

**University of Wyoming**  
**Department of Physics & Astronomy**  
*Laramie, Wyoming 82071*

The following report covers the Department activities from October 2002 through October 2003.

## 1. INTRODUCTION

The Department of Physics and Astronomy continues to expand the graduate program in astronomy and the number of undergraduate majors remains near an all-time high. Also remaining successful are the Research Experience for Undergraduates and the Research Experience for Teachers programs. A new outreach program, "Astro Camp" has been developed that brings high school students from across Wyoming to the campus to explore astronomy, rocketry, and local recreational opportunities.

## 2. PERSONNEL

### Astronomy Faculty:

Antonio Bianchini, cataclysmic variables; Mike Brotherton, quasars and active galaxies; Ron Canterna, gamma Ray Bursts; Daniel Dale, infrared galaxies; clusters; Bob Howell, Planetary science; Io volcanism; Chip Kobulnicky, galaxy chemical abundances; Harold Nations, chromospherically active stars; Mike Pierce, galaxies; instrumentation; J. Allyn Smith, stellar evolution; white dwarfs

### Postdocs:

Robert Berrington, Brent Buckalew, Zhaohui Shang

### New Graduate Students:

Travis Laurance, Mark Reiser, Brian Uzpen

## 3. FACILITIES

### 3.1 Wyoming Infrared Observatory

The recent expansion of the department has dovetailed with the renaissance of the 2.3 m WIRO telescope. The most significant changes are the telescopes new instrumentation: a wide-field 2048<sup>2</sup> CCD prime focus optical camera, an integral field, fiber-fed optical spectrograph that utilizes volume-phase holographic gratings, and a 256<sup>2</sup> InSb infrared camera developed by scientists at NASA/Goddard. The new instruments and numerous upgrades (observatory electronics and infrastructure, instrument/user computer interface) have enabled several new observational programs to begin.

### 3.2 Red Buttes Observatory

The major research activity at RBO is the follow-up response and monitoring of gamma ray bursts to obtain visual photometric data on the afterglows. The gamma ray burst gang (undergraduates Dave Allen, Katie Cantrell, Elinor Davis, Kim Dupczak, Danny Gibbs, Brian Scoggins, Justin Schaefer, Josh Silvey, Josh Spinler, Justin Stute) have responded to every GRB alert, weather permitting, since October 2002. GCN GRB reports on GRB021004, GRB021112, GRB021016, GRB030329, GRB030413, and

GRB030416 were submitted by undergraduates Richard Cool, Justin Schaefer, and graduate students Sabrina Savage and Seyhun Hwang.

Additional undergraduate research projects through the academic years have been the long-term monitoring of northern hemisphere cataclysmic variables with extremely strong magnetic fields, Polars (Allen, Davis, and Silvey; Canterna supervisor), search and monitoring optical counterparts to unidentified Compton/EGRET sources. (Cool, Dupczak; Dale supervisor), UBVR photometry of the open cluster King 13 (Cantrell, Stute; Smith supervisor), and the photometric monitoring of low mass white dwarfs (Schaefer; T. Oswalt supervisor).

Summer projects with the Summer Undergraduate Research Assistantship Program, a national REU site, included an investigation of the binary nature of massive stars in the Cygnus OB2 association from light curves (Leah Simon; Kobulnicky supervisor), the continuation of the search and monitoring of optical counterparts to unidentified Compton/EGRET sources (Anna Haugsjaa; Dale supervisor), and the determination of the photometric properties of the RBO CCD camera (Allen, Davis, and Silvey; Canterna supervisor).

Two major improvements to the observational instrumentation and communications system were completed by August 2003. An Apogee AP8 CCD was permanently acquired giving our imaging capabilities an 18' FOV. Assistant Director Ray Martin oversaw the installation of a high speed microwave link (Integrity Inc) to the campus network. The RBO local computer network and system has been ably developed by Sabrina Savage. Harold Nations and Phil Haynes have developed a miniature optical fiber-coupled spectrograph using a Volume Phase Holographic grating for RBO.

Several classes and the astronomy camp have used RBO throughout the year.

## 4. RESEARCH

**Antonio Bianchini** was on sabbatical leave from the University of Padua. His main research activities focus on: observational studies of selected cataclysmic variables and, in particular, of Intermediate Polars; evolutionary models of post-novae with IP characteristics; and the optical identification of  $\gamma$  ray bursts.

Assistant Professor **Michael Brotherton**'s research seeks to improve our understanding of active galactic nuclei (AGNs), their evolution, and their relationship to their host galaxies. His work on intrinsic AGN absorbers involves radio-selected BALQSOs, using radio (VLA), spectropolarimetry (Keck), X-ray (Chandra, XMM), and near-IR (IRTF) observations. These programs are identifying serious shortcomings in the popular notion that BALQSOs are otherwise

normal quasars seen at large angles and that all quasars possess high-velocity outflows.

Brotherton also works on AGN emission processes. The broad emission lines trace the kinematics and physical conditions of gas in the immediate environment of the central engine. The dynamics, geometry, abundances, and origin of this gas are not yet understood. Recently however significant progress has been made in linking the strongest observed trends, the so-called ‘‘eigenvector 1’’ relationships which include X-ray and radio properties, with the accretion rate (Eddington fraction). Furthermore, it now appears that the central black hole mass can be rather accurately estimated based solely upon the linewidth of the Balmer lines and the continuum luminosity.

Brotherton discovered two spectacular instances of massive post-starburst populations in interacting quasar systems: a radio-quiet/radio-loud binary quasar, and a *post-starburst quasar* with a Milky Way’s worth of stars formed at one epoch.

Assistant Professor **Daniel Dale** continues to study galaxies from a variety of infrared perspectives. A study using Palomar near-infrared integral field spectroscopy highlighted how H II regions differ from galactic nuclei in line/continuum alignment, age, line ratios, color, photon density, and the abundance of ionized iron. An *ISO*-based survey for [O I] 63  $\mu\text{m}$  line emission from  $z \sim 1$  quasars yielded one possible detection and three upper limits. Interestingly, nearby Seyfert galaxies show higher [O I]-to-far-infrared ratios than do normal star-forming galaxies, so the lack of strong [O I] 63  $\mu\text{m}$  emission from these high-redshift ultraluminous sources cannot be attributed to their active cores. The successful launch and initial space-based tests of SIRTf bode well for Dale’s first SIRTf project, a complete imaging and spectroscopy campaign of 75 nearby galaxies (‘‘SINGS: The SIRTf Nearby Galaxy Survey’’).

Dale and Juan Uson just finished a Tully-Fisher study of  $z \sim 0.1$  galaxy clusters, based on Palomar 5 m spectroscopy. The study explored the kinematical zero point of the relation at this distance, and looked for impacts of the interstellar medium. A follow-up study using X-ray data formed the thrust of Richard Cool’s Honors thesis.

**Chip Kobulnicky** completed a study of the chemical abundances of star-forming galaxies at redshifts of  $z = 0.2 - 0.8$ , using data from the Keck telescope in collaboration with a team of eight other astronomers from across the country but based principally at UC Santa Cruz. Published in the December 2003 *Astrophysical Journal*, the research found evidence for significant changes in the luminosities and heavy element abundances in galaxies at these 3-8 billion year lookback times. Small galaxies appear to evolve more significantly than larger ones. In a separate paper, Kobulnicky and UC Santa Cruz astronomer Drew Phillips outlined a method for using equivalent widths of emission lines from star-forming galaxies to measure their interstellar medium chemical compositions. In other programs, Kobulnicky continued as a member of the GLIMPSE SIRTf Legacy team, preparing to map the inner Milky Way at four mid-infrared wavelengths. The team will use 400 hours of dedicated SIRTf observatory time to conduct this survey over

240 square degrees of the sky and catalog the majority of star formation regions, massive stars, evolved stars, and highly obscured objects in the Galaxy beginning in January 2004. Kobulnicky is working with graduate students Travis Lauer and Brian Uzpen to use the GLIMPSE dataset to locate extremely young stars that may be surrounded by protoplanetary disks of dust, and perhaps planets. Kobulnicky was awarded a 3-year grant from the National Science Foundation to measure the frequency of binary stars among the most massive O and B type star in the Cygnus OB2 association. These are the possible progenitors of nature’s most energetic explosions: supernovae and gamma ray bursts. As part of this grant, Kobulnicky has designed a new prime focus corrector for the Wyoming Infrared Observatory 2.3 m telescope. This corrector will allow imaging over a very wide field of view and enable the monitoring of Cygnus OB2 for eclipsing variable stars. Graduate student Dan Kiminki is analyzing data from the program and presented some preliminary results at the Atlanta meeting of the American Astronomical Society.

Visiting Assistant Professor **J. Allyn Smith** continues to work in the Sloan Digital Sky Survey standard star system. He is currently developing a southern hemisphere extension with D.L. Tucker as part of a four year NOAO Survey Program. Smith also recently joined the SNAP (SuperNova Acceleration Probe) calibration team. Allyn has joined the Los Alamos National Laboratory staff.

## 5. EDUCATION & OUTREACH

The department has garnered substantial funding for a revitalization of the undergraduate curriculum. Improvements range from upgrading essentially all the undergraduate labs with new computers, software, and projection capabilities to electronic response systems and general lab equipment.

Our observatories, planetarium, and the Wyoming Space Grant Consortium form the foundation of many outreach activities. The UW planetarium continues to host over 3500 visitors yearly. Physics & Astronomy holds an annual WIRO Open House on homecoming weekend. Space Grant has been involved in bringing two astronauts to campus to talk to the public. A new ‘‘Physics Magic Show’’ has proved to be an effective vehicle for reaching out to middle school students.

The NSF-funded REU program hosted eight students during the summer of 2003. In addition to receiving individual mentoring, each student learned the fundamentals of astronomical observing by participating in RBO and WIRO runs. WyoSTAR (Wyoming Students, Teachers, and Researchers) is a program that joins astronomy educators and students across the state with amateur and professional astronomers. Currently we are focusing on summer research mentoring of high school science teachers; one teacher was involved in research this past summer.

Michael Brotherton has sold his first novel to Tor which was published in hardback in October 2003. *Star Dragons* features an expedition to search for alien creatures living in the accretion disk of SS Cygni, a cataclysmic variable binary star system.

Kobulnicky, in collaboration with Space Grant, colleague Danny Dale, and student Chad Sharpe, conducted the first Wyoming Astronomy Camp for two weekends in the summer of 2003. Astronomy camp served approximately 30 high school students from the Casper area Boys & Girls Clubs by providing hands-on experience with telescopes, rockets and space-related activities designed to provide a positive experience in a college environment for at-risk youth. Kobulnicky has secured funding from the NSF and from NASA to run the Wyoming Astronomy Camp until 2006. Junior high and high school teachers will also be in residence each summer to gain experience with astronomical research and to help design curriculum for science education at the secondary school level.

## PUBLICATIONS

The publication list includes all papers published or submitted between October 2002 and October 2003.

- Allam, S., Tucker, D. & **Smith, J.** 2002, BAAS, 34, 1192 “Properties of Merging Pairs in the SDSS EDR”
- Benjamin, R. *et al.* 2003, PASP, 115, 953 “GLIMPSE. I. An SIRTf Legacy Project to Map the Inner Galaxy”
- Bianchini, A.**, Tappert, C., **Canterna, R.** *et al.* 2003, PASP, 115, 811 “RW Ursae Minoris (1956): An Evolving Post-nova System”
- Bianchini, A.**, **Canterna, R.** *et al.* 2003, PASP, 115, 474 “Evidence for Magnetic Accretion during the 2002 Optical Outburst of the Old Nova GK Persei (1901)”
- Bianchini, A.**, Garcia, C. & **Canterna, R.** 2002, BAAS, 34, 1162 “Evidence of an accreting white dwarf during the 2002 optical outburst of the old nova GK Per(2001)”
- Bloom, S., **Dale, D.** *et al.* 2003, AJ, submitted “An Optical Survey of the Position Error Contours of Unidentified High Energy Gamma-ray Sources at Galactic Latitude  $b > |20^\circ|$ ”
- Brotherton, M.**, Croom, S., De Breuck, C., Becker, R. & Gregg, M. 2002, AJ, 124, 2575 “The Twice-Overlooked, Second FR II Broad Absorption Line Quasar LBQS 1138-0126”
- Brotherton, M.** *et al.* 2002, BAAS, 34, 1288 “X-rays from Radio-Loud Broad Absorption Line Quasars”
- Brotherton, M.**, Ly, C., Wills, B., Laurent-Muehleisen, S., van Breugel, W. & Antonucci, R. 2002, AJ, 124, 1943 “Multiband VLA Observations of the Faint Radio Core of 3CR 68.1”
- Burgh, E., Nordsieck, K., **Kobulnicky, H.** *et al.* 2003, SPIE, 4841, 1463 “Prime Focus Imaging Spectrograph for the Southern African Large Telescope: optical design”
- Canterna, R.** *et al.* 2002, BAAS, 34, 1104 “Variable Stars in M 13”
- Chapman, S., Helou, G., Lewis, G. & **Dale, D.** 2002, ApJ, 588, 186 “The Bi-Variate Luminosity-Color Distribution of IRAS Galaxies, and Implications for the High Redshift Universe”
- Courteau, S., MacArthur, L., Dekel, A., McIntosh, D., Rix, H.-W., van den Bosch, F. & **Dale, D.** 2003, ApJ, submitted “The Scaling Relations in Spiral Galaxies. I. Observational Foundations”
- Dale, D.** & Uson, J. 2003, AJ, 126, 675 “Signatures of Galaxy-Cluster Interactions: Tully-Fisher Observations at  $z \sim 0.1$ ”
- Dale, D.**, Roussel, H., Contursi, A. & Helou, G. 2002, BAAS, 34, 1412 “Near-Infrared Integral Field Spectroscopy of Normal Star-Forming Galaxies”
- Dale, D.**, Roussel, H., Contursi, A. & Helou, G. 2003, ApJ, in press “Near-Infrared Integral Field Spectroscopy of Normal Star-Forming Galaxies”
- Dale, D.** 2003, *The IGM/Galaxy Connection—The Distribution of Baryons at  $z=0$* , J. Rosenberg & M. Putnam, eds, Kluwer Academic Publishers, Dordrecht, p. 311 “Signatures of Galaxy-Cluster Interactions: Spiral Galaxy Rotation Curve Asymmetry, Shape, and Extent”
- Deustua, S. *et al.* 2002, BAAS, 34, 1258 “SNAP Calibration”
- Eftimova, M. & **Dale, D.** 2002, BAAS, 34, 1302 “Modeling the Dark Matter Halo Properties of Cluster Galaxies”
- Elsner, R. *et al.* 2003, BAAS, 202, 33.03 “Preliminary Results from Recent Simultaneous Chandra/HST Observations of Jupiter Auroral Zones”
- Elsner, R. *et al.* 2003, BAAS DPS, 35, 02.02 “Preliminary Results from Recent Simultaneous Chandra/HST Observations of Jupiter Auroral Zones”
- Georgantopoulos, I., Nandra, K., **Brotherton, M.** *et al.* 2003, *Astronomische Nachrichten*, 324, 32 “The SHEEP survey: Observing the hardest of the hard with Chandra”
- Howell, R.** 2003, LPI, 34, 2098 “Mutual Event Observations of Hot Spots on Io”
- Jessup, K. *et al.* 2003, BAAS DPS, 35, 02.05 “The Atmospheric Signature of Io’s Prometheus Plume and Anti-Jovian Hemisphere: Evidence for a Sublimation Atmosphere”
- Kafka, S., Tappert, C., Honeycutt, R. & **Bianchini, A.** 2003, BAAS, 202, 30.01 “Q Cyg: outflow from a long period old nova”
- Kafka, S., Tappert, C., Honeycutt, R. & **Bianchini, A.** 2003, AJ, 126, 1472 “Spectroscopic Study of Q Cygni: Surprises from an Old Nova”
- Kennicutt, R. *et al.* 2003, PASP, 115, 928 “SINGS: the SIRTf Nearby Galaxies Survey”
- Kobulnicky, H.** *et al.* 2002, BAAS, 34, 1194 “The DEEP Groth Strip Survey XII: The Metallicity of Field Galaxies at  $z=0.26-0.82$ ”
- Kobulnicky, H.** *et al.* 2003, SPIE, 4841, 1634 “The Prime Focus Imaging Spectrograph for the Southern African Large Telescope: Operational Modes”
- Kriss, G., Scott, J., Alexander, **Brotherton, M.** *et al.* 2002, BAAS, 201, 146.01 “Ultraviolet Properties of Low-Redshift AGN Observed with FUSE”
- Laurance, T., **Kobulnicky, H.** *et al.* 2002, BAAS, 34, 1223 “WIYN/Hydra Spectroscopy of Stars in the Direction of Star Forming Region W51”
- Lehner, N., **Kobulnicky, H.** *et al.* 2002, BAAS, 34, 1235 “High Resolution Echelle FUV Spectroscopy of the Low Redshift Gas toward the QSO PKS 0312-77”
- Lopes, R. *et al.* 2003, BAAS DPS, 35, 02.02 “Lava Lakes on Io?”
- Lu, N., Helou, G., Werner, M., Dinerstein, H., **Dale, D.** *et al.*

- 2002, ApJ, 588, 199 “Infrared Emission of Normal Galaxies from 2.5 to 12 $\mu$ m: Spectra, Near-Infrared Continuum and Mid-Infrared Emission Features”
- Nations, H.**, Haynes, P. & Brewer, P. 2003, BAAS, 202, 10.09 “Mini-Spec: A Compact, Fiber-Coupled, VPH Grating Spectrograph for Small Observatories”
- Nordhaus, M. *et al.* 2002, BAAS, 34, 1126 “Photometric Separation of Physical Properties of Stars”
- Nordsieck, K., Jahnig, K., Burgh, E., **Kobulnicky, H.**, Percival, J. & Smith, M. 2003, SPIE, 4843, 170 “Instrumentation for High-Resolution Spectropolarimetry in the visible and far-ultraviolet”
- Pierce, M.** & Berrington, R. 2002, BAAS, 34, 1167 “A Northern Survey of the Fundamental Plane of Elliptical Galaxies”
- Smith, J.** *et al.* 2002, BAAS, 34, 1272 “The  $u'g'r'i'z'$  Standard Star System”
- Mallery, R., **Pierce, M.** & **Nations, H.** 2002, BAAS, 201, 18.11 “A Graphical User Interface for the University of Wyoming’s 2.3-m Telescope”
- Smith, J.**, Oswalt, T. & Wood, M. 2003, in White Dwarfs, ed. de Martino, Silvotti, Solheim, and Kalytis, Kluwer, 105, 399 “A Lower Limit to the Age of the Galaxy from the White Dwarf Luminosity Function”
- Scott, J., Kriss, G., Alexander, T., **Brotherton, M.** *et al.* 2002, BAAS, 201, 146.03 “The Intrinsic Absorption Spectrum of Mrk 279”
- Scott, J., Kriss, G., **Brotherton, M.** *et al.* 2003, BAAS, 202, 42.02 “A Composite Extreme Ultraviolet QSO Spectrum from FUSE”
- Shields, G. *et al.* 2003, ApJ, 583 “The Black Hole-Bulge Relationship in Quasars”
- Tamburini, F., Ortolani, S. & **Bianchini, A.** 2002, A&A, 394, 675 “Polarization statistics of extra-solar systems”
- Tamburini, F., Barbieri, C., **Bianchini, A.** & Ortolani, S. 2002, Memorie della Societa Astronomica Italiana, 74, 516 “Futuristic applications of quantum EPR states”
- Tappert, C. & **Bianchini, A.** 2003, A&A, 401, 1101 “GZ Cancri: A cataclysmic variable at the lower edge of the period gap”
- Waite, J. *et al.* 2003, BAAS DPS, 35, 50.10 “Interpreting the Results from Recent Simultaneous Chandra/HST Observations of the Jovian Aurora”
- Yuan, Q., Green, R. & **Brotherton, M.** 2003, ASP Conf. Series, 289, 409 “Intrinsic Far-UV Absorbers in the Radio-Loud Quasar 3C 351”
- Yuan, Q., **Brotherton, M.** & Green, R. 2003, IAU 217 “Outflowing Components in the Prototype NLS1 MRK 478”

D.A. Dale