

The Johns Hopkins University
Center for Astrophysical Sciences
Department of Physics and Astronomy
Baltimore, Maryland 21218

[S0002-7537(93)03831-4]

The following report covers the period from October 1999 through September 2000.

1. INTRODUCTION

Among the highlights of 2000 were the successful ongoing operations of the Far-Ultraviolet Spectroscopic Explorer (FUSE) and the Sloan Digital Sky Survey (SDSS). The former project is managed directly from Johns Hopkins. The latter is a broad collaborative effort, within which astronomers from JHU play a major role. Work continues on the ACS (Advanced Camera for Surveys) for the Hubble Space Telescope. In addition, scientists from JHU have successfully proposed for a Phase A study for a Small EXplorer project, PRIME (PRIMordial Explorer), a near IR, multiple color, wide-field survey. Finally, we continue to pursue a broad range of theoretical and ground-based astronomical projects.

2. PERSONNEL

CAS visitors were E. Agol, R. Burg, C. M. Carollo, P. Chayer, J. Crocker, I. Csabai, A. Dey, A. Fullerton, T. Henry, J. Najita, P. Rosati, P. Tozzi, and R. Walterbos. Departed from CAS are E. Agol (to the California Institute of Technology), T. Henry (to Georgia State University), M. Iovea (to the Institute for Nuclear Reactors in Bucharest, Romania), E. Murphy (to University of Virginia), E. Perlman (to UMBC), K. Roth (to Gemini Observatory, HI), G. Szokoly (to Astrophysikalisches Institut Potsdam), and P. Tozzi (to Osservatorio Astronomico di Trieste).

Permanent staff are Professors S. Beckwith (Director, Space Telescope Science Institute), P. J. Dagdigan, A. F. Davidsen, J. P. Doering, P. D. Feldman, (Chair, Physics and Astronomy), H. C. Ford, K. Glazebrook, T. M. Heckman, R. C. Henry (Director, Maryland Space Grant Consortium), B. R. Judd, C. W. Kim, J. H. Krolik, H. W. Moos, D. Neufeld, C. A. Norman, D. F. Strobel, A. Szalay, E. T. Vishniac (Director, CAS) and R. F. G. Wyse, Research Professor R. Giacconi, Assistant Research Professor S. Lubow, Associate Research Professors W. P. Blair and Z. Tsvetanov, Adjunct Assistant Professors D. Figer (STScI) and K. Weaver (GSFC), Adjunct Associate Professor G. Kriss (STScI), Adjunct Professor R. F. Mushotzky (GSFC), and Visiting Professor M. Finkenthal.

STScI Scientists are R. J. Allen, R. Brown, H. C. Ferguson, M. Hauser, G. A. Kriss, M. Livio, K. S. Long, P. Madau, M. McGrath, M. Postman, P. Stockman.

Research Scientists are L. Bianchi, S. Friedman, M. E. Kaiser, J. Kruk, S. McCandliss, G. Meurer, W. Oegerle, A. Uomoto, H. A. Weaver and W. Zheng.

Associate Research Scientists are B.-G. Andersson, N. Benitez, J. Blakeslee, E. Colbert, D. Golimowski, C. Gron-

wall, C. Holmes, B. Jain, P. Kunszt, S. Malhotra, A. Martel, S. Ridgeway, R. Sankrit, D. Sahnou, K. Sembach, M. Sirianni, D. Stutman, A. Thakar, H. Tran and T. Yaqoob.

Postdoctoral Fellows are G. Catanzaro, R. Chandar, B. Chen, R. C. Fernandes, C. Hoopes, M. Houdashelt, C. Howk, M. Kerscher, N. Levenson, S. Malhotra, T. Matsubara, M. May, E. Neilsen, K. Rauch, R. Shelton, P. Sonnentrucker, D. Strickland, J. Wiseman and B. Wolven.

3. THE FAR ULTRAVIOLET SPECTROSCOPIC EXPLORER

The largest project in the Center for Astrophysical Sciences is the Far Ultraviolet Spectroscopic Explorer (FUSE), an astronomy mission within the NASA Origins program. FUSE has been successfully executing observations of a diverse set of targets for well over one year. FUSE is exploring the Universe through high-resolution ($R \sim 20,000$) spectroscopy at far ultraviolet wavelengths (910-1190 Å). The transitions of many astrophysically-important atoms, ions, and molecules lie in this spectral range, permitting detailed study of the interstellar medium, the intergalactic medium, active galactic nuclei, quasars, massive stars, supernovae, planetary nebulae, and the outer atmospheres of cool stars and planets. FUSE has 10,000 times the sensitivity of the *Copernicus* satellite, which was launched nearly 30 years ago.

The first set of scientific results was published in the 20 July 2000 issue of the *Astrophysical Journal Letters*, which was devoted entirely to FUSE. These papers were based almost entirely on data collected in the first few months of operation. Since then, many additional observations have been made and placed in the MAST archive at STScI. Since the proprietary time for FUSE data is only 6 months, many of these data sets are publicly available now. This year approximately half of the observing time is devoted to guest investigators (GIs), and the remaining half is guaranteed to the FUSE science team. Next year 75% will be devoted to GIs, and 100% thereafter.

FUSE was developed by a team led by JHU, with participation by the University of Colorado, UC Berkeley, several commercial companies, and the space agencies of Canada and France. It is operated from the Bloomberg Center on JHU's Homewood campus, and is the largest, most complex mission NASA has ever allowed a university to develop and operate. It has a three year lifetime, but NASA recently authorized a two year extension.

JHU personnel participating in the FUSE mission are Principal Investigator Warren Moos, and T. Ake, B-G Andersson, L. Bianchi, W. Blair, P. Chayer, A. Davidsen, P. Feldman, S. Friedman, A. Fullerton, C. Hoopes, C. Howk, M. Kaiser, J. Kruk, N. Lehner, W. Oegerle, D. Sahnou, R. Sankrit, K. Sembach, R. Shelton, P. Sonnentrucker, H. Weaver, and W. Zheng. In addition, a group of about 20

engineering and technical staff at JHU participate in mission operations and support activities.

4. THE SLOAN DIGITAL SKY SURVEY

SDSS was officially dedicated in October 2000 and routine observations are now under way at Apache Point Observatory. Again this year the highest redshift quasar ($z=5.8$) was found in the five-band imaging data. Other discoveries include new methane dwarfs (with new objects filling the spectral space between the L and T spectral classes), description of an A-star halo component to the galaxy, and evidence of a thick disk component to the Galaxy by JHU postdoc B. Chen.

JHU hosted a successful collaboration meeting in September, 2000, where the above research, and more, was presented.

JHU's contribution to SDSS include the two fiber optic spectrographs on the 2.5 m telescope, development of the high speed science database, and installation of the 20-inch photometric telescope used to calibrate the 2.5 m SDSS imaging.

5. THE ADVANCED CAMERA FOR SURVEYS

The Advanced Camera for Surveys (ACS) will be installed in the Hubble Space Telescope during the fourth servicing mission (SM-3B), now scheduled for November 2001. The ACS is being built by collaboration between Ball Aerospace, the Johns Hopkins University and the Goddard Space Flight Center. Members of the science team, led by the PI Holland Ford, are at JHU, the Space Telescope Science Institute, the University of Arizona, the University of California Santa Cruz, Leiden University, the European Southern Observatory, and the Goddard Space Flight Center.

A list of science and engineering team members and information about the ACS can be found at <http://adcam.pha.jhu.edu/>. The ACS now has excellent flight detectors for the Solar Blind Camera, the High Resolution Camera (HRC), and the Wide Field Camera (WFC). The cause of the image motion that was described in last year's BAAS report was finally found to be due to warping of the forward bulkhead that carries the M2 mirrors. The M2 mirrors were removed from the bulkhead and mounted on a small optical bench attached to the bottom of the ACS optical bench. Extensive testing at Ball Aerospace during June 2000 suggests that the image motion is now smaller than the specifications. This will be confirmed during thermal vacuum testing at the Goddard Space Flight Center in late October 2000.

The engineering model of the WFC revealed two serious problems. The first was scattered light from point sources positioned near the edge of an internal thermal mask. Two steps were taken to correct the problem. The interior of the WFC was coated with a multi-layer dielectric "black mirror" that reduced the reflectivity in the red to a few percent, and the edge of the mask was machined into a knife-edge. Subsequent stray light measurements showed that the WFC now meets the specifications for scattered light.

The second problem appeared during vacuum bakeout of the WFC. Expansion of the inner radiation shield broke one or more of the two-stage thermoelectric coolers (TECs) that

both cool and support the housing. The problem was solved by mounting the radiation shield on stainless steel flexures and connecting the TECs to the radiation shield with heat straps. There is still adequate thermal margin, and the TECs no longer break. We now have two Wide Field Cameras, one for flight and one for a spare. Both cameras have successfully completed all of their environmental tests.

During the summer the ACS was tested at GSFC for overall noise performance and for susceptibility to noise induced by either the Aft Shroud Cooling System's external heat pipes, or by the NICMOS Cryo-cooler. The ACS detectors have shown no susceptibility to operation of any of the Aft Shroud or NICMOS Cryo-cooler components during testing with the Cooling systems Hardware Electrical System Test. Final tests of noise susceptibility will be made during forthcoming thermal-vacuum tests. We expect the CCDs to have 4 to 5.5 electrons rms read noise, depending on the CCD and the individual amplifiers.

We expect the ACS to be ready for a launch in November 2001. The ACS will provide the HST with important new capabilities, including a factor of 10 improvement in survey efficiency that will be made with twice the resolution of the WFPC2 and ~ 8 times the overall spatial information. We think that observations with the ACS will greatly improve our understanding of phenomena ranging from nearby circumstellar disks to the evolution of galaxies in the early universe to the present.

6. RESEARCH AND ACTIVITIES

Steven Beckwith, Stefano Casertano (STScI), and Paul Kalas (STScI) have been pursuing an idea to improve the astrometric accuracy of HST using WFPC2 in a scanning mode. The fundamental limit to the accuracy of present astrometry with the cameras is sub-pixel and pixel-to-pixel variations in sensitivity that sets a floor to the precision by which positions of objects can be measured in the images. The basic idea is that by scanning the objects across the detector array creating long trails, we can average over many (~ 1000) pixels and reduce the inherent uncertainties of dealing with a small number of pixels in pointed images. In principle, we could gain more than an order of magnitude in astrometric precision with HST taking it to below the 1 millisecond of arc level. At that accuracy, HST becomes interesting to look for astrometric signatures of extrasolar planetary systems. The first data were obtained in August 2000.

Beckwith, Michael Meyer (U. Arizona), and Massimo Robberto (STScI) had time on ISO to search for thermal emission from circumstellar disks around stars between the ages of 10^6 and 10^8 years, the period during which planet-building is thought to occur. The data have been analyzed with several different versions of the PIA reduction software. Early versions of this software produced results that were inconsistent with extant data on some of the objects (mainly from IRAS); in some cases, they were internally inconsistent. There is now a consistent set of reduced data, and the group is preparing the results for publication.

Meyer, Beckwith, Antonella Natta (Arcetri), and Roberto obtained observations of 16 stars in Chameleon to give spectral energy distributions from 3 to 200 μm , including

continuous spectra (PHOT-S) from 3 to 13 μm for the first time. The scientific goal is to distinguish among the various geometrical models for circumstellar disks around these stars - for example, flared vs. flat disks. The spectra demonstrate that 10 μm silicate emission features from optically thin dust are commonly seen in these disks. This result was recently published. Thomas Herbst (MPIf Astronomie), Beckwith and their collaborators surveyed a large area with the Calar Alto Omega camera to search for brown dwarfs. The limits established were very good, and the data were published. Unfortunately, the survey could not reach the same area as the 2MASS survey, whose results on brown dwarfs have superseded those of this group.

Robberto, Beckwith, Herbst, and Meyer used the MAX camera to detect disks around ionized and silhouette disks in the Orion nebula. During 1997, the team observed and detected essentially all of the disks in the Trapezium core that were discovered with HST - both the ionized and dark disks. Owing to the strong background emission from the nebula, background subtraction is difficult. By varying the spacing used for background subtraction, it was possible to eliminate most of the extended emission to get photometry on the unresolved disks. The preliminary results have been published in two conference proceedings, and the final results are in preparation for publication in the *Astrophysical Journal*.

David Thompson (Caltech), Filippo Mannucci (Arcetri), and Beckwith continued their search for young, emission line galaxies at high redshift using narrow-band interference filters to look for emission-line objects (MAGIC and Omega Prime cameras on the Calar Alto 3.5m telescope) and the CGS4 spectrometer on UKIRT for spectroscopic follow-up. The first survey targeted emission-lines at the same redshifts as quasars in the survey fields. One object was discovered in a survey of 276 square minutes of arc described in a publication in 1998. A second survey targeted the redshifts of damped Lyman alpha or metal absorption systems seen in the spectra of quasars in the fields. This survey covered only 150 square minutes of arc but revealed 18 emission-line objects. Two of these objects were imaged by the Hubble Space Telescope as part of another program. A paper describing the results of this second survey has been published and follow-up with CGS4 of one of the objects confirmed the emission-line. It appears that damped Lyman alpha absorption systems pinpoint regions of vigorous star formation and will lead to a revision of the search strategies for young galaxies at high redshift.

The team continued its research by including new observations with HST taken last year (data analysis underway). Part of this research is the study of extremely red objects that show up in our survey fields (mainly the CADIS survey fields). We published the first paper describing this research early last year, and we are preparing a second that incorporates new Keck observations for publication in the coming year.

Herbst, Beckwith, Thompson, and Dietrich Lemke (MPIf Astronomie) continued their program to observe faint light associated with galaxy halos. Evidence for luminous matter was reported by Sackett *et al.* (1994, Nature), who looked at the edge-on Sc galaxy NGC 5907 for faint R-band light, and

subsequently by Rudy *et al.* (1997, Nature), who observed near infrared emission at K. They reported the detection of excesses in the halo well above and below the disk plane. Herbst's group observed several edge-on spirals, including NGC 5907, with the MAGIC and Omega Prime cameras, reaching limits of 26th and 25th mag/sq. arcsec in J and K bands, respectively, and do not see the emission claimed by Rudy *et al.* The group believes the initially reported results are in error, and they can show that the intensity profiles above and below the disk plane are inconsistent with a luminous component of the dark matter needed to produce the observed rotation curves. This work is currently being prepared for publication.

Luciana Bianchi is co-Investigator of the NASA SMEX mission GALEX (The Galaxy Evolution Explorer), and is leading the GALEX science data archive development (Bianchi *et al.* 2000a, b and references therein). GALEX will be launched in late 2001 to perform Ultraviolet imaging and spectroscopic surveys of the sky in a 28 month mission.

Bianchi continues to lead a study of hot massive stars in Local Group galaxies based on HST, FUSE and ground based data. In this program she involved postdocs Gianni Catanzaro and Rupali Chandar, and graduate student Miriam Garcia (from the University of La Laguna). Bianchi is using 46 orbits of Hubble Space Telescope in cycle 10 to characterize a young co-eval population of NGC 6822, discovered from her earlier WFPC2 multiband photometry. The photometry also led to the discovery of several very massive star candidates in this metal poor environment.

From October 1999, science data from the FUSE satellite allowed her to significantly expand the study of stellar winds and mass loss properties of hot massive stars. In an ApJ Letter dedicated to the FUSE ERO's, Bianchi (*et al.* 2000c) demonstrated the potential of the far-UV lines to measure for the first time the ionization of supersonic winds, and compared the ionization in two O7 supergiants in the LMC and SMC. She is also co-author of 3 other papers in the issue dedicated to the FUSE ERO's (Moos *et al.* 2000, Fullerton *et al.* 2000, Massa *et al.* 2000) and of three works presented at the AAS 195, on FUSE data.

Bianchi also continues the study of stellar clusters and HII regions in Local Group galaxies with Rupali Chandar and Holland Ford (Chandar, Bianchi and Ford, 2000).

Bianchi is serving on the Organization Committee of IAU Comm. 42, and served on the HST TAC panels in 1999.

William P. Blair is an Associate Research Professor in the Department of Physics and Astronomy. He is the Chief of Mission Planning for the Far Ultraviolet Spectroscopic Explorer (FUSE) mission, which is headquartered at JHU, and he is in charge of the operation of the mission planning segment of the ground operations system. While these duties have taken the bulk of his time, Blair has continued his independent research projects on supernova remnants using FUSE, the Hubble Space Telescope (HST), and other space and ground-based observatories.

Work with HST has concentrated in two areas. With postdoc R. Sankrit (JHU/CAS), K. S. Long (STScI), and J. C. Raymond (SAO), HST/STIS data on a non-radiative shock in the northeastern Cygnus Loop have been analyzed and an

initial paper published. This faint filament is at the very edge of the X-ray emission represents the primary blast wave as it first encounters the interstellar medium. With STIS spectra cutting across the filament at one position, we are able to measure differences in the spatial distributions of various UV lines behind the shock. Comparing to shock model calculations allowed us to constrain the shock velocity and pre-shock density at the observed position. On-going work with additional STIS spectra, and including FUSE O VI observations, will allow us to generalize this result over the coming year.

Another HST project came to fruition this year after several years of effort. Blair led a large group of collaborators in publishing HST images and FOS spectroscopy on two oxygen-rich young supernova remnants in the nearby galaxies known as the Magellanic Clouds. Even though these objects are much more distant than galactic supernova remnants, they do not suffer from very much foreground extinction, making observations possible across the entire UV/optical region. Careful modeling of the FOS spectra has provided the best information on the chemical make-up of the debris from these exploded stars, and points toward masses of 25-40 solar masses for the progenitor stars. Blair gave an invited review talk at the 2000 Maryland Astrophysics Conference on these young supernova remnants. With graduate student Charles Danforth, postdoc Nancy Levenson, and collaborators from NASA/GSFC, Blair published an atlas of UV/optical imagery of selected regions in the Cygnus Loop. The UV data were from the Ultraviolet Imaging Telescope. Combining these images with optical ground-based images of the same regions, we have characterized the spatial distributions of the various emissions and investigated the effects of resonance line scattering, which are more widespread than thought previously. Other projects have included an X-ray study of a luminous supernova remnant in the galaxy NGC 6946 with E. M. Schlegel (SAO) and R. A. Fesen (Dartmouth), and an optical ground-based study of shock precursors in Tycho's supernova remnant with P. Ghavamian and P. Hartigan (Rice University) and Raymond.

Blair participated in numerous papers on Early Release Observations from FUSE, leading the paper on the supernova remnant N49 in the Large Magellanic Cloud. Several additional FUSE projects are already in the works and should be published over the coming year. Important duties on the FUSE operations team have included continued development of the mission planning system and support of on-going FUSE mission planning activities. In addition, Blair maintains the public Web site for the FUSE project (see <http://fuse.pha.jhu.edu/>) and participates in various education and outreach activities, including duties as Press Liaison Officer.

Rupali Chandar is a Postdoctoral Fellow working with Holland Ford and Luciana Bianchi, continuing a long term project to understand the formation of late-type galaxies through star cluster properties. By measuring age, mass, metallicity, and radial velocity for a system of star clusters, one can constrain the different evolutionary pathways of these galaxies. Comparison of age and metallicity of two clusters in NGC 6822 hint that this galaxy has had a slower chemical enrichment than either the Small or Large Magellanic Cloud.

Abundances of seven HII regions suggest that there is a correlation of abundance with position in NGC 6822 (Chandar, Bianchi, and Ford 2000, AJ, vol.120). To extend our results, data has been collected from the VLT FORS1 (integrated optical spectroscopy of 25 clusters and cluster candidates in NGC 6822). Integrated spectra of Galactic globular clusters and intermediate age Magellanic Cloud clusters were also obtained, from the CTIO 1.5-m. The CTIO spectra (all clusters have resolved color magnitude diagrams) are used to study age and metallicity degeneracy in integrated spectra of single stellar populations, and to derive an empirical calibration of line strengths for intermediate age populations. In addition to obtaining ground based spectroscopy, R. Chandar is obtaining samples of star clusters in nearby galaxies (M81, NGC 55, and NGC 253) by identifying them in multiband HST WFPC2 images. These will serve as the basis for future spectroscopic work.

Paul D. Feldman currently serves as Chair of the Department of Physics and Astronomy. He directs the NASA supported sounding rocket program, collaborating with S. R. McCandliss (JHU) in the development of new instrumentation for far- and extreme-ultraviolet astronomy. He has continued his collaboration with H. A. Weaver (JHU) in a program of HST/STIS observations of comet LINEAR, with H. W. Moos, D. F. Strobel (JHU), and M. A. McGrath (STScI) in HST/STIS observing programs of Io and Europa, and with A. Vidal-Madjar (IAP) and colleagues in HST and FUSE studies of CO and atomic carbon in the gaseous disk surrounding β Pictoris. He is a member of the science teams for the Far Ultraviolet Spectroscopic Explorer (FUSE), the Advanced Camera for HST, the Alice ultraviolet spectrometer experiment for Rosetta, and the Comet Nucleus Tour mission.

Scott D. Friedman is the Hopkins project scientist for the Far Ultraviolet Spectroscopic Explorer (FUSE) mission, which was launched June 24, 1999. FUSE is making high spectral resolution ($R \sim 20000$) measurements in the 910-1190 Å spectral region. With FUSE Friedman is addressing problems such as the properties of molecular hydrogen in the Milky Way and the Large and Small Magellanic Clouds, and the deuterium/hydrogen ratio in the local interstellar medium. Friedman's interests also include astronomical instrumentation.

David Golimowski is an associate research scientist who splits his time between searching for and studying substellar objects and performing functional work as a member of the Hubble Space Telescope (HST) Advanced Camera for Surveys (ACS) Instrumental Definition Team (IDT). His searches for substellar objects, as companions to nearby stars or as isolated members of the solar neighborhood, are both ground- and space-based. This work includes searching for very low mass (VLM) stars and brown dwarfs in the Sloan Digital Sky Survey (SDSS) image data, photometric monitoring of substellar objects for possible planetary eclipses using NASA's Infrared Telescope Facility, and astrometric monitoring of nearby brown dwarfs for possible planet-induced perturbations using HST.

Substellar objects presently fall into two categories: "L dwarfs," whose near-IR spectra feature carbon exclusively

in the form of carbon monoxide (CO), and even cooler “T dwarfs,” whose near-IR spectra show carbon predominantly in methane (CH₄). In mid-2000, the SDSS team, including Golimowski, broke new ground by producing the first three examples of the “missing link” between the CO-dominated L dwarfs and the CH₄-dominated T dwarfs. These transition objects thus completed a continuous spectral sequence from the hottest O stars ($T_{\text{eff}} \approx 40,000$ K) to the coolest known brown dwarfs ($T_{\text{eff}} \approx 750$ K). Golimowski and collaborator Tom Geballe (Gemini Observatory) presented this discovery at the semiannual meeting of the American Astronomical Society in June 2000.

With collaborator Todd Henry (Georgia State University), Golimowski has established a JHU chapter of the Research Consortium on Nearby Stars (RECONS), consisting of Golimowski, Alan Uomoto, and five JHU undergraduate students. These students participate in several activities germane to the study of the solar neighborhood. These activities include (1) searching for nearby stars and brown dwarfs using SDSS, (2) forming a census of all known objects lying within 25 pc of the Sun, (3) obtaining SDSS photometry of nearby stars using the SDSS Photometric Telescope at Apache Point Observatory (APO), (4) mapping the location of VLM stars and brown dwarfs in the color spaces of SDSS and the Two Micron All Sky Survey, and (5) analyzing spectra of M and L dwarfs obtained by Golimowski and Henry at APO and Cerro Tololo Inter-American Observatory.

As a member of the ACS IDT, Golimowski manages JHU laboratory tests of non-flight ACS Wide Field Camera (WFC) detectors and oversees the development of the ACS Guaranteed Time Observer (GTO) science data archive. This archive will contain all the data products from the GTO team’s internal data reduction and analysis pipeline, as well as data from supporting ground-based observations. In January 2000, Golimowski presented an analysis of the effects of cosmic radiation upon the charge transfer efficiency (CTE) of the WFC detectors at the Workshop on Hubble Space Telescope CCD Detector CTE.

Caryl Gronwall is an Associate Research Scientist with the Advanced Camera for Surveys science team. She has spent the last year planning for the development of the science data analysis software pipeline. This pipeline will be used for reducing distant galaxy images and grism spectroscopy acquired as part of the guaranteed observing time awarded to the ACS science team.

In collaboration with John Salzer (Wesleyan), Gronwall has continued working on the KPNO International Spectroscopic Survey (KISS) for nearby emission-line galaxies. This is a modern objective-prism survey which combines the wide field survey capability of a Schmidt telescope combined with the deep sensitivity of a CCD detector. The first survey lists for galaxies selected both in the red (H α) and the blue ([OIII] λ 5007) have been completed. A detailed description of the survey was published in Salzer *et al.* (2000). The first blue survey strip covers 117 deg² and includes 223 ELG candidates or 1.9 per square degree. The first red (H α -selected) survey strip covers 62 deg² and includes 1128 ELG candidates for a surface density of 18.1 per square de-

gree. These surface densities are significantly higher than previous surveys of this type.

Gronwall and Salzer are also currently pursuing a vigorous program of follow-up spectroscopy of these ELGs using a variety of telescopes, including the Apache Point Observatory. We have in hand spectra of ~ 800 ELG candidates which confirm that 94% of our H α -selected sample are confirmed ELGs with about 10% being AGN. The spectroscopic data are being used to study the chemical evolution, spatial distribution, and star-formation rates of these galaxies.

Timothy M. Heckman conducts research on starburst and active galaxies and serves as the Chair of the Board of Governors of the Astrophysical Research Consortium, which manages the 3.5-meter telescope and Sloan Digital Sky Survey at the Apache Point Observatory. He is also a member of the science team for the Galaxy Evolution Explorer (GALEX) mission (PI, C. D. Martin, Caltech).

Heckman, with D. Strickland (JHU), K. Weaver (GSFC/JHU), C. L. Martin (Caltech), and M. Lehnert (MPIE, Garching), is continuing a long-term program to elucidate the physics of starburst-driven galactic winds (“superwinds”) and thereby ascertain their role in the evolution of galaxies and the inter-galactic medium. Recent work has focused on the analysis of new Chandra X-ray data for the prototypical starbursts NGC 253 and NGC 1569, and spectroscopy of the interstellar absorption-lines using ground-based telescopes, FUSE and HST. The two approaches are complementary: the X-ray data probe the hot gas that may contain the majority of the energy in the superwind, while the absorption-lines yield unique diagnostics of the dynamics and energetics of cooler material entrained into the hot outflow. The data show that superwinds are ubiquitous in local starbursts, and that starbursts are ejecting metal-enriched material at a rate similar to the star-formation rate and at a velocity sufficient in principle to leave low-mass (but not high-mass) galaxies. The absorption-line data strongly suggest that dust is also being carried out in the flow. These results quantitatively support models in which powerful galactic winds driven by the starbursts associated with the formation of bulges and elliptical galaxies have chemically-enriched and heated the intra-cluster and inter-galactic media.

Heckman, with G. Meurer (JHU), C. Leitherer (STScI), D. Calzetti (STScI) and C. Tremonti (JHU), is conducting several complementary programs designed to document the UV properties of local starbursts. The overall goals are to understand the roles played by dust, metallicity, “host” galaxy mass, etc., in determining the UV properties of local starbursts, and to use these results to make inferences about actively-star-forming galaxies at high-redshift. Results to date suggest that typical UV-selected galaxies at high-z suffer 2 to 3 magnitudes of extinction, have metallicities from 0.1 solar to solar, and may represent less extreme (lower metallicity, lower mass, lower luminosity) versions of the high-z sources selected by sub-mm surveys. The lessons learned for local starbursts will ultimately be exploited to interpret the data obtained with GALEX.

Heckman, with R. Cid Fernandez (JHU), R. Gonzalez-Delgado (Instituto de Astrofísica de Andalucía), C. Leitherer (STScI), H. Schmitt (STScI), and T. Storchi-Bergmann (Uni-

versidad Federal do Rio Grande do Sul), is engaged in a systematic spectroscopic survey of the brightest Type 2 Seyfert nuclei. Near-UV spectra directly demonstrate that an unusually hot (young) stellar population is present in roughly half of these nuclei and *may* be present at a low-level in the others. In the best-studied cases, these young stars are located in a compact (radius of 10^2 pc) dusty starburst that provides a significant fraction of the bolometric luminosity of the galaxy. Heckman, with N. Levenson (JHU) and K. Weaver (GSFC), has extended this investigation into the X-ray regime and shows that the Seyfert/starburst composite nature of these nuclei determines the X-ray properties. Taken together, the available evidence suggests that the luminosity of the starburst and hidden AGN correlate with one another. These nuclei are valuable local laboratories in which we can investigate the processes that built supermassive black holes and galactic spheroids at high-redshift.

Heckman, with S. Ridgway (JHU), M. Lehnert (MPIE) and D. Calzetti (STScI), has obtained and analysed HST NICMOS near-IR images of 5 high-redshift ($z \sim 2$) radio-quiet quasars. An underlying “host” galaxy is detected in all 5 cases. These galaxies are surprisingly small and faint compared to radio galaxies at similar redshifts and to the hosts of similarly-powerful quasars at lower redshifts. They are however quite similar to the Lyman Break population of field galaxies at similar redshifts. These results support the standard model for the hierarchical assembly of galaxies at moderate redshifts, and imply that the relatively rare radio-loud AGN population is not representative of AGNs as a whole.

Richard C. Henry conducts research on the interstellar medium, cosmology, and ultraviolet background radiation. Henry is principal investigator for HUBE, the Hopkins Ultraviolet Background Explorer, which in the first MIDEX round was selected by NASA as an “Alternate” Mission. A disappointment of 2000 was NASA’s failure to select HUBE (which is now named “Hot Universe Background Explorer”) in the most recent SMEX round.

With Murthy, Henry continues work on the Voyager body of observations of the cosmic ultraviolet background radiation, as well as on data acquired during the Air Force MSX Mission. Their “modeling” report on the Air Force work (dated 1998) appeared in 1999 and is referenced below. Newton’s method of establishing the acceleration that is associated with circular motion was re-discovered by Henry, who has published it in the *American Journal of Physics*. Henry submitted *two* versions of the paper, with two different authorships, asking the Editor to decide what was appropriate. The Editor “called Henry’s bluff,” as may be seen in the publication list below.

Henry calculated the expression for the Kretschmann scalar for the most general possible black hole (mass, angular momentum, and electric charge), and the result appears in the *Astrophysical Journal*. Henry is continuing to calculate other scalar quantities that are associated with such black holes.

Henry was a member of the Scientific Organizing Committee for “Small Missions for Energetic Astrophysics,” J. Robert Oppenheimer Study Center, Los Alamos, in 1999, where he presented papers on “The Interstellar Medium”

and “The Intergalactic Medium;” these papers have now appeared.

Henry continues as the Director of Maryland Space Grant Consortium, a NASA program for career advancement of females and under-represented minorities, education, and public outreach. Henry was Chair of the National Council of Space Grant Directors until June 2000, and he continues on the Executive Committee *ex officio*, as Past Chair.

Bhuvnesh Jain currently works on gravitational lensing and the clustering of galaxies. In collaboration with U. Seljak at Princeton University and S. White at the Max-Planck-Institute for Astrophysics, Jain has developed ray tracing simulations to compute weak lensing statistics in different cosmological models. Jain has worked on different approaches to measure the signal due to weak lensing by dark matter structures. In collaboration with L. van Waerbeke at CITA, Toronto and T. Matsubara at Johns Hopkins, Jain has proposed new statistical measures of the non-Gaussianity of the lensing signal to measure the cosmic mass density. With A. Szalay at Johns Hopkins, he has worked with the Sloan Digital Sky Survey collaboration to measure the magnification effect of large-scale structure through the cross-correlation of low and high redshift galaxies.

Mary Elizabeth Kaiser, a research scientist in the Department of Physics and Astronomy, has joined the FUSE team and is a co-investigator with the Space Telescope Imaging Spectrograph (STIS) Investigation Definition Team. Kaiser and collaborators are pursuing research activities focussed on the kinematics and ionization structure of Seyfert galaxies and the dynamics and kinematics of the near-nuclear regions of normal galaxies.

As part of the STIS team investigating the central dynamics of normal galaxies led by Green (NOAO), Kaiser has analyzed STIS and KPNO spectra of the Ca II triplet stellar line profiles in NGC 4742. Axisymmetric 3-Integral models are being run to model the observed stellar kinematics and hence constrain the central dark mass in this galaxy. These results will help populate the low luminosity region of the black hole mass to bulge luminosity distribution and further our understanding of the relationship between the formation of galaxy spheroids and central black holes.

Together with collaborators Bower (NOAO) and Green (NOAO), STIS long-slit spectroscopy of the nuclear gas disk in the elliptical galaxy NGC4552 is being analyzed to search for the kinematic signature of a central black hole.

As part of the FUSE AGN team led by Kriss (STScI), FUSE and STIS spectra of the Seyfert 1 galaxy NGC3783 are being analyzed for the presence of intrinsic absorption. FUSE observations of O VI are important for characterizing the ionization state of this warm X-ray absorbing gas and providing a link between the lower ionization species, such as N V and C IV, seen in the ultraviolet, with spectrographs such as STIS, and the higher ionization X-ray warm absorber.

As a member of the STIS NGC4151 team, Kaiser and collaborators Hutchings (DAO), Bradley (JHU), Crenshaw (CUA), Gull (GSFC), Kraemer (CUA), Nelson (UNLV), Ruiz (CUA), Weistrop (UNLV) have analyzed STIS slitless, long-slit, and echelle observations to probe the kinematics

and physical conditions in the near nuclear region of this nearby Seyfert 1.5 galaxy. Our results include the detection of a high velocity kinematic component ($v < 1400 \text{ km s}^{-1}$) of emission-line gas in the narrow line region (NLR) and a decreasing gas density in the NLR as a function of radial distance.

VLA observations of M51 at 3.6 cm have been obtained and are being analyzed in collaboration with Baan (NFRA) and Bradley (JHU). These data complement high spatial resolution STIS spectra of M51, obtained in collaboration with Bradley (JHU) and Crenshaw (CUA), which extend from $3100\text{\AA} - 9000\text{\AA}$. We are analyzing these data to determine the relative importance of photoionization versus shocks for the emission-line clouds observed in the near nuclear region of this Seyfert 2 galaxy.

Gerard A. Kriss is an Adjunct Associate Professor in the Department of Physics and Astronomy and an Associate Astronomer at the Space Telescope Science Institute where he is the Spectrographs Group Lead in the Science and Instrument Support Department.

Kriss is studying the far-ultraviolet spectra of AGN in collaboration with Wei Zheng (JHU), Arthur Davidsen (JHU), graduate student Randall Telfer (JHU) and other members of the Far Ultraviolet Spectroscopic Explorer (FUSE) team. At low redshift, they are obtaining FUSE spectra of the 100 UV-brightest AGN. To supplement these 900-1200 Å spectra, a Cycle 8 HST snapshot program (in collaboration with A. Koratkar and W. Zheng) obtained STIS spectra covering 1200-3200 Å of 25 AGN to date, many simultaneously with FUSE observations. This sample will have a mean redshift of ~ 0.1 when it is complete. At the higher redshift end, mining of the HST archive is continuing. Randall Telfer has more than doubled the number of QSOs now contributing to on-going construction of a spectral composite. This will permit study of the spectral shape as a function of redshift or luminosity, a crucial perspective that will illuminate not only our understanding of the energy generation mechanism in AGN, but also the shape of the meta-galactic ionizing spectrum as a function of redshift.

A topic of high current interest concerning the near-nuclear structure of AGN is the nature of the “warm” (or ionized) absorbing gas that is common in the spectra of low-redshift AGN. About half of all low-redshift AGN show absorption by ionized gas, and a similar fraction show associated UV absorption in highly ionized species such as C IV. A key question is how the two spectral domains are related. Mathur *et al.* suggest that the UV absorption is caused by the same gas as that producing the X-ray absorption. Kriss *et al.* argue that the strongest UV absorption lines arise in lower ionization gas with a lower total column density. The case for this disparity between the UV and X-ray absorbers is bolstered by two recent results. A study of NGC 7469 (Kriss *et al.* 2000) shows again that most of the UV absorption is by lower ionization, lower-column-density gas than that absorbing the X-rays. The disparity between the UV and X-ray absorbers is illustrated most clearly by the high spectral resolution observation using FUSE of the O VI absorption in the Seyfert 1 galaxy Mrk 509 (Kriss *et al.* 2000b). This observation resolves the UV absorption into multiple kinematic

components. Comparison of the O VI, H I, and C III column densities permits one to independently assess the total column density of each kinematic component. Of the seven systems present, only one, a system near the systemic velocity of Mrk 509, stands out clearly as having the same level of ionization and the same column density as that required by ASCA X-ray observations. This clearly shows that the warm absorber phenomenon is complex. On-going observations with FUSE show O VI absorption in about half of all AGN observed. The high-ionization components are obvious in the FUSE spectra. These high spectral resolution UV observations together with the studies of the X-ray absorbing gas enabled by the Chandra X-ray Observatory should finally unravel the location and kinematics of this new structural component of AGN.

Jeffrey Kruk is presently the System Scientist for the Far Ultraviolet Spectroscopic Explorer (FUSE) project at JHU. He is responsible for Science Data Processing, including instrument calibration, data processing software, and archiving, and for providing scientific oversight of FUSE systems engineering. Kruk is a member of the FUSE groups investigating the deuterium to hydrogen ratio and the distribution of ionized helium in the intergalactic medium. Other projects include a collaboration with Klaus Werner and Stefan Dreizler (Tubingen) to investigate the properties of PG 1159 stars, a collaboration with Pierre Chayer (JHU) to study hot DA white dwarfs, and a collaboration with Robin Shelton (JHU) and others to investigate the emission from diffuse O VI in the Galactic halo.

Nancy Levenson is a Postdoctoral Fellow studying Seyfert galaxies and Galactic supernova remnants at X-ray energies and the Galactic interstellar medium at near-infrared wavelengths. Collaborating with K. Weaver and T. Heckman, she has identified the signatures of Seyfert/starburst composite galaxies in X-rays, which include extended, soft thermal emission due to the starburst “superwind,” and the characteristic unresolved power-law spectral component of the active nucleus. In these composite galaxies, the starburst contributes to the obscuration of the central engine. These results imply that X-ray observations may be used to identify composite galaxies and further support the suggestion that the Seyfert and starburst phenomena are related.

Levenson is investigating observations of the Cygnus Loop supernova remnant from the Chandra X-Ray Observatory in collaboration with J. Graham of UC Berkeley. The goal of this work is to obtain spatially resolved spectroscopy of interactions between the supernova blast wave and interstellar clouds.

Knox S. Long is an adjunct professor at JHU and an astronomer at STScI. Long pursues research topics in the ultraviolet characteristics of cataclysmic variables, supernova remnants, and the properties of the interstellar medium in nearby galaxies. He is an active investigator with Hubble Space Telescope, Chandra, and FUSE. He also has active instrumentation interests as a result of his involvement in phase A studies for NGST. Long and Froning (STScI) have conducted an intensive set of FUSE observations of the dwarf nova U Geminorum with FUSE in order to better understand the evolution of the disk and wind of this system.

The observations during the peak of the outburst are reasonably well understood in terms of emission from a steady-state disk with absorption from relatively low-velocity material located near outer edge of the disk. However, by the time the optical magnitude has dropped to 12.5, still well-above optical quiescence, the FUV spectrum has transitioned to that of an approximately 45,000 K white dwarf.

Long, Knigge (Southampton), Hoard (CTIO), Szkody (Washington), and Dhillon (Sheffield) have completed an initial analysis of HST data obtained of the SW Sex star DW UMa. The data, obtained in an unusual optical low state, are well-fit in terms of a WD spectrum with a temperature of 46,000 K. The UV flux shortward of 1450 Å is actually greater than observed when the system is in its normal optical high state. The observations suggest that the disk rim blocks our view of the WD primary in the high state. If flared accretion disks are common among SW Sex stars, we can account for many of the defining characteristics of SW Sex stars. Long, Drew (Imperial), Knigge, and Proga (GSFC) have begun an intensive search for wind variability in 3 novalike variables – IX Vel, V3885 Sgr, and QU Car – with HST/STIS. Our goal is to attempt to test theoretical suggestions by Drew and Proga that the wind in these systems should be very inhomogeneous, as well as to model the overall flow. We plan to model the time-averaged spectrum using a Monte Carlo spectral synthesis program developed by Long and Knigge. Beginning with a kinematic description of the wind, the ionization state of the wind is then determined, followed by a synthesis of the spectrum.

Long, Dubus (Caltech), and Charles (Oxford) conducted HST/STIS observations of the nucleus of M33 in an attempt to identify the counterpart to the brightest X-ray source in the Local Group. There are no obvious signatures of the X-ray source in the FUV spectra. An analysis of the data in order to constrain the star formation history will be carried out when the remainder of the data, covering the NUV and optical are obtained later this year.

Long and Winkler (Middlebury) have continued their work on SN1006. This remnant of a type Ia supernova explosion was already known to contain freely expanding ejecta as a result of UV observation of the Schweitzer-Middleditch star located beyond the SNR. We have identified 5 more objects (4 stars and 1 quasar) that also appear to lie behind the SNR. HST UV spectroscopy is now scheduled to use these objects as probes of unshocked material in the ejecta of SN1006. In addition we, in collaboration with Raymond (SAO), Petre (NASA/GSFC) and Reynolds (NCSU) have begun a detailed study of the X-ray properties of the NE (synchrotron-dominated) and NE (plasma-dominated) rims of SN1006. The combination of UV absorption line and X-ray emission spectra should allow us to create a far better 3-dimensional picture of the SNR, and to explore the characteristics of shocks parallel and perpendicular to the interstellar magnetic field in SN1006.

Stephan R. McCandliss is a Research Scientist in the Department of Physics and Astronomy. He is a Principal Investigator on a NASA supported grant to develop windowless lamps and is a Co-Investigator with the NASA supported sounding rocket program where he is directly engaged

with the preparation and calibration of far UV long slit spectroscopic telescopes. The group's most recent flight, launched from White Sands Missile Range as NASA sounding rocket 36.186 UG on 11 February 2000, was a successful mission to study the extended nebular emissions and dust scattered far UV radiation field in the reflection nebula NGC 2023 over the 912 – 1400 Å bandpass. Future research directions for these program include: the ongoing development of a high dynamic range dual-order spectrograph; the use of windowless lamps as onboard calibration devices; the development of a portable full aperture vacuum collimator for in-the-field characterization of the telescope sensitivity and imaging properties; and the pursuit of light weight telescope designs. This work is being carried out with graduate students Eric Burgh and Kevin France and is overseen by Paul Feldman (PI).

McCandliss has a broad interest in the variation of far UV dust scattering and extinction within different stellar environments and how it influences the abundances of molecules sensitive to destruction by far UV radiation. He has recently published a paper, along with Eric Burgh, B.-G. Andersson and Paul Feldman, describing a correlation between CO absorption and far UV extinction. He continues his collaboration with Principle Investigator Brian Espey and Co-Investigators Gary Ferland, Francis Keenan, and Fiona McKenna on an ongoing cycle 1 FUSE guest investigator program to study the variation in far UV atomic and molecular absorption lines created by cool star atmospheres eclipses of hot white dwarf companions in symbiotic binary systems. He is also working with Ken Sembach analyzing the very hot molecular hydrogen absorption features in a recently obtained FUSE spectrum of the central star of the planetary nebula M27.

Warren Moos is the Principal Investigator for the Lyman Far Ultraviolet Spectroscopic Explorer. Warren Moos also participates as a Co-Investigator in the analysis of data from the Space Telescope Imaging Spectrograph. Moos is also Principal Investigator of the DOE-supported XUV Diagnostics Based on Layered Synthetic Microstructures for Magnetically Confined Fusion Plasmas.

David Neufeld's primary research interests lie in the field of molecular astrophysics. During the past year he has continued to work on the planning, analysis and interpretation of observations with the Submillimeter Wave Astronomy Satellite (SWAS), a NASA Small Explorer Mission on which he is a co-investigator. The SWAS satellite has continued to operate perfectly, producing a wealth of data that probe the chemistry of interstellar molecular clouds and its relation to star-formation. SWAS observations have led to the detection of water vapor in several dozen interstellar sources, in three circumstellar outflows, as well as in the coma of Comet C/1999 H1 (Lee) and in the atmospheres of Mars, Jupiter and Saturn. In addition, large scale maps of submillimeter emissions from CI and ¹³CO have been obtained for several photodissociation regions, and stringent upper limits placed upon the abundance of interstellar O₂. An analysis of the implications of these data for our understanding of the chemistry and thermal balance in molecular clouds continues: first results from the SWAS mission were presented in a dedi-

cated issue of the *Astrophysical Journal Letters* on August 20th, 2000. Neufeld has also continued to work on theoretical models for emissions from the masing circumnuclear gas found in active galaxies; a recent paper presents results on the response of circumnuclear masers to changes in the luminosity of an AGN.

Eric Perlman, in collaboration with J. Biretta, W. Sparks and F. Macchetto, continued his work on the jet of the prototype radio source M87. These results, presented in Perlman *et al.* (2000a) show that its spectrum is considerably harder than previously thought.

Perlman has also been working with J. Stocke, C. Reynolds (Colorado) and J. Conway (Onsala) on HST observations of the youngest radio galaxies. Those observations show massive nuclear dust disks in the three objects observed, but normal elliptical morphologies, thus placing interesting constraints on the triggering of activity in radio sources. These results are presented in Perlman *et al.* (2000b).

Perlman has continued his work on the Wide-Angle ROSAT Pointed Survey, WARPS, a serendipitous X-ray survey for Clusters of galaxies. This survey has found no evolution in the X-ray luminosity function of clusters out to $z \sim 0.8$, and also no evolution in the X-ray temperature function at high redshifts (see Fairley *et al.* 2000). It has also found the two highest z X-ray luminous clusters now known (see Ebeling *et al.* 2000a, b). Perlman *et al.* (2000c) have published the WARPS catalog for the first stage of the survey.

Perlman has continued his work with P. Padovani, H. Landt (STScI), R. Sambruna (George Mason U.) and P. Giommi (ASI/SAX SDC) on the Deep X-ray Radio Blazar Survey, DXRBS, which is probing the blazar population at radio fluxes 20 times deeper than was previously possible. DXRBS has found a new class of X-ray bright flat-spectrum radio quasars, previously thought not to exist, and has also expanded our knowledge of the radio luminosity function of blazars at luminosities 1-2 orders of magnitude than was possible previously, including right down to the limit predicted by unified schemes. Further results from DXRBS have been published in Landt *et al.* (2000). Perlman also continued his work on the Einstein Extended Medium Sensitivity sample of BL Lacs, publishing a summary paper on the properties of the sample in Rector *et al.* (2000). Perlman also gave a review paper at the Snowbird meeting on gamma-ray astrophysics on the topic of blazar surveys (Perlman 2000) which summarized the findings of blazar surveys and their findings about the evolution and energetics of blazars. Perlman and his collaborators (G. Madejski, GSFC, J. Stocke, Colorado, T. Rector, NOAO) were also lucky enough to be observing PKS2005-489 with RXTE when it began a spectacular flare, the brightest blazar flare ever seen in the X-rays. They have published their results on the variability and spectral changes in Perlman *et al.* (1999).

Robin Shelton has been working with the FUSE team to examine the hot component of the Galactic interstellar medium. She and collaborators have made the first observation with a good signal to noise of the emission from diffuse O VI ions in the general interstellar medium outside of supernova remnants and superbubbles. The observation has been

used to indicate the physical conditions within the hot gas, the probable location, and an estimate of the cooling rate of the hot plasma. The results were described in a presentation at the January 2000 American Astronomical Society meeting and in a paper submitted to the *Astrophysical Journal*. Shelton is also a co-investigator on several proposals for future instruments capable of examining the interstellar medium. These proposals include SPEAR, which was accepted by NASA in 2000 for a Phase A study.

During this period, Shelton continued her theoretical, computational, and observational work on supernova remnants. This work is part of a long term effort to determine how the interstellar medium is affected by supernova remnants, and how particular physical processes affect supernova remnants. To these ends, Shelton computationally simulated the spectral signatures of supernova remnants in diffuse environments. The results will be compared with ultraviolet data from FUSE and X-ray data from Chandra and XMM in order to determine if supernova remnants in the lower halo may be producing much of the hot gas previously seen with older observatories. Shelton, Cox, Maciejewski, Smith, Plewa, and Rozycka, and Pawl found that thermal conduction influences the distribution of mass within supernova remnants. This may explain the odd appearances of an emerging class of remnants. They also found some evidence indicating that compression in the collapsing shells of middle aged remnants adiabatically accelerate cosmic rays and boost the synchrotron emission rates. While at JHU, Shelton has been working with the FUSE SNR group (led by B. Blair) in a campaign to observe supernova remnants. At the time of writing, FUSE data on N49 in the Large Magellanic Cloud, and the Vela supernova remnant have been examined.

Marco Sirianni is an Associate Research Scientist working for the Advanced Camera for Survey team. His primary functional responsibility is testing and selection of CCD detectors for ACS.

He has been assisting the lead detector scientist Mark Clampin (STScI) in the characterization and selection of the CCD detectors. This includes planning for tests of charged-coupled devices, observing tests, assisting in data acquisition and logging, and analyzing of test results; reviewing and analyzing image data generated during tests, and making recommendations concerning fabrication and treatment of CCDs to improve image quality.

Sirianni's primary research interests lie in the field of low mass star Initial Mass Function (IMF) in young clusters. The quest for a universal IMF has been a long standing problem in stellar astrophysics. With HST and the new generation of large ground based telescopes, the studies of the IMF have expanded to new domain of the faintest and least massive stars but also triggered new questions, and added new uncertainties. If we consider the situation in the IMF of star clusters, where the distance effects are removed and the star formation history is simpler, at high and intermediate masses (10-100 M_{\odot}) there is a good agreement that the Salpeter IMF is ubiquitous. At smaller masses (1-10 M_{\odot}) the situation is very different: deep photometry of clusters has produced wildly discrepant results, ranging from very steep IMF to much shallower slopes. Are the IMF discrepancies at the

smallest masses true deviations from the Salpeter IMF, most likely triggered by local conditions of stellar density or star formation history? Or are we simply dominated by the observational uncertainties, related to the data analysis and interpretation, such as the choice of the evolutionary models or treatment of completeness?

In collaboration with Antonella Nota (STScI/ESA), Claus Leitherer (STScI), Guido De Marchi (STScI/ESA) and Mark Clampin (STScI) we started to investigate the low end of the IMF in a number of young, rich clusters in the LMC/SMC, at different conditions of star density, metallicity and age, to explore how the local conditions may impact the IMF at low masses. We collected HST/WFPC2 and VLT IR deep high resolution imaging of eleven clusters. All the data will be analyzed and interpreted in uniform manner. In our first target, R136, the dense core of the giant HII region 30 Doradus we found that the shape of the IMF at masses larger than $\sim 3M_{\odot}$ is compatible with a slope of $\Gamma \approx -1.2$, in agreement with previous IMF determination and with the Salpeter slope. Below the $3M_{\odot}$ limit, however, we find a flattening in the logarithmic plane indicating that increase of the number of objects with decreasing mass proceeds at a lower pace. Although in principle crowding could be the origin of this effect, the flattening of the IMF occurs where our photometry is robust with a completeness better than 75%. Our larger program will clarify whether the flattening that we observe in R136 is characteristic of this cluster or a more general feature depending on density, age or metallicity.

David Sahnou continues as the instrument scientist for the Far Ultraviolet Spectroscopic Explorer, and is responsible for tracking and optimizing the performance of the delay line detectors. He also has numerous duties related to the optical performance of the FUSE instrument, such as developing astigmatism correction algorithms in order to improve the spectral resolution of the data.

Aniruddha R. Thakar and **Peter Z. Kunszt** have continued their development of the Science Archive for the Sloan Digital Sky Survey. The Science Archive (the SX) is being developed at JHU under the supervision of A. Szalay. Thakar and Kunszt have devoted the past three years to the design, development and support of the software for the SX, which will be the ultimate repository of all the calibrated and pipeline-processed SDSS data. The SX features a client/server interface to a commercial object-oriented database management system (DBMS). Both the client (a Tcl/Tk Graphical User Interface or GUI) and the server (a multi-threaded, distributed C++ application) have been developed at JHU, representing nearly 100,000 lines of code. The SX is already being used by the entire SDSS collaboration for conducting scientific research as well as for testing the data and selecting targets for follow-up spectra of quasars and galaxies. The SX can be deployed on a range of different hardware platforms, from multi-processor machines like the SGI Origin 2000 to PC/Linux clusters, and is accessible from any user platform including laptops. The SX is the first scalable, parallel, distributed multi-terabyte astronomical archive, and Szalay, Kunszt and Thakar propose to use it as a basis for designing an archive template for the National Virtual Ob-

servatory. Public release of the data in the SX is scheduled to begin in 2001.

Paolo Tozzi worked as a Postdoctoral Fellow at the Johns Hopkins University during the last year. He works on the physics of the Intra Cluster Medium (ICM) and on the X-ray data from the Chandra Deep Field South.

Tozzi worked with Colin Norman (JHU) on the physics of the ICM. He explored the effects of the non-gravitational heating of the cosmic baryons on the X-ray emission from groups and clusters of galaxies. The topic raised a strong interest in the scientific community after the direct observation of an entropy excess in the center of small groups. The semianalytic model of Tozzi and Norman allows to connect in great detail the X-ray emissivity of the ICM to its thermodynamic quantities. The work shows that the entropy is the key quantity to understand the ICM. In fact, the model provides detailed predictions for the entropy profiles in groups and clusters and, in particular, for the signature of the accretion shocks in the outskirts of large clusters. Such profiles can be observed with the present-day X-ray satellites (Chandra, XMM), and can be used as a probe of the thermal history of the cosmic baryons (Tozzi, Scharf & Norman 2000).

Tozzi is currently working on the data reduction of the Chandra Ultra Deep Field South (PI R. Giacconi). The data at present consists of 4 exposures for a total of 300 ksec. The exceptional quality of the data allowed identification of about 200 X-ray sources, mostly AGNs, with a high degree of confidence, down to fluxes of $F \approx 10^{-16}$ erg s $^{-1}$ cm $^{-2}$ in the soft band (0.5–2 keV) and to fluxes of $F \approx 10^{-15}$ erg s $^{-1}$ cm $^{-2}$ in the hard band (2–10 keV). This set of data extends by more than one order of magnitude in flux the number counts from previous X-ray missions, especially in the hard band, where about 60–80% of the total X-ray background (XRB) has been resolved. The number counts and the spectrum of the X-ray sources are consistent with the predictions of AGN synthesis models. In particular, sources at fainter fluxes have harder spectra. Most of the hard sources are expected to be highly absorbed AGN or type II quasars. The nature of the sources responsible for the hard XRB will be investigated in greater detail when the optical follow up will be completed (fall 2000).

H.D. Tran, in collaboration with M. S. Brotherton (NOAO), S. A. Stanford (LLNL), W. van Breugel (LLNL), A. Dey (NOAO), D. Stern (UC Berkeley) and R. Antonucci (UCSB) completed the spectropolarimetric analysis of three radio-selected ultraluminous infrared galaxies (ULIRGs). These galaxies were discovered in the positional correlations between sources detected in deep radio surveys and the IRAS Faint Source Catalog. Only the high-ionization Seyfert 2 galaxy TF J1736+1122 is highly polarized, displaying a broad-line spectrum visible in polarized light. The other two objects, TF J1020+6436 and FF J1614+3234, display spectra dominated by a population of young (A-type) stars similar to those of ‘‘E + A’’ galaxies. They are unpolarized, showing no sign of hidden broad-line regions. The presence of young starburst components in all three galaxies indicates that the ULIRG phenomenon encompasses both AGN and starburst activity, but the most energetic ULIRGs do not nec-

essarily harbor “buried quasars.” We find that a luminous infrared galaxy is most likely to host an obscured quasar if it exhibits a high-ionization spectrum typical of a classic Seyfert 2 galaxy with little or no Balmer absorption lines, is “ultraluminous,” and has a “warm” IR color. The detection of hidden quasars in this group but not in the low-ionization, starburst-dominated ULIRGs (classified as LINERs or H II galaxies) may indicate an evolutionary connection, with the latter being found in younger systems.

With collaborators M. H. Cohen (Caltech) and M. Villar-Martin (IAP), Tran completed a study of the ULIRG IRAS P09104+4109 using imaging and spectropolarimetric observations with the 10-m Keck Telescope. We detected the clear presence of broad H β , H γ , and Mg II λ 2800 emission lines in the polarized flux spectra of the nucleus and of an extranuclear emission region $\sim 5''$ away, confirming the presence of a hidden central quasar. One notable characteristic of the extranuclear knot is that all species of Fe are markedly absent in its spectrum, while they appear prominently in the nucleus. In addition, narrow Mg II is observed to be much weaker than predicted by ionization models. Our favored interpretation is that there is a large amount of dust in the extranuclear regions, allowing gaseous refractory metals to deposit. Near the nucleus, dust is destroyed in the strong radiation field of the quasar, inhibiting metal depletion onto grains. The extended emission regions are most likely material shredded from nearby cluster members and not gas condensed from the cooling flow or expelled from the obscured quasar.

Alan Uomoto continues work on the Sloan Digital Sky Survey (SDSS), a catalog of 1/4 of the sky in five broad band colors with spectra of one million galaxies and 100,000 quasars. Installation and commissioning of the 20-inch SDSS Photometric Telescope, formerly a student telescope at JHU, was completed. This instrument is used to calibrate 2.5 m telescope imaging data.

Jennifer J. Wiseman is continuing as a Hubble Fellow at JHU and studies active regions of star formation within local molecular clouds. In particular, Wiseman is studying the dense gas surrounding the equatorial accretion region of forming protostars using radio interferometry. She is also studying the larger-scale disruption of dense gas where jets and outflows from protostars disrupt it. In 2000, she conducted a VLA ammonia survey of circumstellar gas around the youngest (Class 0 and Class I) protostars and protostellar jets, with collaborators G. Fuller (UMIST) and A. Wootten (NRAO). The sources of study are all systems with powerful and collimated jets such as L1634, NGC 2023, HH 111, IRAM 04191, and HH 24-25. In these very young systems, a large part of the system mass is still distributed in an extended circumstellar envelope and has not yet been accreted onto the protostar nor dispelled by the outflowing jets or winds.

Wiseman’s preliminary results for several of these sources show that the equatorial gas is flattened in morphology, extending several thousand AU from the embedded source, with the major axis perpendicular to the jet axis. In cases analyzed so far, the ammonia emission reveals a velocity gradient across the disk as evidence for rotation. These

discoveries illustrate an important stage in the star formation process where angular momentum has not yet been fully shed from the condensing gas. Wiseman is studying the rotation curves in these systems, looking for evidence of rigid versus Keplerian rotation signatures in the disk gas kinematics, in an effort to relate observed envelope kinematics to the evolutionary stage of the embedded protostar. She is also studying the plausibility of outflowing jets as a path of release for excess angular momentum in these accreting systems.

She has detected evidence for heating of this gas by the escaping protostellar jets as they chisel through the environment. She has also begun a comparative study of protostellar jets with extragalactic jets with collaborator J. Biretta, looking for similar processes on these vastly differing scales. As part of this effort, she participated in a workshop on the “Collimation of Astrophysical Flows” at the Aspen Center for Physics in the summer of 2000. Wiseman also presents talks on astronomy and space exploration to elementary schools and adult science groups.

Wei Zheng, a research scientist, studies quasars and active galactic nuclei (AGN). He and other JHU researchers are using the imaging data of the Sloan Digital Sky Survey in the search for high-redshift quasars. The five-band imaging data enable them to distinguish quasars of redshift 5 or less with most stars. To further select quasars at higher redshifts, Zheng and Z. Tsvetanov carry out near-infrared photometry at the IRTF. They also use the APO 3.5m telescope for optical spectroscopic follow-up. They have found five quasars at $z > 4.7$, including one at $z = 5.28$. A collaborative project has been carried out at the AAT and with the 2dF instrument. As a result of these efforts, a number of T-dwarfs have also been found, which share similar colors.

The SDSS database also enables Zheng, A. Davidsen and their SDSS colleagues to investigate the UV property of many newly discovered bright ($V < 18$) quasars at $z \sim 3$. If any of them has a detectable flux below 1500 Å, the HeII absorption lines in its spectrum will serve as a valuable probe of the intergalactic medium in the early universe. Such an observation is being carried out at a slightly lower redshift with FUSE. Zheng, G. Kriss (STScI) and W. Oegerle have been involved in the data analyses of the FUSE spectrum of HE2347-43.

Zheng is a team member of the Chandra Deep Field South, led by R. Giacconi (AUI) and C. Norman. His task is to determine the photometric redshifts using the optical and infrared imaging data taken at ESO and CTIO. He also analyzes the optical spectra taken with the VLT. The observations, even at their initial stage, have revealed many new previously unknown objects in the deep universe.

The collaborative work with J. Huang of NanJing University, China has led to the discovery of two new Wolf-Rayet galaxies. They have also studied the multi-band properties of LINERs and find a possible correlation between starburst and AGN.

Zheng continues his collaboration with the astronomers at the Crimean Observatory in Ukraine to monitor the spectral variations in several AGN. A proposal, with B. Peterson of Ohio State University, has been approved by The U. S. Ci-

vilian Research and Development Foundation (CDRF) to enhance such activities.

Zheng's SMEX proposal "PRIME - The Primordial Explorer" has been selected by NASA for a phase-A concept study. The proposed mission will carry out a deep sky survey in four near-infrared bands, as a pilot mission for the Next Generation Space Telescope (NGST). PRIME will reach an epoch during which the first quasars, galaxies and clusters of galaxies were formed in the early Universe, discover hundreds of Type-Ia supernovae to be used in measuring the acceleration of the expanding Universe, and detect hundreds of small cool stars known as brown dwarfs and even Jupiter-size planets in the vicinity of the solar system. PRIME fits NASA's long-term science themes of "Astronomical Search for Origins" and "Structure and Evolution of the Universe." The JHU participants are: W. Zheng (Principal Investigator), H. Ford (deputy P. I.), Z. Tsvetanov, A. Davidsen, A. Szalay and J. Kruk.

7. ACKNOWLEDGEMENTS

The CAS Director is indebted to Professor Richard Henry and Ms. Anne Albinak for the preparation of this report.

PUBLICATIONS

- Ashby, M. L. N., Bergin, E. A., Plume, R., Carpenter, J. M., Neufeld, D. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Patten, B. M., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "An Analysis of Water Line Profiles in Star Formation Regions Observed by the Submillimeter Wave Astronomy Satellite," *ApJ*, 539, L115
- Ashby, M. L. N., Bergin, E. A., Plume, R., Carpenter, J. M., Melnick, G. J., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G. & Zhang, Y. F. 2000. "Water Abundance and Velocity Structure in S140, Rho Oph A, and B335," *ApJ*, 539, L119
- Beckwith, S. V. W., Henning, T. & Nakagawa, Y. 2000. "Dust Properties and Assembly of Large Particles in Protoplanetary Disks," in *Protostars and Planets IV*, eds. V. Mannings, A. P. Boss, & S. S. Russell, (Tucson: University of Arizona Press), 533
- Beckwith, S. V. W. 2000. "Circumstellar Disks," in *Proceedings of Star Formation 1999*, Nagoya, Japan, June 21 - 25, 1999. ed. T. Nakamoto, (Nobeyama: Nobeyama Radio Observatory), 211
- Beckwith, S. V. W. 2000. "Vom Urknall zum Leben - die Entstehung von Komplexität im Universum," in *Wie entstehen neue Qualitäten in komplexen Systemen?* ed. G. Plehn & R. Gerwin, (Gottingen: Vandenhoeck & Ruprecht), 29
- Bergin, E. A., Melnick, G. J., Stauffer, J. R., Ashby, M. L. N., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Snell, R. L., Tolls, V., Wang, Z., Winnewisser, G. & Zhang, Y. F. 2000. "Implications of Submillimeter Wave Astronomy Satellite Observations for Interstellar Chemistry and Star Formation," *ApJ*, 539, L129
- Bergin, E. A., Lellouch, E., Harwit, M., Gurwell, M. A., Melnick, G. J., Ashby, M. L. N., Chin, G., Erickson, N. R., Goldsmith, P. F., Howe, J. E., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G. & Zhang, Y. F. 2000. "Submillimeter Wave Astronomy Satellite Observations of Jupiter and Saturn: Detection of 557 GHz Water Emission from the Upper Atmosphere," *ApJ*, 539, L147
- Bianchi, L. and the GALEX Team 2000a. "The Galaxy Evolution Explorer (GALEX)," *Mem. SAIt*, Vol. 71 n. 3
- Bianchi, L. and the GALEX Team 2000b. "The Ultraviolet Digital Sky," *Mem. SAIt*, Vol. 71 - 3
- Bianchi, L., Hutchings, J.B., Fullerton, A.W., *et al.* 2000c. "Measuring the Ionization of O Star Winds," *ApJ*, 538, L57
- Blair, W. P., Sankrit, R., Shelton, R. L., Sembach, K. R., Moos, H. W., Raymond, J. C., York, D. G., Feldman, P. D., Chayer, P., Murphy, E. M., Sahnou, D. J. & Wilkinson, E. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of the Supernova Remnant N49 in the Large Magellanic Cloud," *ApJ*, 538, L61
- Blair, W. P., Sankrit, R., Raymond, J. C. & Long, K. S. 1999. "Distance to the Cygnus Loop from Hubble Space Telescope Imaging of the Primary Shock Front," *AJ*, 118, 942
- Blair, W. P., Morse, J. A., Raymond, J. C., Kirshner, R. P., Hughes, J. P., Dopita, M. A., Sutherland, R. S., Long, K. S. & Winkler, P. F. 2000. "Hubble Space Telescope Observations of Oxygen-rich Supernova Remnants in the Magellanic Clouds. II. FOS Spectroscopy of N132D and E0102.2-7219," *ApJ*, 537, 667
- Burgh, E. B., McCandliss, S. R., Andersson, B-G. & Feldman, P. D. 2000. "On the Correlation Between CO Absorption and Far-Ultraviolet Nonlinear Extinction toward Galactic OB Stars," *ApJ*, 541, 250
- Cha, A. N., Sahnou, D. J., Moos, H. W. 1999. "Processing and Interpretation of Pre-Flight FUSE Spectra," *SPIE Proc*, 3765, 495
- Chayer, P., Kruk, J. W., Ake, T. B., Dupree, A. K., Malina, R. F., Siegmund, O. H. W., Sonneborn, G. & Ohl, R. G. 2000. "The Discovery of Photospheric Phosphorus and Iron in the FUSE spectrum of the Hot White Dwarf GD394," *ApJ*, 538, L91
- Cox, D. P., Shelton, R. L., Maciejewski, W., Smith, R. K., Plewa, T., Pawl, A. & Rozycka, M. 1999. "Modeling W44 as a Supernova Remnant in a Density Gradient, with a Partially Formed Dense Shell and Thermal Conduction in the Hot Interior: I. The Analytic Model," *ApJ*, 524, 179
- Crenshaw, D. M., Kraemer, S. B., Hutchings, J. B., Bradley, L. D., II, Gull, T. R., Kaiser, M. E., Nelson, C. H., Ruiz, J. R., Weistrop, D. 2000. "A Kinematic Model for the Narrow-Line Region in NGC 4151," *AJ*, 120, 1731
- Crowther, P.A., Brownsberger, K., Fullerton, A.W., Willis, A.J., Bianchi, L., De Marco, O., Hutchings, J.B., Snow,

- T., FUSE Science Team 2000. "FUSE Observations of the Resonance OVI Doublet in Sand 2 (WO), the Fastest Stellar Wind Known," *AAS*, 195, 6.24
- Dahlem, M., Parmar, A., Oosterbroek, T., Orr, A., Weaver, K. & Heckman, T. 2000. "Ambiguities in Fits to the Complex X-Ray Spectra of Starburst Galaxies," *ApJ*, 538, 555
- Danforth, C. W., Cornett, R. H., Levenson, N. A., Blair, W. P. & Stecher, T. P. 2000. "A Comparison of Ultraviolet, Optical, and X-ray Imagery of Selected Fields in the Cygnus Loop," *AJ*, 119, 2319
- de Mello, D., Leitherer, C. & Heckman, T. 2000. "B Stars as a Diagnostic of Star Formation at Low and High Redshift," *ApJ*, 530, 251
- Dupuis, J., Chayer, P., Vennes, S., Christian, D. J. & Kruk, J. W. 2000. "Adding More Mysteries to the DA White Dwarf GD 394," *ApJ*, 537, 997
- Ebeling, H., Jones, L., Perlman, E., Scharf, C., Mullis, C., Wegner, G. & Malkan, M. 2000. "The WARPS Survey: III. The Discovery of an X-ray Luminous Galaxy Cluster at $z=0.833$ and the Evolution of X-ray Luminous Clusters of Galaxies at $z<1$," *ApJ*, 534, 133
- Fairley, B. W., Jones, L. R., Scharf, C., Ebeling, H., Perlman, E., Horner, D., Wegner, G. & Malkan, M. 2000. "The WARPS Survey - IV: The X-ray Luminosity Temperature Relation of High Redshift Galaxy Clusters," *MNRAS*, 315, 669
- Fan, X. *et al.* 1999. "The Discovery of a High-Redshift Quasar without Emission Lines from Sloan Digital Sky Survey Commissioning Data," *ApJ*, 526, L57
- Feldman, P. D., McGrath, M. A., Strobel, D. F., Moos, H. W., Retherford, K. D. & Wolven, B. C. 2000. "HST/STIS Ultraviolet imaging of Polar Aurora on Ganymede," *ApJ*, 535, 1085
- Feldman, P. D., Strobel, D. F., Moos, H. W., Retherford, K. D., Wolven, B. C., McGrath, M. A., *et al.* 2000. "Lyman- α Imaging of the SO₂ Distribution on Io," *Geophysical Res Ltrs*, 27, (12), 1787
- Feldman, P.D., Burgh, E. B., Durrance, S. T. & Davidsen, A. F. 2000. "Far-Ultraviolet Spectroscopy of Venus and Mars at 4 Å Resolution with the Hopkins Ultraviolet Telescope on Astro-2," *ApJ*, 538, 395–400
- Feldman, P. D. 1999. "Ultraviolet Observations of Comet Hale-Bopp," *Earth, Moon and Planets*, 79, 145
- Ferlet, R., Andr, M., Hbrard, G., Lecavelier des Etangs, A., Lemoine, M., Pineau des Forts, G., Roueff, E., Rachford, B. L., Shull, J. M., Snow, T. P., Tumlinson, J., Vidal-Madjar, A., York, D. G. & Moos, H. W. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of the HD Molecule toward HD 73882," *ApJ*, 538, L69
- Ferrarese, L., Ford, H. C., Huchra, J., Kennicutt, R. C., Mould, J. R., Sakai, S., Freedman, W. L., Stetson, P. B., Madore, B. F., Gibson, B. K., Graham, J. A., Hughes, S. M., Illingworth, G. D., Kelson, D. D., Macri, L., Sebo, K., Silbermann, N. A., 2000. "A Database of Cepheid Distance Moduli and Tip of the Red Giant Branch, Globular Cluster Luminosity Function, Planetary Nebula Luminosity Function, and Surface Brightness Fluctuation Data Useful for Distance Determinations," *ApJS*, 128, 431
- Ferrarese, L., Mould, J. R., Kennicutt, R. C., Huchra, J., Ford, H. C., Freedman, W. L., Stetson, P. B., Madore, B. F., Sakai, S., Gibson, B. K., Graham, J. A., Hughes, S. M., Illingworth, G. D., Kelson, D. D., Macri, L., Sebo, K., Silbermann, N. A. 2000. "The Hubble Space Telescope Key Project on the Extragalactic Distance Scale. XXVI. The Calibration of Population II Secondary Distance Indicators and the Value of the Hubble Constant," *ApJ*, 529, 745
- Friedman, S. D., Conard, S. J., Barkhouser, R. H., Cha, A. N., Fullerton, A. W., Kruk, J. W., Murphy, E., Ohl, R. G., Sahnou, D. J., Weaver, H. A. & Brownsberger, K. R. 1999. "Pre-Launch Optical Tests and Performance Estimates of the Far Ultraviolet Spectroscopic Explorer Satellite," *SPIE* 3765, 460
- Fullerton, A. W., Crowther, P.A., De Marco, O., Hutchings, J. B., Bianchi, L., Brownsberger, K., Massa, D., Morton, D., Rachford, B.L., Snow, T.P., Sonneborn, G., Tumlinson, J. & Willis, A.J. 2000. "FUSE Observations of the Stellar Winds of Two O7 Supergiants in the Magellanic Clouds," *ApJ*, 538, L43
- Fullerton, A. W., Hutchings, J. B., Willis, A.J., Sonneborn, G., L. Bianchi, *et al.* 2000. "FUSE Observations of the Stellar Winds of Two O7 Supergiants in the Magellanic Clouds," *AAS*, 195, 6.23
- Ghavamian, P., Raymond, J. C., Hartigan, P. & Blair, W. P. 2000. "Evidence for Shock Precursors in Tycho's Supernova Remnant," *ApJ*, 535, 266
- Giommi, P., Padovani, P. & Perlman, E. S. 2000. "Detection of Exceptional Spectral Variability in the TeV BL Lac Object IES 2344+514," *MNRAS*, 317, 743
- Goldsmith, P. F., Melnick, G. J., Bergin, E. A., Howe, J. E., Snell, R. L., Neufeld, D. A., Harwit, M., Ashby, M. L. N., Patten, B. M., Kleiner, S. C., Plume, R., Stauffer, J. R., Tolls, V., Wang, Z., Zhang, Y. F., Erickson, N. R., Koch, D. G., Schieder, R., Winnewisser, G. & Chin, G. 2000. "O₂ in Interstellar Molecular Clouds," *ApJ*, 539, L123
- Golimowski, D. A., Henry, T. J., Krist, J. E., Schroeder, D. J., Marcy, G.W., Fischer, D. A. & Butler, R. P. 2000. "The Very Low Mass Component of the Gliese 105 System," *AJ*, 120, 2082
- Gonzalez-Delgado, R., Leitherer, C. & Heckman, T. 1999. "Synthetic Spectra of H Balmer and HE I Absorption Lines. II. Evolutionary Synthesis Models for Starburst and Poststarburst Galaxies," *ApJS*, 125, 489
- Grimes, J. P., Kriss, G. A. & Espey, B. R. 1999. "Spatially Resolved Hopkins Ultraviolet Telescope Spectra of NGC 1068," *ApJ*, 526, 130
- Gurwell, M. A., Bergin, E. A., Melnick, G. J., Ashby, M. L. N., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G. & Zhang, Y. F. 2000. "Submillimeter Wave Astronomy Satellite Observations of the Martian Atmosphere: Temperature and Vertical Distribution of Water Vapor," *ApJ*, 539, L143
- Heckman, T. & Lehnert, M. 2000 "The Detection of the

- Diffuse Interstellar Bands in Dusty Starburst Galaxies,” *ApJ*, 537, 690
- Heckman, T. 2000. “Starbursts & the Formation of Galaxies & AGN,” *Phil. Trans. Roy. Soc.*, 358, No. 1772, 2077
- Henry, R. C. 2000. “Kretschmann Scalar for a Kerr-Newman Black Hole,” *ApJ*, 535, 350
- Henry, R. C. 2000. Review of “The Applicability of Mathematics as a Philosophical Problem,” by Mark Steiner, Harvard University Press; *The Mathematical Intelligencer*, 22, 77
- Henry, R. C. 1999. “The Interstellar Medium,” in “Small Missions for Energetic Astrophysics, Ultraviolet to Gamma-Ray,” ed. S. P. Brumby, *AIP Conference Proceedings*, 499, 100
- Henry, R. C. 1999. “The Intergalactic Medium,” in “Small Missions for Energetic Astrophysics, Ultraviolet to Gamma-Ray,” ed. S. P. Brumby, *AIP Conference Proceedings*, 499, 90
- Henry, R. C. 1999. Review of “New Trends in Astronomy Teaching,” ed. L. Gouguenheim, D. McNally, & J. R. Percy, *The Observatory*, 119, #1150, 150, June
- Henry, R. C. 1999. “The Diffuse Ultraviolet Background Radiation,” invited paper presented at “Multifrequency Behaviour of High Energy Cosmic Sources,” *Memorie della Societa Astronomica Italian*, eds. F. Giovannelli and L. Sabau-Graziati, 70, No.s 3/4, pp. 825-830
- Henry, R. C. 1999. “Hopkins Ultraviolet Background Explorer,” paper presented at “Multifrequency Behaviour of High Energy Cosmic Sources,” *Memorie della Societa Astronomica Italian*, eds. F. Giovannelli and L. Sabau-Graziati, 70, No.s 3/4, pp. 1347-1352
- Henry, R. C. & Murthy, J. 1998. “Modeling of Celestial Ultraviolet Sources,” *Air Force Research Laboratory Report AFRL-VS-HA-TR-98-0070*
- Herbst, T. M., Thompson, D., Fockenbrock, R., Rix, H.-W. & Beckwith, S. V. W. 1999. “Constraints on the Space Density of Methane Dwarfs and the Substellar Mass Function from a Deep Near-Infrared Survey,” *ApJ*, 526, L17
- Howe, J. E., Ashby, M. L. N., Bergin, E. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Hollenbach, D. J., Kaufman, M. J., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. “Extended [C I] and ^{13}CO J = 5–4 Emission in M17SW,” *ApJ*, 539, L137
- Huang, J.-H., Gu, Q.-S., Ji, L., Li, W.-D., Wei, J. Y. & Zheng, W. 1999. “New Wolf-Rayet Galaxies with Detection of WC Stars,” *ApJ*, 513, 215
- Hutchings, J.B., Crenshaw, D.M., Danks, A.C., Gull, T.R., Kraemer, S.B., Nelson, C., Weistrop, D., Kaiser, M.E., Joseph, C.L. 1999. “High Velocity Line Emission in the Narrow-Line Region of NGC4151,” *AJ*, 118, 2101
- Jain, B., Seljak, U. & White, S. 2000. “Ray Tracing Simulations of Weak Lensing by Large-Scale Structure,” *ApJ*, 530, 547
- Jain, B. & van Waerbeke, L. 2000. “Statistics of Dark Matter Halos from Gravitational Lensing,” *ApJL*, 530, 1
- Jain, B. & van Waerbeke, L. 2000. “The Mass Function of Halos from Gravitational Lensing,” in *Gravitational Lensing: Recent Progress and Future Goals*, ed. T.G. Brainerd and C.S. Kochanek
- Kaiser, M.E., Bradley II, L.D., Hutchings, J.B., Crenshaw, D.M., Gull, T.R., Kraemer, S.B., Nelson, C., Ruiz, J., Weistrop, D. 2000. “The Resolved Narrow Line Region in NGC4151,” *ApJ*, 528, 260
- Kelson, D.D., Illingworth, G.D., Tonry, J.L., Freedman, W.L., Kennicutt, R.C., Jr., Mould, J.R., Graham, J.A., Huchra, J.P., Macri, L.M., Madore, B.F., Ferrarese, L., Gibson, B.K., Sakai, S., Stetson, P.B., Ajhar, E.A., Blakeslee, J.P., Dressler, A., Ford, H.C., Hughes, S.M.G., Sebo, K.M. & Silbermann, N.A. 2000. “The Hubble Space Telescope Key Project on the Extragalactic Distance Scale. XXVII. A Derivation of the Hubble Constant Using the Fundamental Plane and $D_n-\sigma$ Relations in Leo I, Virgo, and Fornax,” *ApJ*, 529, 768
- Knigge, C., Long, K. S., Hoard, D. W., Szkody, P., Dhillon, V. S. 2000. “A Self-Occulting Accretion Disk in the SW Sex Star DW UMa,” *ApJ*, 539, L49
- Kraemer, S.B., Crenshaw, D.M., Hutchings, J.B., Gull, T.R., Kaiser, M.E., Nelson, C. & Weistrop, D. 2000. “STIS Long-Slit Spectroscopy of the Narrow Line Region of NGC4151 II. Physical Conditions Along Position Angle 221,” *ApJ*, 531, 278
- Kriss, G. A., Davidsen, A. F., Zheng, W. & Lee, G. 1999. “The Ultraviolet Peak of the Energy Distribution in 3C 273: Evidence for an Accretion Disk and Hot Corona around a Massive Black Hole,” *ApJ*, 528, 123
- Kriss, G. A., Peterson, B. A., Crenshaw, D. M. & Zheng, W. 2000. “A High Signal-to-Noise UV Spectrum of NGC 7469: New Support for Reprocessing of Continuum Radiation,” *ApJ*, 535, 58
- Kriss, G. A., *et al.* 2000. “FUSE Observations of Intrinsic Absorption in the Seyfert 1 Galaxy Mrk 509,” *ApJ*, 538, L17
- Kruk, J. W., Bianchi, L., Chayer, P., *et al.* 2000. “FUSE Observations of the CSPN K1-16,” *AAS*, 195, 6.18
- Kruk, J. W., Brown, T. M., Davidsen, A. F., Espey, B. R., Finley, D. S. & Kriss, G. A. 1999. “Final Astro-2 Calibration of the Hopkins Ultraviolet Telescope,” *ApJS*, 122, 299
- Kudritzki, R., Méndez, R. H., Feldmeier, J. J., Ciardullo, R., Jacoby, G. H., Freeman, K. C., Arnaboldi, M., Capaccioli, M., Gerhard, O., Ford, H. C. 2000. “Discovery of Nine $\text{Ly}\alpha$ Emitters at Redshift $Z\sim 3.1$ Using Narrowband Imaging and VLT Spectroscopy,” *ApJ*, 536, 19
- Kunszt, P. Z., Szalay, A. S., Csabai, I. & Thakar, A. R. 2000. “The Indexing of the SDSS Science Archive,” in *ASP Conf. Ser.*, Vol. 216, *Astronomical Data Analysis Software and Systems IX*, eds. N. Manset, C. Veillet, D. Crabtree (San Francisco: ASP), 141
- Kurk, J. D., Röttgering, H. J. A., Pentericci, L., Miley, G. K., van Breugel, W., Carilli, C. L., Ford, H., Heckman, T., McCarthy, P., Moorwood, A. 2000. “A Search for Clusters at High Redshift. I. Candidate $\text{Ly}\alpha$ Emitters near 1138-262 at $z=2.2$,” *AAP*, 358, L1
- Lacy, M., Kaiser, M. E., Hill, G. J., Rawlings, S., Leyshon, G. 1999. “A Complete Sample of Radio Sources in the

- North Ecliptic Cap, Selected at 38 MHz – III. Further Imaging Observations and the Photometric Properties of the Sample,” *MNRAS*, 308, 1087
- Lecavelier des Etangs, A., Hobbs, L. M., Vidal-Madjar, A., Beust, H., Feldman, P. D., Ferlet, R., Lagrange, A.-M., Moos, H. W. & McGrath, M. 2000. “Possible Emission Lines from the Gaseous Beta Pictoris Disk,” *A&A*, 356, 691
- Leggett, S. K., Geballe, T. R., Fan, X., Schneider, D. P., Gunn, J. E., Lupton, R. H., Knapp, G. R., Strauss, M. A., McDaniel, A., Golimowski, D. A., Henry, T. J., Peng, E., Tsvetanov, Z. I., Uomoto, A., Zheng, W., Hill, G. J., Ramsey, L. W., Anderson, S. F., Annis, J. A., Bahcall, N. A., Brinkmann, J., Chen, B., Csabai, I., Fukugita, M., Hennessy, G. S., Hindsley, R. B., Ivesic, Z., Lamb, D. Q., Munn, J. A., Pier, J. R., Schlegel, D. J., Smith, J. A., Stoughton, C., Thakar, A. R. & York, D. G., 2000. “The Missing Link: Early Methane (“T”) Dwarfs in the Sloan Digital Sky Survey,” *ApJ*, 536, L35
- Lehnert, M., Heckman, T. & Weaver, K. 1999. “Very Extended X-Ray and H alpha Emission in M82: Implications for the Superwind Phenomenon,” *ApJ*, 523, 575
- Levenson, N. A., Graham, J. R., McLean, I. S., Becklin, E. E., Figer, D. F., Gilbert, A. M., Larkin, J. E., Teplitz, H. I., Wilcox, M. K. 2000. “Hot Stars and Cool Clouds: The Photodissociation Region M16,” *ApJ*, 533, L53
- Levenson, N. A., Graham, J. R., Snowden, S. L. 1999. “The Cygnus Loop: A Soft-Shell Supernova Remnant,” *ApJ*, 526, 874
- Levenson, N. A., Weaver, K. A., Heckman, T. M. 2000. “The Seyfert-Starburst Connection in X-rays,” *AAS/High Energy Astrophys. Div.*, 32, 04.10
- Long, K. S. 2000. “What We Learn from Quantitative Spectroscopy of Naked White Dwarfs in Cataclysmic Variables,” in *Cataclysmic Variables: A 60th Birthday Symposium in Honour of Brian Warner*, ed. P. Charles, A. King, & D. O’Donoghue, *New Astronomy Reviews*, 44, 125
- Marconi, A., Axon, D., Binney, J., Capetti, A., Carollo, M., Dressel, L., Ford, H., Hughes, M., Macchetto, D., Maciejewski, W., Merrifield, M., Sparks, W., Stiavelli, M., Tsvetanov, Z., van der Marel, R. 2000. “The Black Hole Mass versus Bulge Mass Relationship in Spiral Galaxies,” *IAU Symposia*, 205, 26
- Massa, D., Fullerton, A., Hutchings, J.B., Morton, D.C., Sonneborn, G., Willis, A.J., Bianchi, L., Brownsberger, K.B., Crowther, P. A., Snow, T.P. & York, D.G. 2000, “The Detection of Wind Variability in Magellanic Cloud O Stars,” *ApJ*, 538, L47
- May, M. J., Fournier, K. B., Pacella, D., Kroegler, H., Rice, J. E., Gregory, B., Finkenthal, M., Moos, H. W., Mazzitelli, G., Goldstein, W. H. 2000. “Observations of the VUV Brightness Profiles and Cooling Rates of Kr and Ar in FTU and Alcator C-Mod Tokamak Plasmas,” *Physical Review E*, 61, (3), 3042
- Melnick, G. J., Stauffer, J. R., Ashby, M. L. N., Bergin, E. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Snell, R. L., Tolls, V., Wang, Z., Winnewisser, G. & Zhang, Y. F. 2000, “The Submillimeter Wave Astronomy Satellite: Science Objectives and Instrument Description,” *ApJ*, 539, L77
- Melnick, G. J., Ashby, M. L. N., Plume, R., Bergin, E. A., Neufeld, D. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Patten, B. M., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G. & Zhang, Y. F. 2000. “Observations of Water Vapor toward Orion BN/KL,” *ApJ*, 539, L87
- Moos, H. W., Cash, W. C., Cowie, L. L., Davidsen, A. F., Dupree, A. K., Feldman, P. D., Friedman, S. D., Green, J. C., Green, R. F., Gry, C., Hutchings, J. B., Jenkins, E. B., Linsky, J. L., Malina, R. F., Michalitsianos, A. G., Savage, B. D., Shull, J. M., Siegmund, O. H. W., Snow, T. P., Sonneborn, G., Vidal-Madjar, A., Willis, A. J., Woodgate, B. E., York, D. G., Ake, T. B., Andersson, B.-G., Andrews, J. P., Barkhouser, R. H., Bianchi, L., Blair, W. P., Brownsberger, K. R., Cha, A. N., Chayer, P., Conard, S. J., Fullerton, A. W., Gaines, G. A., Grange, R., Gummin, M. A., Hebrard, G., Kriss, G. A., Kruk, J. W., Mark, D., McCarthy, D. K., Morbey, C. L., Murowinski, R., Murphy, E. M., Oegerle, W. R., Ohl, R. G., Oliveira, C., Osterman, S. N., Sahnou, D. J., Saisse, M., Sembach, K. R., Weaver, H. A., Welsh, B. Y., Wilkinson, E., Zheng, W. 2000. “Overview of the Far Ultraviolet Spectroscopic Explorer Mission,” *ApJ*, 538, L1
- Mould, J. R., Huchra, J. P., Freedman, W. L., Kennicutt, R. C., Ferrarese, L., Ford, H. C., Gibson, B. K., Graham, J. A., Hughes, S. M. G., Illingworth, G., D. Kelson, D. D., Macri, L. M., Madore, B. F., Sakai, S., Sebo, K. M., Silbermann, N. A. & Stetson, P. B. 2000. “The Hubble Space Telescope Key Project on the Extragalactic Distance Scale. XXVIII. Combining the Constraints on the Hubble Constant,” *ApJ*, 529, 786
- Mould, J.R., Hughes, S.M.G., Stetson, P., Gibson, B.K., Huchra, J.P., Freedman, W.L., Kennicutt, R.C., Jr., Bresolin, F., Ferrarese, L., Ford, H.C., Graham, J.A., Han, M., Hoessel, J.G., Illingworth, G.D., Kelson, D., Macri, L., Madore, B., Phelps, R., Prosser, C. Rawson, D., Saha, A., Sakai, S., Sebo, K.M., Silbermann, N.A. & Turner, A.M. 2000. “The Hubble Space Telescope Key Project on the Extragalactic Distance Scale. XXI. The Cepheid Distance to NGC 1425,” *ApJ*, 528, 655
- Munshi, D. & Jain, B. 2000. “The Statistics of Weak Lensing at Small Angular Scales: Probability Distribution Function,” *MNRAS*, 318, 109
- Murphy, E. M., Sembach, K. R., Gibson, B. K., Shull, J. M., Savage, B. D., Roth, K. C., Moos, H. W., Green, J. C., York, D. G., Wakker, B. P. 2000. “Far Ultraviolet Spectroscopic Explorer Spectroscopy of High-Velocity Cloud Complex C,” *ApJ*, 538, L35
- Murthy, J., Hall, D., Earl, M., Henry, R. C. & Holberg, J. B. 1999. “An Analysis of 17 Years of Voyager Observations,” *ApJ*, 522, 904
- Natta, A., Meyer, M. R. & Beckwith, S. V. W. 2000. “Silicate Emission in T Tauri Stars: Evidence for Disk Atmospheres?” *ApJ*, 534, 838

- Nelson, C, Weistrop, D., Hutchings, J.B., Crenshaw, D.M., Gull, T.R., Kaiser, M.E., Kraemer, S.B., Lindler, D. 2000. "STIS Long-slit Spectroscopy of the Narrow Line Region of NGC4151 I. Kinematics and Line Ratio Diagrams," *ApJ*, 531, 257
- Neufeld, D. A., Ashby, M. L. N., Bergin, E. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Kleiner, S. C., Koch, D. G., Patten, B. M., Plume, R., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "Observations of Absorption by Water Vapor toward Sagittarius B2," *ApJ*, 539, L111
- Neufeld, D. A., Stauffer, J. R., Bergin, E. A., Kleiner, S. C., Patten, B. M., Wang, Z., Ashby, M. L. N., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Howe, J. E., Koch, D. G., Plume, R., Schieder, R., Snell, R. L., Tolls, V., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "Submillimeter Wave Astronomy Satellite Observations of Water Vapor toward Comet C/1999 H1 (Lee)," *ApJ*, 539, L151
- Neufeld, D. A. 2000. "Response of Circumnuclear Water Masers to Luminosity Changes in an Active Galactic Nucleus," *ApJ*, 542, L99
- Newton, I. & Henry, R. C. 2000. "Circular Motion," *American Journal of Physics* 68, 637
- Oegerle, W. R., Tripp, T. M., Sembach, K. R., Jenkins, E. B., Bowen, D. V., Cowie, L. L., Green, R. F., Kruk, J. W., Savage, B. D., Shull, J. M. & York, D. G. 2000. "FUSE Observations of the Galactic and Intergalactic Medium Towards H1821+64," *ApJ*, 538, L23
- Ohl, R. G., Chayer, P. & Moos, H. W. 2000. "Photospheric Metals in the *FUSE* Spectrum of the Subdwarf B Star PG0749+658," *ApJ*, 538, L95
- Ohl, R. G., Friedman, S. D., Saha, T. T., Barkhouser, R. H., Moos, H. W. 1999. "Optical Testing of the Far Ultraviolet Spectroscopic Explorer Primary Mirrors and Predicted On-Orbit Performance," *SPIE Proc.* 3765, 482
- Ohl, R. G., Saha, T. T., Barkhouser, R. H., Friedman, S. D., Moos, H. W. 2000. "Optical Testing of the Far Ultraviolet Spectroscopic Explorer Primary Mirrors Demonstrates Their Readiness for Space Science," *Laser Focus World*, January 2000, 183
- Ohl, R.G., Saha T.T., Friedman, S.D., Barkhouser, R.H. & Moos, H.W. 2000. "Imaging Performance of Telescope Mirrors for Far Ultraviolet Astronomy," *Applied Optics*, 39(25), 4513
- Papovich, C., Norman, C., Bowen, D., Heckman, T., Savaglio, S., Koekemoer, A. & Blades, J. C. 2000. "Hubble Space Telescope Observations of the Associated Absorption-Line Systems in Q0122+0338," *ApJ*, 531, 251
- Perlman, E. S. 2000. "X-ray Selected BL Lacs and Blazars," (invited review) in "GeV-TeV Astrophysics Workshop: Towards a Major Atmospheric Cerenkov Detector," proceedings ed. B. Dingus, M. Salamon & M. Kieda (AIP: Provo), p. 53; also astro-ph/9910321
- Plume, R., Bensch, F., Howe, J. E., Ashby, M. L. N., Bergin, E. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Kleiner, S., Koch, D. G., Neufeld, D. A., Patten, B. M., Schieder, R., Snell, R. L., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "Large-scale ^{13}CO J = 5-4 and [C I] Mapping of Orion A," *ApJ*, 539, L133
- Prosser, C. F., Kennicutt, R. C., Jr., Bresolin, F., Saha, A., Sakai, S., Freedman, W. L., Mould, J. R., Ferrarese, L., Ford, H. C., Gibson, B. K., Graham, J. A., Hoessel, J. G., Huchra, J. P., Hughes, S. M., Illingworth, G. D., Kelson, D. D., Macri, L., Madore, B. F., Silbermann, N. A., Stetson, P. B. 1999. "The Hubble Space Telescope Key Project on the Extragalactic Distance Scale. XXII. The Discovery of Cepheids in NGC 1326A," *ApJ*, 525, 80
- Rauch, T., Bianchi, L. & Heber, U. 2000. "NTLE Spectral Analysis of K648, the Exciting Star of Ps 1 in M15," *AGM*, 17, 5
- Rector, T. A., Stocke, J. T., Perlman, E. S., Morris, S. L. & Gioia, I. M. 2000. "The Properties of the X-Ray-selected EMSS Sample of BL Lacertae Objects," *AJ*, 120, 1626
- Robberto, M., Beckwith, S. V. W., Meyer, M. R. & Natta, A. 1999. "ISO-PHOT Observations of Circumstellar Disks Around YSOs," in *The Universe as Seen by ISO*, ESA Pub. SP-427
- Robberto, M., Beckwith, S. V. W. & Herbst, T. M. 2000. "Circumstellar Disks in Orion: First Results from a Mid-IR Survey," in *Proceedings of Star Formation 1999*, Nagoya, Japan, June 21 - 25, 1999, ed. T. Nakamoto, (Nobeyama: Nobeyama Radio Observatory), 231
- Roberge, A., Feldman, P. D., Lagrange, A.-M., Vidal-Madjar, A., Ferlet, R., Jolly, A., Lemaire, J.-L. & Rostas, F. 2000. "High Resolution HST STIS Spectra of C I and CO in the β Pictoris Circumstellar Disk," *ApJ*, 538, 904-910
- Sahnow, D. J., Moos, H. W., Ake, T. B., Andersen, J., Andersson, B.-G., Andre, M., Artis, D., Berman, A. F., Blair, W. P., Brownsberger, K. R., Calvani, H. M., Chayer, P., Conard, S. J., Feldman, P. D., Friedman, S. D., Fullerton, A. W., Gaines, G. A., Gawne, W. C., Green, J. C., Gummin, M. A., Jennings, T. B., Joyce, J. B., Kaiser, M. E., Kruk, J. W., Lindler, D. J., Massa, D., Murphy, E. M., Oegerle, W. R., Ohl, R. G., Roberts, B. A., Romelfanger, M. L., Roth, K. C., Sankrit, R., Sembach, K. R., Shelton, R. L., Siegmund, O. H. W., Silva, C. J., Sonneborn, G., Vaclavik, S. R., Weaver, H. A., Wilkinson, E. 2000. "On-Orbit Performance of the Far Ultraviolet Spectroscopic Explorer Satellite," *ApJ*, 538, L7
- Sahnow, D. J., Moos, H. W., Ake, T. B., Andersson, B.-G., Andre, M., Berman, A. F., Blair, W. P., Brownsberger, K. R., Calvani, H. M., Chayer, P., Conard, S. J., Feldman, P. D., Friedman, S. D., Fullerton, A. W., Gaines, G. A., Green, J. C., Gummin, M. A., Joyce, J. B., Kaiser, M. E., Kruk, J. W., Lindler, D. J., Massa, D., Murphy, E. M., Oegerle, W. R., Ohl, R. G., Osterman, S. N., Roberts, B. A., Roth, K. C., Sankrit, R., Sembach, K. R., Shelton, R. L., Siegmund, O. H. W., Weaver, H. A., Wilkinson, E. 2000. "On-Orbit Performance of the Far Ultraviolet Spectroscopic Explorer (FUSE)," *SPIE*, 4013, 334
- Sakai, S., Ferrarese, L., Kennicutt, R.C., Graham, J.A., Sil-

- bermann, N.A., Mould, J.R., Freedman, W.L., Bresolin, F., Ford, H.C., Gibson, B.K., Han, M., Harding, P., Hoessel, J.G., Huchra, J.P., Hughes, S. M., Illingworth, G.D., Kelson, D., Macri, L., Madore, B.F., Phelps, R.L., Saha, A., Sebo, K.M., Stetson, P.B. & Turner, A. 1999. "The Hubble Space Telescope Extragalactic Distance Scale Key Project. XXIII. The Discovery of Cepheids in NGC 3319," *ApJ*, 523, 540
- Salzer, J. J., Gronwall, C., Lipovetsky, V. A., Kniazev, A., Moody, J. Ward, Boroson, T. A., Thuan, T. X., Izotov, Y. I., Herrero, J. L. & Frattare, L. M. 2000. "The KPNO International Spectroscopic Survey I: Description of the Survey," *AJ*, 120, 80
- Sankrit, R. & Blair, W. P. 2000. "Far Ultraviolet Emission from Supernova Remnant Shocks," in *IAU Symp. 195, "Highly Energetic Physical Processes and Mechanisms for Emission,"* ed. by P.H.C. Martens & S. Tsurata, ASP Conf. Series, p.425
- Sankrit, R., Blair, W. P., Raymond, J. C. & Long, K. S. 2000. "HST-STIS Observations of the Cygnus Loop: Spatial Structure of a Non-Radiative Shock," *AJ*, 120, 1925
- Savage, B. D., Sembach, K. R., Jenkins, E. B., Shull, J. M., York, D. G., Sonneborn, G., Moos, H. W., Friedman, S. D., Green, J. C., Oegerle, W. R., Blair, W. P., Kruk, J. W., Murphy, E. M. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of O VI Absorption in the Galactic Halo," *ApJ*, 538, L27
- Schlegel, E. M., Fesen, R. A. & Blair, W. P. 2000. "Rosat HRI and ASCA Observations of the Spiral Galaxy NGC 6946 and Its Northeast Complex of Luminous Supernova Remnants," *AJ*, 120, 791
- Schroeder, D. J., Golimowski, D. A., Brukaradt, R. A., Burrows, C. J., Caldwell, J. J., Fastie, W. G., Ford, H. C., Hesman, B., Kletskin, I., Krist, J. E., Royle, P., Zubrowski, R. A. 2000. "A Search for Faint Companions to Nearby Stars Using the Wide Field Planetary Camera 2," *AJ*, 119, 906
- Sembach, K. R., Savage, B. D., Shull, J. M., Jenkins, E. B., Murphy, E. M., York, D. G., Ake, T., Blair, W. P., David- sen, A. F., Friedman, S. D., Gibson, B. K., Kruk, J. W., Moos, H. W., Oegerle, W. R., Sahnou, D., Sonneborn, G. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of O VI in High-Velocity Clouds," *ApJ*, 538, L31
- Shelton, R. L. 1999. "Simulations of Supernova Remnants in Diffuse Media. II. Three Remnants and Their X-ray Emission," *ApJ*, 521, 217
- Shelton, R. L., Cox, D. P., Maciejewski, W., Smith, R. K., Plewa, T., Pawl, A. & Rozyczka, M. 1999. "Modeling W44 as a Supernova Remnant in a Density Gradient, with a Partially Formed Dense Shell and Thermal Conduction in the Hot Interior: II. The Hydrodynamic Models," *ApJ*, 524, 192
- Shelton, R. L. 2000. "On Determining the Sources of Hot Gas in the Halo," in *Revista Mexicana de Astronomi'a y Astrofi'sica*, ed. Jose Franco, Jane Arthur and Nancy Brickhouse
- Shelton, R. L., Murphy, E. M., Kruk, J. W., Moos, H. W., Oegerle, W. R., Jenkins, E. B. & the FUSE Team 1999. "Local Bubble O VI Surface Brightness Observations with FUSE," *BAAS*, 195, 604
- Shull, J. M., Giroux, M. L., Penton, S. V., Tumlinson, J., Stocke, J. T., Jenkins, E. B., Moos, H. W., Oegerle, W. R., Savage, B. D., Sembach, K. R., York, D. G., Green, J. C., Woodgate, B. E. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of the Low-Redshift Ly beta Forest," *ApJ*, 538, L13
- Shull, J. M., Tumlinson, J., Jenkins, E. B., Moos, H. W., Rachford, B. L., Savage, B. D., Sembach, K. R., Snow, T. P., Sonneborn, G., York, D. G., Blair, W. P., Green, J. C., Friedman, S. D. & Sahnou, D. J. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of Diffuse Interstellar Molecular Hydrogen," *ApJ*, 538, L73
- Sirianni, M., Clampin, M., Hartig, G.F., Ford, H.C., Golimowski, D.A., Illingworth, G., Sullivan, P., Blouke, M., Lesser, M., Burmester, B., Schrein, R. & Kimble, R. 2000. "CCD Detectors for the Advanced Camera for Surveys," *Proc. SPIE*, Vol 4008, 669
- Sirianni, M., Nota, A., Leitherer, C., De Marchi, G. & Clampin, M. 2000. "The Low End of The Initial Mass Function in Young LMC Clusters: I. The Case of R136," *ApJ*, 533, 203
- Smith, E. & Long, K. S., eds. 2000. "Next Generation Space Telescope Science and Technology," ASP Conf Series, Vol 207 Proceedings of a conference held at Hyannis MA, 13-16 Sept. 1999.
- Snell, R. L., Howe, J. E., Ashby, M. L. N., Bergin, E. B., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "Submillimeter Wave Astronomy Satellite Observations of Extended Water Emission in Orion," *ApJ*, 539, L93
- Snell, R. L., Howe, J. E., Ashby, M. L. N., Bergin, E. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "The Distribution of Water Emission in M17SW," *ApJ*, 539, L97
- Snell, R. L., Howe, J. E., Ashby, M. L. N., Bergin, E. A., Chin, G., Erickson, N. R., Goldsmith, P. F., Harwit, M., Kleiner, S. C., Koch, D. G., Neufeld, D. A., Patten, B. M., Plume, R., Schieder, R., Stauffer, J. R., Tolls, V., Wang, Z., Winnewisser, G., Zhang, Y. F. & Melnick, G. J. 2000. "Water Abundance in Molecular Cloud Cores," *ApJ*, 539, L101
- Snow, T. P., Rachford, B. L., Tumlinson, J., Shull, J. M., Welty, D. E., Blair, W. P., Ferlet, R., Friedman, S. D., Gry, C., Jenkins, E. B., Lecavelier, A., Lemoine, M., Morton, D. C., Savage, B. D., Sembach, K. R., Vidal-Madjar, A., York, D. G., Andersson, B.-G., Feldman, P. D., Moos, H. W. 2000. "Far Ultraviolet Spectroscopic Explorer Observations of Molecular Hydrogen in Translucent Interstellar Clouds: The Line of Sight toward HD 73882," *ApJ*, 538, L65
- Soukhanovskii, V. A., Lippman, S., May, M. J., Finkenthal, M., Moos, H. W., Fournier, K. B., Goldstein, W., Pacella,

- D. & Mazzitelli, G. 2000. "Laboratory Observation and Modeling of Extreme Ultraviolet Spectra of Highly Ionized Calcium," *A&AS*, 142, 95
- Szalay, A.S., Kunszt, P.Z., Thakar, A., Gray, J., Slutz, D. & Brunner, R.J. 2000. "Designing and mining multi-terabyte astronomy archives: the Sloan Digital Sky Survey," Proceedings of the 2000 ACM SIGMOD on Management of Data, 451
- Thakar, A. R., Kunszt, P. Z., Szalay, A. S. & Szokoly, G. P. 2000. "Multi-threaded Query Agent and Engine for a Very Large Astronomical Database," in ASP Conf. Ser., Vol. 216, Astronomical Data Analysis Software and Systems IX, eds. N. Manset, C. Veillet, D. Crabtree (San Francisco: ASP), 231
- Thompson, D., Beckwith, S. V. W., Fockenbrock, R., Fried, J., Hippelein, H., Hopp, U., Huang, J.-S., Leinert, C., Meisenheimer, K., Phleps, S., Roser, H. -J., Thommes, E. & Wolf, C. 1999. "The Surface Density of Extremely Red Objects," *ApJ*, 523, 100
- Tozzi, P., Scharf, C. & Norman, C. 2000. "Detection of the Entropy of the Intergalactic Medium: Accretion Shocks in Clusters, Adiabatic Cores in Groups," *ApJ*, 542, 106
- Tozzi, P. & Norman, C. 1999. "The Connection Between X-ray Clusters and Star Formation," Proceedings of the "VLT Opening Symposium," Antofagasta (Chile), 1-4 March 1999, Jacqueline Bergeron and Alvio Renzini (eds.), Springer (Berlin, Heidelberg), pg. 180 (astro-ph/9905046)
- Tran, H. D., Brotherton, M. S., Stanford, S. A., van Breugel, W., Dey, A., Stern, D. & Antonucci, R. 1999. "A Polarimetric Search for Hidden Quasars in Three Radio-selected Ultraluminous Infrared Galaxies," *ApJ*, 516, 85
- Tran, H. D., Cohen, M. H. & Villar-Martin, M. 2000. "Keck Observations of the Hidden Quasar IRAS P09104 +4109," *AJ*, 120, 562
- Tsvetanov, Z. I., Golimowski, D. A., Zheng, W., Geballe, T. R., Leggett, S. K., Ford, H. C., Davidsen, A. F., Uomoto, A., Fan, X. Knapp, G. R., Strauss, M. A., Brinkmann, J. Lamb, D. Q., Newberg, H. J., Rechenmacher, R. Schneider, D. P., and York, D. G., Lupton, R. H., Pier, J. R., Annis, J., Csabai, I., Hindsley, R. B., Ivesi, Zeljko, Munn, J. A., Thakar, A. R., & Waddell, P. 2000. "The Discovery of a Second Field Methane Brown Dwarf from Sloan Digital Sky Survey Commissioning Data," *ApJ*, 531, L61
- Vidal-Madjar, A., Kunth, D., Lecavelier des Etangs, A., Lequeux, J., Andre, M., BenJaffel, L., Ferlet, R., Hebrard, G., Howk, J. C., Kruk, J. W., Lemoine, M., Moos, H. W., Roth, K. C., Sonneborn, G. & York, D. G. 2000. "No Diffuse H2 in the Metal-deficient Galaxy I Zw 18," *ApJ*, 538, L77
- Walters, J. L., McKee, C. F., Klein, R. I., Graham, J. R., Levenson, N. A. 2000. "X-Ray Spectroscopy of a Cloud-Blast Wave Interaction in the Cygnus Loop," *AAS/High Energy Astrophys. Div.*, 32, 03.08
- Weaver, K., Heckman, T., & Dahlem, M. 2000. "An X-Ray MiniSurvey of Nearby Edge-on Starburst Galaxies. II. The Question of Metal Abundance," *ApJ*, 534, 684
- Wiseman, J. 2000. "Dynamics of Molecular Gas Around Protostars," in "Star Formation from the Small to the Large Scale," ESA SP-445, eds. F. Favata, A. A. Kaas, & A. Wilson, 195
- Wiseman, J. J., Wootten, A., Fuller, G. A., Zinnecker, M. J., & McCaughrean, M. J. 1999. "Rotating Molecular Gas Disks Around Protostellar Jets," *BAAS* 31, No. 5, 1292
- Wolf, C., Meisenheimer, K., Roser, H.-J., Beckwith, S. V. W., Fockenbrock, R., Hippelein, H., von Kuhlmann, B., Phleps, S., & Thommes, E. 2000. "Have most high-redshift quasars been over-looked? in Imaging the Universe in Three Dimensions: Astrophysics with Advanced Multi-wavelength Imaging Devices, eds. W. van Breugel & J. Bland-Hawthorn, (ASP Conf. Series), 398
- Woods, T. N., Feldman, P. D. and Rottman, G. J. 2000. "Ultraviolet Observations of Comet Hale-Bopp by the UARS SOLSTICE," *ApJ*, 144, 182
- York, D.G. et. al. 2000. "The Sloan Digital Sky Survey: Technical Summary," *AJ*, 120(3), 1579
- Zheng, W. *et al.* 2000. "Five High-Redshift Quasars Discovered in Commissioning Imaging Data of the Sloan Digital Sky Survey," *AJ*, 120, 1607