP), in press.
- C. Struck**, B.E. Cohanin, & **L.A. Willson**, 2003, “Continuous and Burst-like Accretion on to Substellar Companions in Mira Winds,” *MNRAS*, in press.
- C. Struck** & B.J. Smith, 2002, “Models of the Morphology, Kinematics, and Star Formation of the Prototypical Collisional Starburst System: NGC 7714/7715 = Arp 284,” *ApJ*, 589, 157.
- G. Tautvaisiene, G. Wallerstein, D. Geisler, **G. Gonzalez**, & C. Carbonnel, 2003, “Elemental Abundances of three Red Giants in Terzan 7, a Globular Cluster Associated with the Sagittarius Galaxy,” *AJ*, in press.
- L. Wells, J. Armstrong, & **G. Gonzalez**, 2003, “Impact Re-seeding of Early Earth During the Late Heavy Bombardment,” *ICARUS*, 162, 83.
- G. Wallerstein, G. Tautvaisiene, **G. Gonzalez**, & D. Geisler, 2003, “Chemical Abundances in the Sagittarius Galaxy: Terzan 7,” 25th meeting of the IAU, Joint Discussion 6, July 17.
- T.C. Weekes**, *et al.* (including **D.A. Carter-Lewis**, **F. Krennrich**, **S. LeBohec** & **D. Petry**), 2002, “VERITAS: the Very Energetic Radiation Imaging Telescope Array System,” *Astropart. Phys.*, 17, 221.
- L.A. Willson**, **C. Struck**, & B.E. Cohanin, 2004, “Planets and Brown Dwarfs in the Winds of Dying Stars,” in *Asymmetric Planetary Nebulae III, ASP Conf. Series*, eds. M. Meixner, J. Kastner, B. Balick, & N. Soker (San Francisco: ASP), in press.
- P.R. Wood, E.A. Olivier, & **S.D. Kawaler**, 2003, “Long secondary periods in pulsating AGB stars: pulsation, rotating spheroids, or orbiting brown dwarfs?,” *ApJ*, in press.

Steven D. Kawaler