University of Virginia

Department of Astronomy
Leander McCormick Observatory

Charlottesville, Virginia, 22903-0818

This report covers the period 1 September 1996 to 31 August 1997.

1 Personnel

During this time the departmental faculty consisted of Steven A. Balbus, Roger A. Chevalier, John F. Hawley, Philip A. Ianna, Shiv S. Kumar, Steven R. Majewski Robert W. O'Connell, Mercedes T. Richards, Robert T. Rood, Craig L. Sarazin, William C. Saslaw, Trinh X. Thuan, Charles R. Tolbert, and D. Mark Whittle. Z.-Y. Li (Caltech) joined the faculty as Assistant Professor at the end of this period.

The Virginia Institute for Theoretical Astronomy (VITA) continued operations during this period with support from the University of Virginia and NASA Astrophysical Theory Program grants. Visitors under VITA auspices for the year included M. Fall (STScI), F. Ferraro (Bologna), Y. Izotov (Kiev), S. Kulkarni (Caltech), M. Loewenstein (GSFC), B. Paltrinieri (Bologna), and J. Stone (UMd). Postdocs in residence during this period included Carolyn Cox, Ben Dorman, Paul Ricker, and Duane Rosenberg.

Eric W. Weisstein continued as Research Scientist. Astrometric support positions were held by Michael C. Begam and Richard J. Patterson, who spent most of the year at Mount Stromlo Observatory. James Barr continued as electronics technician. Charles Lam replaced Cliff Mawyer as instrument maker. Virginia Bossong and Jacquelynn Harding continued as our secretaries. Nick Nichols is the resident caretaker at the Fan Mountain Station.

There were 14 graduate students in residence at the end of this period. Vikram Dwarkadas, Fan Fang, and Jimmy Irwin completed their Ph.D.s during the year.

2 Facilities

The McCormick 67-cm refractor and the Fan Mountain 0.7-m and 1-m reflectors were used for student research and education in both undergraduate and graduate courses during the year. A new drive and control system were installed on the 1-m by DFM Engineering in Fall 1996, and these work well. A SITe 2K $\times$ 2K CCD, employing San Diego State University controller boards and software, was installed on the 1-m. A new tailpiece for the 1-m is being designed by Lam, Majewski, Barr, and Ianna. A new spectrograph and CCD camera were acquired for the refractor with University and NSF funds, and Majewski is coordinating their implementation into our teaching programs. The PDS 1010GM measuring engine was in nearly continuous use scanning plates for our astrometric and galactic structure programs. It was also used on several occasions by other University researchers from biology and medicine. We are planing to acquire a second, surplus PDS machine from Goddard Space Flight Center. Only limited astrometric observations were carried out with the refractor. Observations for the southern parallax program continued to be made under a cooperative agreement with Mount Stromlo and Siding Spring Observatories (Australia).

3 Research

3.1 Stars and Stellar Evolution

Balbus has extended earlier work on disk turbulence to the convective zone of rotating stars. Whereas angular momentum flux and angular velocity gradients must be antiparallel in disks if turbulent fluctuations are to have a dynamical source, the same quantities must be parallel in convective zones if the mean differential rotation is to have a dynamical source. To the extent that the two gradients are proportional to one another, Balbus argues that the angular velocity will satisfy the Laplace equation. This hypothesis yields an angular velocity profile remarkably similar to those inferred from helioseismology, using the radiative zone and surface profile as boundary conditions.

Balbus has undertaken a program to study the source of flickering noise in CV systems. These fluctuations in the luminosity in accretion disks are not well understood, but appear to be a ubiquitous observational feature. Flickering is probably telling us something very fundamental about the turbulent origin of the disk viscosity process. The time power spectra of the dynamics of numerical disk simulations will be translated into radiative losses and compared with what is becoming an extended set of observations.

Balbus is investigating the role of magnetic instabilities in the solar nebula. Current modeling shows that dissipational heating associated with the instability is hot enough to maintain good ionization coupling out to scales of order 1 AU. Models which include only thermal ionization from the sun have much smaller zones of good coupling. It is likely that ionization maintained by turbulence is unstable, since heating leads to more ionization, which in turn leads to more efficient dissipational heating. An understanding of the MHD physics of protostellar disks may provide an alternative explanation of FU Orionis outbursts, as well bear on the absence of gas planets in the inner solar system.

Balbus and Massimo Ricotti (Arcetri) are studying

the properties of equilibrium magnetic field configurations in rotating disks. The field lines are ellipses and hyperbolæ, and have the noteworthy property that they rotate uniformly rather than shearing. Both prograde and retrograde flow is a possibility. Keplerian as well as galactic disks are possible venues for these solutions. If these solutions are present in disks they are of practical interest: they correspond to X-type and O-type neutral points. Furthermore, the dynamical effects of elliptical magnetic islands may play a role in confining molecular gas in the galaxy.

Chevalier investigated the importance of synchrotron self-absorption for radio supernovae in the context of the circumstellar interaction model. Previous observations of the low frequency absorption in these events have frequently been interpreted in terms of free-free absorption. However, in some objects, synchrotron self-absorption is expected to dominate unless the shock velocity is very high, but the supernova cannot drive a high velocity shock wave into a high density circumstellar medium. This argument applies to the 4 observed Type Ib/c supernovae and to the early observations of SN 1987A. The dominance of synchrotron self-absorption in these objects gives estimates of the shock velocities. The Type Ib/c supernovae have remarkably similar radio properties, which suggests that mass loss might lead to a convergence of properties for the supernova progenitors. The same line of argument shows that synchrotron self-absorption is unlikely to be important for the Type II supernovae SN 1979C and SN 1980K. The radio light curves of these supernovae are well fit by an external free-free absorption model.

N. D'Cruz (graduate student), O'Connell, and Rood are analyzing HST WFPC2 exposures of the luminous globular cluster ω Cen in the far-UV (1600 Å) and V-band. As indicated by earlier Ultraviolet Imaging Telescope data, the horizontal branch in ω Cen is extended to extremely high temperatures and shows discontinuities or gaps which appear to coincide with those found by Rood, Dorman, Ferraro and colleagues in other clusters. Their origin is presently unclear. The HST color-magnitude diagrams include hot objects below the horizontal branch, as found in UIT data by Whitney et al. (1994), and a population of "AGB-Manque" stars above the HB. The group is also analyzing HST/FOS spectra of some of the very hot EHB and post-HB objects in ω Cen found by UIT.

V. Dwarkadas (graduate student) and Chevalier investigated the interaction of realistic models for Type Ia supernovae with their surroundings. An exponential density profile gives an approximate fit to a number of profiles computed by Khokhlov and Höflich, but some of the models show substantial deviations at low velocities. Dwarkadas and Chevalier computed the detailed properties of the exponential profile case and found an approximate analytic description of the evolution. However, this interaction model is not compatible with X-ray observations of Tycho's supernova remnant, which is thought to be the result of a Type Ia supernova. Models with regions of higher density, which do occur in some of the Type Ia supernova models, are more consistent with the observations. Another possibility is an early phase of circumstellar interaction.

C. Fransson (Stockholm) and Chevalier are examining the evidence for a possible pulsar nebula in the supernova SN 1993J in M81. Spectra of the supernova show relatively narrow (~ 1000 km s^{-1}) lines of O and Mg. The set of observed lines is consistent with emission from the inner O-rich zone of the exploded star; we had previously calculated the lines to be expected from pulsar excitation. One alternative in this case is photoionization by a companion star to the star that exploded. Models for the stellar evolution leading up to SN 1993J indicate that such a star may be present. However, with stellar photoionization, the observed amount of neutral O would not be present. Another possibility is ionization by the shock emission produced by the outer circumstellar interaction. This possibility appears unlikely because of the unusual density profile that would be required, but it will be further investigated.

Hawley and Balbus continue to investigate the nature of the angular momentum transport mechanism in astrophysical disk systems through combined analytical and numerical studies. Recently they have focused on purely hydrodynamical (unmagnetized) turbulence. Following up on a finding that disks of constant specific angular momentum are nonlinearly unstable, they have undertaken a detailed high resolution study of disks with a small but finite angular momentum gradient. Such disks are also nonlinearly unstable, provided that the gradient is sufficiently small. By using mathematical symmetry arguments, Balbus and Hawley have pointed out that the observed laboratory phenomenon of subcritical instability is closely related to this behavior. They have also carried out further three-dimensional simulations of Keplerian disk flows at high resolution; the results support the conclusion that self-generated hydrodynamical turbulence is not a source of anomalous viscosity in disks.

Hawley and J. Stone (University of Maryland) have developed an MHD code which allows ion and neutral fluids to be separately tracked while allowing the degree of coupling to widely vary. The first application of this code is to a parameter study of the effects of ionization fraction and coupling strength in local disk simulations. The results both confirm the general ion-neutral linear stability theory and find unexpected results in the nonlinear domain. The most interesting of these is the persistence of two-fluid effects on either side of the critical collision frequency for good coupling. Linear theory suggests that when the neutral–ion collision rate equals or exceeds the rotation frequency of Keplerian disk, the two fluid should be coupled. But the nonlinear calculations revealed that the neutrals started to respond to the magnetic field when the collision frequency was as low as 0.01 of Keplerian; furthermore, two-fluid effects persist when the collision frequency was 100 Keplerian. The significance of this for protostellar disks is the implication that the transition between zones of good coupling and

no coupling is far from sharp.

Hawley and Stone continue the development of three-dimensional MHD numerical code as the first step toward extending simulations to more realistic global disks. They have been adapting and optimizing these codes to distributed memory parallel supercomputers.

Majewski and M. Siegel (graduate student) continued their work on the Selected Areas Starcounts Survey (SASSY), the first systematic CCD starcounts survey of the Milky Way, in collaboration with I. N. Reid (Caltech) and I. B. Thompson (OCIW). Observations in more than a dozen Kapteyn Selected Areas now include B, V, R and I band CCD frames of 2 square degrees per fields from the Swope 40" at Las Campanas. Preliminary analysis of SASSY indicates that the thick disk (or "low halo" in some literature), is more extensive than previously believed, possibly comprising as much as 15% of the stars in the Milky Way. The SASSY also revealed extension of the tidal stream of the Sagittarius dwarf spheroidal galaxy to $b = -40°$ (25° south of the Sgr nucleus), more than double the previously reported size of the Sgr stream.

Majewski and J. Ostheimer (undergraduate student) in collaboration with Allan Sandage (OCIW) are generating additional starcount data to fainter (V=22) magnitudes. The latter data come from sky-limited Mayall 4-m photographic plates scanned on the UVa PDS microdensitometer. Catalogues generated with these plates are input to the deep proper motion and multifiber spectroscopic survey by Majewski, J. Munn (Yerkes) and S. Hawley (MSU). Radial velocities for some 1000 survey stars has been completed, and abundance analysis of these stars is underway. The goal is complete, magnitude-limited star samples towards strategically-placed directions of the sky, for analysis of the abundance, density, and kinematical distributions of Galactic stellar populations.

Majewski, Ostheimer, and W. Y. Johnson (undergraduate student), in collaboration with W. Kunkel (Las Campanas), have developed a technique for finding distant halo giant stars. They have discovered a population of giant stars with properties suggesting they may be extended tidal debris from the Magellanic Clouds. The data agree well with model predictions of LMC tidal streaming by collaborator K. Johnston (Inst. Advanced Study). If real LMC debris, these giant stars would be the first strong evidence for the tidal destruction of the Magellanic Clouds.

Richards and L. Moore (undergraduate student) used the Hα spectra of U Sge and U CrB to examine the time- and phase-dependence of the Hα emission sources in Doppler tomograms of these binaries. Their aim was to identify chromospheric emission sources associated with the late-type mass losing secondary star.

Richards and P. Koubský (Ondřejov Observatory, Czech Republic) have continued their project on eclipsing and non-eclipsing Algols with the aim of obtaining the 3-D structure of the accretion regions in these systems. They now have Hα and HeI (6678.15 Å) spectra of six non-eclipsing Algols (CX Dra, b Per, u Her, HR2545, KX And, and HD 183133) for the purpose of producing Doppler tomograms which will be compared with the tomograms of the eclipsing Algols. Richards and Koubský are participants in an international exchange sponsored jointly by the NSF Division of International Programs and the Czech Academy of Sciences.

P. Ricker and Chevalier are continuing Chevalier's investigation of accretion in the late stages of supernova explosions. In a supernova like SN1987a, the primary shock passes through interfaces between shells left by the different phases of pre-explosion nuclear burning. Ricker and Chevalier expect interactions with the density discontinuities at these interfaces to produce a reverse shock which can deposit material on the surface of the remnant neutron star, possibly enough to produce a black hole. To study this, they are conducting 1D hydrodynamic simulations of point explosions in a SN1987a progenitor model supplied by K. Nomoto (U. Tokyo), examining the accretion rate as a function of explosion energy and the mechanism by which the explosion is introduced. To date the results are consistent with a very low level of accretion.

Rood, Dorman, and O'Connell, in collaboration with Fusi Pecci, Ferraro, Paltrinieri, and others in Bologna, continue their project on HST observations of globular cluster stars. The project has two major components. The first is to achieve the largest possible photometric samples of globular clusters. This will allow the most stringent possible tests of stellar model calculations and the assumptions required to make these calculations. The results should eventually be useful for problems like the the accuracy of the globular cluster age scale. The second part involves observations of UV bright objects in globular cluster. Most of these are core helium burning (horizontal branch) stars, which have undergone extreme mass loss during the preceding red giant phase, and their helium shell burning progeny. One goal is to empirically learn something about the factors affecting mass loss in cool stars, one of the *bête noires* of stellar evolution theory. The results should also be useful in interpreting the "UV upturn" phenomenon in elliptical galaxies. The first results from both projects were published during the year. New data has just been received, and more observations are scheduled in early 1998.

Rosenberg and Chevalier have been computing models for photoionized interacting stellar winds. The results show an instability in the ionization front while it is in the swept-up shell of an interacting wind situation. The instability involves a D-type ionization front that is preceded by a shock front. They are investigating the physical basis for the instability.

Sarazin and W. Dalton (former grad student) are constructing models for the high mass X-ray binary (HMXRB) populations in the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC). In particular, they investigate the effects which the lower stellar metallicities of the Magellanic Clouds (MCs) have on the evolution and properties of HMXRBs. From the ob-

served properties of the relatively small number of identified HMXRBs in the MCs, it has been suggested that MC sources have very high X-ray luminosities, and may contain a higher proportion of black holes than HMXRBs in our Galaxy.

3.2 Interstellar Medium

Rood, Bania (BU), Balser (NRAO) and Wilson (MPIfR) [RBBW] are continuing their project to determine the cosmic abundance of ^{3}He. Observations of H II regions continued at the Green Bank 140ft. These are now focused on determining higher precision line parameters for a few sources which are easy to model (a necessary step in getting the abundances) and low density "simple" extensions of previously observed giant H II regions. RBBW have found a fairly large sample of such H II regions and have derived preliminary ^{3}He/H abundances. These abundances show no systematic trend as a function either of galactocentic radius or the H II region metallicity ([O/H]). Thus the gas in the Galaxy shows no evidence for the stellar production of ^{3}He expected from standard stellar evolution theory and as observed by RBBW in planetary nebulae. The apparently contradictory results are referred to by the chemical evolution and cosmological nucleosynthesis communities as the "^{3}He Problem." Even if the underlying mechanisms are not understood, it is empirically established that stars neither produce nor destroy ^{3}He in a major way. Thus the level of the observed "^{3}He/H Plateau" ($^3\mathrm{He/H} = 1.5^{+1.0}_{-0.5} \times 10^{-5}$) is hypothesized to be a reasonable estimate for the primordial ^{3}He.

R. Shah (graduate student) and A. Wootten (NRAO) are completing a survey of Galactic dark clouds for deuterated ammonia. They will attempt to understand the sensitivity of this species to temperature and density conditions, as well as use it to diagnose proto–stellar formation and evolution.

3.3 Galaxies and Active Galactic Nuclei

Balbus, and Michel Perault and Edith Falgarone (Ecole Normale Superieure) are studying the interaction between large scale interstellar turbulence and differential rotation in the Galaxy. If a local coupling exists, magnetic stresses are probably involved, since these tap most efficiently into the local shear. Comparisons (by other groups) of millimeter and infrared observations with hydrodynamic simulations suggest a relationship between emission peaks and turbulent vorticity gradients. The current goal is a comparison between numerical studies of MHD turbulence and interstellar observations will be carried through, in hopes of better understanding interstellar gas morphology.

Cox and Sarazin are analyzing a ROSAT HRI image of the elliptical galaxy NGC 4636 in the Virgo cluster. They find the galaxy has an asymmetrical X-ray halo which may be contributed to in part by an unrelated, background group of galaxies. NGC 4636 also contains an central bar-like structure about 10 arcseconds in radius that is perpendicular to the radio jet in the galaxy. This bar may be a rotating disk of cooling X-ray gas, a portion of which eventually feeds the central radio source. The X-ray surface brightness of the galaxy is not fit well by a beta model because it is too strongly peaked toward the center, suggesting that the gas is cooling significantly within the central regions of the galaxy.

Cox and J. N. Bregman (Michigan), B. Snider (Michigan) and L. Grego (Caltech) have studied elliptical galaxies that emit in the far-infrared (FIR). They find a correlation between the optical apparent brightness and the FIR brightness of these objects ($F_{FIR} \propto F_B^{0.24}$), which is expected but not seen in previous studies.

Dorman, O'Connell, and Rood have created synthetic mid-UV (2200-3200 Å) spectra for old stellar populations of a range of age and metallicities using Dorman's grid of interiors models and Kurucz atmospheres. These demonstrate that broad-band UV-optical colors offer discrimination in age-dating and abundance determination which is much improved over optical-IR colors. They are studying the detailed comparison between the predicted spectra and IUE/HST spectra for M31, M32, and several elliptical galaxies, after correction for contamination by the hot "UV-upturn" component. They are also comparing the Kurucz models to ones based on empirical libraries of IUE spectra (for solar abundance). They find various small deficiencies in the theoretical spectra. But a basic outcome is that the shape of the mid-UV spectra of the galaxies implies the presence of a warmer stellar population, possibly a younger component, than does the broad-band 2500–V color. This has implications for the age-dating of distant E galaxies based on their restframe UV spectra.

Majewski and M. Bershady (Penn State) have been exploring the luminosity function of $z > 3$ galaxies brighter than L^*. They are using the "U-band dropout" technique pioneered by Majewski in the 1980's. Using a variety of moderately deep ($V \approx 23$) images to search relatively large areas (compared to much deeper surveys, like the Hubble Deep Field) they have constrained the high z luminosity function to be of a rather prosaic, Schechter function form, in contrast to the much flatter, higher volume density of another published survey.

O'Connell and P. Marcum (TCU), together with members of the UIT team at Goddard SFC, B. Madore (IPAC), and W. Freedman (Carnegie), are in the final stages of preparing an Atlas which compares UV and optical-band morphologies for nearby galaxies, using UIT data accumulated during the *Astro*-1 and -2 missions. The image fields are up to 40′ in diameter. 27 objects are included in the first edition of the Atlas, which includes ground-based optical (UBVRI) as well as Hα data for comparison. Both images and surface photometry are presented. O'Connell and G. Becker (undergraduate student) are using the Atlas UV data to predict the appearance of this kind of normal object as observed at high redshifts in the laboratory optical/IR bands with HST or ground-based telescopes.

O'Connell and R. Ohl (graduate student) have an-

alyzed the far-UV (1500 Å) surface brightness distributions of 8 elliptical galaxies observed with the Ultraviolet Imaging Telescope during the *Astro-2* mission. All objects show significant gradients in UV/optical band colors but with a wide range of amplitude. The UV/optical color gradients do not correlate with gradients of the Mg (5170 Å) feature index derived from ground-based observations of the same objects. This is surprising because the central UV/optical colors of galaxies do have a strong dependence of Mg line strength. The far-UV light is probably produced by metal-rich, extreme horizontal branch and post-EHB stars with small envelopes, and these are highly sensitive to mass loss on the red giant branch. The possible influence on the UV colors of gradients in helium abundance, age, or [Mg/Fe] are being studied.

C. Palma (graduate student) and Majewski are analyzing spectroscopic (KPNO 4 m) and photometric (Palomar 1.62 m & KPNO 4 m) observations of the host of the giant FR II radio galaxy NVSS J214530+815455. They have identified the optical counterpart to the radio source to be a $z = 0.146$ elliptical galaxy with a V magnitude of 17.5. The radio galaxy has a lobe to lobe separation of $\approx 20'$ and is therefore ≈ 4 Mpc in linear size. This makes it the second largest FR II known. Contrary to expectations based on studies of the clustering properties of FR II radio galaxies, they find this object to reside in an Abell richness class 1 cluster. This object is therefore the only low redshift ($z < 0.25$) FR II known to reside in a rich cluster. Palma, F. Bauer (graduate student) and Sarazin have planned ROSAT observations of the field surrounding the radio galaxy to determine the properties of the IGM in which the radio galaxy is embedded.

E. Richards (graduate student) with K. Kellermann (NRAO) and collaborators recently completed a very deep radio survey at 8 GHz centered on the Hubble Deep Field (HDF). Fluctuation analysis in this field and others has established that the slope of the integral radio number counts is continuous from 1000 μJy to 1 μJy at about -1.2, implying a sky density of about $10^{8.5}$ ster^{-1}. The optical identifications of these microJansky radio sources are primarily with interacting or merging disk systems at redshifts between 0.1 and 2. The remainder of sources are associated with low-luminosity AGN. Two radio sources remain unidentified down to the optical limits of R$\sim$29 and J$\sim$23.5 in the HDF and R$\sim$ 27 and J$\sim$23.5 in an adjacent field. These two sources are believed to be very high redshift radio galaxies located at $z > 6$. These sources are the focus of a program using near infrared imaging with the NICMOS camera aboard the Hubble Space Telescope in order to identify the host galaxies.

E. Richards is also imaging the HDF at 1.4 GHz with the VLA in order to investigate the radio spectral index distribution of microJansky radio sources. This survey is among the deepest ever performed at this wavelength and should reach a completeness level of about 30 μJy. MicroJansky radio sources have been demonstrated to have a flattening of their average spectral index over populations selected at higher flux density limits, the reason for which is unknown. Richards hopes to understand the physical mechanisms which are driving the rapid evolution in faint radio populations such as synchrotron self-absorption associated with AGN activity, free-free emission and possibly absorption associated with large scale star-formation, and optically thin non-thermal emission associated with either star-formation or AGNs by examining a large number of radio spectral indices together with supplementary optical data. As a supplement to these deep radio observations, Richards is collaborating with T. Muxlow (Jodrell Bank) using the MERLIN array to image the HDF with $0.2''$ resolution. These very sensitive high resolution images will be compared with the high resolution HST images to examine the relationship between radio and optical structure in the microJansky source population. As part of this project, Richards and O'Connell obtained deep $BVRI$ images at the KPNO 4m in order to make the optical identifications of the 1.4 GHz radio sources located outside of the available HST fields.

Sarazin and J. Irwin (U.Mich) are studying the X-ray spectra of X-ray–faint elliptical galaxies, spiral bulges, and low mass X-ray binaries. The X-ray emission from the faintest X-ray elliptical and S0 galaxies is characterized by a hard $\sim$5 keV component, and a very soft $\sim$0.2 keV component. The hard component has generally been regarded as the integrated emission from low mass X-ray binaries (LMXBs), but the origin of the soft component is unknown. Irwin and Sarazin suggest that LMXBs also exhibit a soft component, which is responsible for the very soft X-ray emission in the faintest early-type galaxies. This soft component is present in two Galactic LMXBs which lie in directions of low Galactic hydrogen column densities, and in LMXBs in the bulge of M31, which comprise a majority of the X-ray emission in the bulge of that galaxy. The X-ray spectral characteristics and X-ray–to–blue luminosity ratios of the bulges of M31 and the Sa galaxy NGC 1291 are very similar to those of the X-ray faintest early-type galaxies, indicating that LMXBs are responsible for both soft and hard components in the latter.

Sarazin and Irwin have determined the X-ray fluxes and colors for a complete sample of 61 early-type galaxies observed with the PSPC. The colors indicate that galaxies with high L_X/L_B have different spectral properties than galaxies with low L_X/L_B. The brightest X-ray galaxies have colors consistent with thermal emission from hot gas with roughly constant metallicity. The spatial variation of the colors indicates that the gas temperature in these galaxies increases radially. Galaxies with medium L_X/L_B also have spectral properties consistent with emission from hot gas, but with a variation in metallicity, in the sense that galaxies with lower L_X/L_B have lower abundances. Galaxies with the lowest L_X/L_B values have spectral properties consistent with emission from low mass X-ray binaries (LMXBs). They show that M stars, RS CVn stars, and supersoft sources

are not major contributors to the X-ray emission in the X-ray faintest galaxies.

Sarazin and Irwin are also studying the ASCA X-ray spectrum of the elliptical galaxy NGC 499.

Thuan in collaboration with Izotov (Kiev Observatory), Foltz (MMT), Green (NOAO) and Guseva (Kiev Observatory) has found broad Wolf-Rayet emission lines in the spectrum of the NW component of IZw18, the lowest-metallicity blue compact dwarf galaxy known. Two broad WR bumps at the wavelengths λ4650 and λ5800 are detected indicating the presence of WN and WC stars. The total numbers of WN and WC stars inferred from the luminosities of the broad He II λ4686 and CIV λ5808 lines are equal to 17 ± 4 and 5 ± 2, respectively. The WR-to-O stars number ratio is equal to 0.02, in satisfactory agreement with the value predicted by massive stellar evolution models, but with enhanced mass loss rates. The WC stars in the NW component of IZw18 can be responsible for the presence of the nebular He II λ4686 emission line, however the observed intensity of this line is several times larger than model predictions and other sources of ionizing radiation at wavelengths shorter than 228Å are necessary.

Thuan, in collaboration with Izotov (Kiev Observatory) has obtained Hubble Space Telescope UV spectrophotometry of three extremely metal-deficient blue compact dwarf (BCD) galaxies, SBS 0335–052 ($Z \sim Z_{\odot}/40$), Tol 65 ($Z \sim Z_{\odot}/24$) and T1214–277 ($Z \sim Z_{\odot}/23$). Broad damped Ly-α absorption is seen in the first two BCDs. For SBS 0335-052, the H I column density derived by fitting the Ly absorption file profile is N(HI) $= (7.0 \pm 0.5) \times 10^{21}$ cm^{-2}, the highest derived thus far for a BCD, and ∼2 times larger than IZw18. As for Tol 65, N(HI) $= (2.5 \pm 1.0 \times 10^{21}$ cm^{-2}, also in the high range of H I column densities derived for BCDs, and only ∼1.4 times smaller than in IZw18. The interstellar absorption line OI λ1302 has also been detected in both galaxies. In SBS 0335–052, measures of unsaturated lines yield abundances of oxygen, silicon and sulfur 37000, 4000 and 116 times lower, respectively than the solar values. The oxygen abundance is a whole 37 times lower than in the neutral gas of IZw18. However, these highly discrepant deficiency factors between different elements suggest that the absorption lines are produced, not in the H I, but the H II gas. Adopting that hypothesis, the derived abundance from the UV absorption lines are then consistent with that derived from the optical emission lines ($Z \sim Z_{\odot}/40$). The H I cloud in SBS 0335–052 would then be truly *primordial*, unpolluted by heavy elements. Only a lower limit for the oxygen abundance, ∼6000 times lower than the solar value, could be derived for Tol 65. Contrary to the situation in the two previous BCDs, a strong Ly-α line is seen in the spectrum of T1214–277, making it the lowest-metallicity BCD with detected Ly-α emission. Its equivalent width of 70Å is the largest found in star-forming galaxies. The Ly-α emission is not redshifted with respect to the H II gas velocity, so that the escape of Ly-α photons in T1214–277 is not dictated by the velocity structure of the H I gas but probably by its porosity. The absence of Ly-α emission in SBS 0335–052 and Tol 65, is probably caused by a combination of dust extinction, multiple scattering over the whole area of the H I cloud, and the geometry of the cloud.

The spectrum of SBS 0335–052 shows stellar Si IV λ1394 and λ1403 lines with P Cygni profiles, suggesting the presence of numerous hot supergiant stars. A strong stellar NV λ1240 line with a P Cygni profile is seen in the spectrum of T1214–277, suggesting the presence of a large population of massive ($M \gtrsim 60 M_{\odot}$) stars. The stellar wind terminal velocity is very low in SBS 0335–052, being only ∼500 km/sec. It is higher, ∼2000 km/sec in T1214–277, in the low range of terminal velocities found for other BCDs. These BDS are the two most metal-deficient galaxies known with P Cygni profiles. The presence of such profiles raises the question of how to set up a wind in stellar atmospheres devoid of heavy elements as in SBS 0335–052.

Thuan, in collaboration with Condon (NRAO), Yin (NRAO) and Boller (MPI, Garching) have studied galaxies in the ROSAT/IRAS sample selected by their soft X-ray (0.1-2.4 keV) and far-infrared ($\lambda = 60\mu$m) emission. They used new 1.4 Ghz VLA images of all objects north of $\delta = -45°$ along with improved X-ray and far-infrared positions to eliminate incorrect identifications, many of which appeared to be starburst galaxies with high X-ray luminosities $\log X$ (ergs/sec) > 43. They also used VLA images to search for new X-ray identifications among the "high-flux" sources with $\delta > 45°$. Only two were found, indicating that luminous starburst galaxies have relatively low X-ray luminosities, probably due to absorption by a dense interstellar medium. No starburst galaxies in the sample have X-ray luminosities approaching $\log X$ (ergs/sec) $= 43$. They conclude that most galaxies in the revised ROSAT/IRAS sample contain X-ray emitting AGN residing in star-forming disks which emit most of their 60μm radiation. Normal and starburst galaxies probably do not account for a significant fraction of the soft X-ray background.

C.-Y. Wang (graduate student) and Sarazin are analyzing the ROSAT HRI observation of the elliptical galaxy NGC 1404 in the Fornax cluster.

Whittle has continued a study of gas kinematics in galactic nuclei, extending his earlier work on Seyfert nuclei to related nuclei of LINER galaxies and starburst galaxies. Sample sizes of ∼75 require careful compilation of nuclear spectroscopic information and information on host galaxy properties. Initial results indicate that while the gas in LINER nuclei has bulge virial velocities, the gas in starburst nuclei does not, and can be significantly more quiescent. This suggests that the nuclear gas in starburst galaxies has a different history from the nuclear gas in active galaxies. This history may include more dissipation and cooling within the bulge potential before star formation occurs. In contrast the gas which makes up the line emitting regions in LINERS and Seyferts probably does not originate from a settled component, but instead arises in a phase which permeates

the bulge and is to some degree dispersion supported.

Whittle and Nelson (U. Nevada) continued their work on stellar populations in the bulges of Seyfert galaxies. Their overall aim is to test the canonical model of normal bulges with power law nuclear contribution, and look for evidence of alternatives to this, for example the presence of significant star formation. Using measurements of the Mgb and CaT absorption features they were able to show that in the majority of Seyferts the relative strengths of these two features was consistent with the canonical model. In a number of cases, however, the CaT feature was significantly stronger, suggesting the presence of a much younger population with red supergiants. This suggestion is all but confirmed by the fact that these same galaxies have far infra-red colors similar to those of starbursts.

Whittle and Wilson (U. Maryland) have continued their HST and VLA study of the Seyfert galaxy Markarian 78. The overall theme is to understand the nature of the interaction between the near nuclear jet with the ISM. Progress has been made on two fronts. Analysis of near UV images using FOC shows a close correspondence of UV continuum with the distribution of line emitting gas. This raises the important possibility that the UV ionizing continuum is generated in fast shocks, in accord with the suggestions of Sutherland, Bicknell, and Dopita. Further testing of this scenario requires detailed calculations of the near UV spectra of fast shocks. The second line of analysis makes use of FOS spectra from ten locations across the nebulosity. Kinematic information from line profiles, when combined with the [OIII] λ5007 emission image and VLA radio image, has allowed a fairly detailed reconstruction of the flow patterns associated with the radio jet and line emitting knots. Evidence for a number of interesting physical processes has been found, including ablation, flow deflection, gas sweep up, cloud shocks, and a lack of interpenetration of radio and line emitting gas phases. Analysis of the ionization conditions is proceeding but is complicated by the need for reliable stellar continuum subtraction to ascertain the strengths of some of the weaker emission lines. Whittle, Wilson, and Nelson will be obtaining HST/STIS data on this object.

3.4 Clusters of Galaxies

F. Bauer (graduate student) and Sarazin are analyzing a new ASCA observation and an archival ROSAT PSPC observation of the X-ray cluster Abell 644.

Cox and E. Schulman (NRAO) are analyzing multi-filter far-infrared ISOPHOT maps of clusters of galaxies.

Cox is using ROSAT data to derive electron densities for the intracluster medium (ICM) in clusters of galaxies that show far-infrared emission, in order to test the plausibility of dust heating by collisions between dust particles and hot ICM electrons.

D'Cruz, Sarazin, and J. Dubau (Obs. Paris) have determined the rate of excitation of the 3.071 mm hyperfine line from Li-like ^{57}Fe in astrophysical plasmas. The distorted wave approximation was used to compute the direct electron collision strength between the two hyperfine sublevels of the ground configuration; it was found to be small. Proton collisional excitation was calculated and found to be negligible. They determine the rate of line excitation by electron collisional excitation of more highly excited levels, followed by radiative cascades. The branching ratios for hyperfine sublevels for allowed radiative decays and electron collisional excitation or de-excitation are derived. They show that the dominant line excitation process is electron collisional excitation of the 2p levels followed by radiative decay. Because the hyperfine line is near the peak in the Cosmic Microwave Background Radiation spectrum, induced radiative processes are also very important. They determine the intensity of the hyperfine line from an isothermal, coronal plasma in collisional ionization equilibrium and from a coronal plasma cooling isobarically due to its own radiation. D'Cruz and Sarazin have used these atomic rates to determine the luminosities, surface brightness profiles, and spectral line profiles for the 3.071 mm hyperfine line from Li-like ^{57}Fe in cooling flow and non-cooling flow clusters.

Z. Huang (graduate student) and Sarazin are studying the X-ray structure Abell 4059 using ROSAT data. They find that the X-ray emission is anticorrelated with the radio emission, suggesting that the radio lobes have displaced the thermal X-ray emitting gas.

Huang and Sarazin are studying the relationship between the X-ray and radio properties of the central regions of cooling flow clusters. In cooling flow cDs with radio sources with well-defined lobes and radio jets, the X-ray and radio are anticorrelated and the X-ray and radio pressures are similar. This suggests that the radio lobes have displaced and are confined by the ambient X-ray emitting gas. In cDs with amorphous radio sources, the radio pressures are much lower than the thermal pressures and the radio and X-ray images correlate. This suggests that the radio and X-ray emitting plasmas are mixed in this cases.

P. Ricker and Sarazin are studying the evolution of colliding clusters of galaxies via three-dimensional N-body/hydrodynamics simulations, with particular emphasis on the behavior of cooling flows during such collisions. They are investigating the possibility that mergers may disrupt cooling flows by simulating pairs of idealized colliding clusters. By varying collision parameters such as relative mass, impact parameter, and gas fraction, they determine the time required for virialization of the merger remnant, the factors which influence the survival of cooling flows, and the observability of merging clusters in X-ray surface brightness, temperature, and velocity. They also compare simulation results to individual clusters from Sarazin's observational program to identify merger candidates for further study.

P. Ricker and S. Dodelson (Fermilab) have completed the integration, parallelization, and testing of Dodelson's particle-mesh N-body code with a 3D parallel hydrodynamics code developed by Ricker. The combined code is being used in the cluster collision simulations

performed with Sarazin, and the hydrodynamical component is being used in the 1D supernova accretion simulations performed with Chevalier. Ricker and Dodelson are also beginning to use the combined code in simulations of Lyα cloud formation.

Sarazin and D. Christodoulou (LSU) have numerically simulated the time-evolution of complex magnetized cluster cooling flows. The cooling gas was initially threaded by weak magnetic fields ($\sim$1 μG) organized on large scales, but the field direction was reversed once every 10 kpc. Such initial field configurations are prone to generating tangled magnetic-field lines, twisted filaments in the gas, current sheets, and other irregular structures.

Sarazin, W. Jaffe (Leiden), M. Bremer (Leiden), B. McNamara (CfA), C. O'Dea, S. Baum (both STScI), and M. Wise (MIT) are using ISO to search for infrared line and continuum emission from cold gas and dust in cluster cooling flows with evidence for excess X-ray absorption.

The quasar B2 1028+313 is located in the central dominant galaxy of the cluster Abell 1030 ($z = 0.177$). Sarazin, A. Koekemoer (STScI), O'Dea, Baum, F. Owen (NRAO), and M. Ledlow, (NMSU) obtained HST UV spectra of the quasar to search for absorption due to cool material in the cluster. They detected Lyα and CIV absorption lines at a redshift of the quasar, and derived constraints on the nature of the absorbing material. They also place stringent upper limits on other absorption lines from the intracluster medium.

Sarazin, Wise, Koekemoer, O'Dea, Baum and Owen have acquired ROSAT PSPC and HRI X-ray images and ASCA X-ray spectra of the quasar in a cluster, B2 1028+313/A1030. They are trying to use the images and spectra to separate the cluster emission from the brighter quasar. They will also search for X-ray absorption features due to the cluster and/or cooling flows in the spectrum of the quasar.

Sarazin, E. Lufkin, and R. White (UA) are using hydrodynamical models to determine the time-dependence of the mass accretion rate and cooling rate in cluster cooling flows. Detailed agreement is found between previous steady-state models and time-dependent models at fixed times in the simulations. The mass accretion rate $\dot{M}$ is found either to increase or remain nearly constant once the flows reach a steady state.

Sarazin, M. Markevitch, W. Forman, and A. Vikhlinin (CfA) are determining the X-ray spectra for a complete sample of low redshift clusters of galaxies using ASCA. They find that the clusters have a universal, radially decreasing temperature profile which implies that the baryon fraction of the universe is high. They have also determined the cluster temperature function for this sample.

Sarazin, Markevitch, and Wise are using ASCA X-ray observations of the cluster A2029 to determine the radial variation of the gas temperature and the properties of the cooling flow.

Sarazin and Rosenberg have made magnetohydrodynamic simulations of the magnetized plasma in cluster cooling flows. Recent radio observations have shown that the magnetic fields in cooling flows are very strong. They hope to understand the dynamical effects of the field, and to learn what ultimately happens to the advected magnetic flux.

Sarazin and Wise are calculating models for the X-ray emission in cluster cooling flows in which a fraction of the cooled gas is stored as cold, X-ray absorbing gas. The spectra of these models agree with recent observations of excess X-ray absorption in cluster cooling flows. Sarazin and Wise find that the spectra are distinguishable from foreground absorption in ways that should be detectable in ASCA spectra. Also, the absorption effects the X-ray surface brightness profiles, from which the local rates of gas cooling have been derived.

Whittle, Moss (U. Cambridge), and Pesce (STScI) have worked on their study of star formation in galaxies in Abell clusters. Work on their most well studied cluster, Abell 1367, was completed and submitted for publication. In this study, 200 CGCG galaxies were surveyed for Hα emission using an objective prism technique, and approximately 35% of galaxies of types S0/a and later were detected and classified as having either compact or diffuse emission. There is a very significant tendency for galaxies with compact emission to be disturbed, suggesting that in these galaxies the star formation is tidally induced. By comparing subsamples in the cluster core, halo and field, it is found that spirals with tidally triggered star formation are preferentially located towards the cluster core. By scrutinizing the details of each star forming galaxy, the origin of the tidal interactions was investigated. As expected, near neighbors play an important role, but there are also candidates for tidal triggering by the cluster potential, as well as candidates for high velocity 'harassment'. Whittle and Moss extended their study to include 8 Abell clusters which span a range of richness. Initial results from this study suggest that the degree to which cluster galaxies experience enhanced star formation is strongly dependent on the cluster richness. Results on environmentally induced star formation in these nearby clusters can be used in the study of galaxy and cluster evolution at higher redshifts.

3.5 Cosmology

F. Fang (graduate student) and Saslaw are exploring models which place limits on the amount and distribution of dark matter in the universe consistent with the observed spatial and velocity distribution functions of galaxies. They have developed a new formalism which extends their earlier approach using specific models to new more general classes of models.

Hawley (with Katherine Holcomb) has authored a new cosmology textbook published by Oxford University press. This text is intended for undergraduate study following traditional introductory astronomy courses.

E. Richards continued his investigations of small scale structure in the cosmic microwave background (CBR) using the NRAO Very Large Array, along with collaborators B. Partridge (Haverford College), E. Fomalont (NRAO), K. Kellermann (NRAO), and R. Wind-

horst (Arizona State). The group is searching for signatures in the CBR on angular scales between six arcseconds and 60 arcseconds possibly imprinted by such astrophysical processes as the rescattering of the CBR at high redshift (10–30) by a reionized intergalactic medium (Vishniac effect) or the Sunyaev-Zel'dovich effect in distant ($z > 1$) galaxy clusters. Recently, the group has discovered one such anisotropy believed to be induced by a massive cluster (M $\sim 10^{14} M_{\odot}$) at $z \sim$2.6. At present, they are involved in intense follow-up at optical (KPNO 4m BVI, narrow band Lyman alpha imaging and optical spectroscopy) and near infrared wavelengths (Wyoming Infrared Observatory 2.2 μm imaging) to identify the galaxy members.

Saslaw and Fang have been developing a new approach to calculating galaxy distribution functions by using semi-conserved integrals of motion for systems of particles in an expanding universe.

Saslaw and S. Haque-Copilah have determined the spatial and projected distribution functions of galaxies in and around the Pisces-Perseus supercluster. This will be compared with distribution functions for more homogeneous catalogs of galaxies. They find that at the center of Pisces-Perseus the galaxies are dynamically semi-relaxed. Although large groups of several hundred galaxies near the center have a Gaussian distribution of velocities, they contain subclusters which have non-Gaussian velocity distributions. This indicates partial relaxation. They also find that the spatial distribution function for a well-determined sample of 4501 Pisces-Perseus galaxies can be described very well by the gravitational quasi-equilibrium distribution with the average number of galaxies in a cell of 103 Mpc and the ratio of gravitational correlation energy to twice the kinetic energy of peculiar velocities $b = 0.8$. These properties indicate that the Pisces-Perseus supercluster was built up through the gravitational accumulation of smaller clusters.

Saslaw is continuing to write a monograph on large-scale structure in the universe for Cambridge University Press.

R. Shah (graduate student) and A. Wootten (NRAO) have been studying redshifted lines of DCO^+ and DCN towards the lensed galaxy PKS1830–211. Their observations with the NRAO 12–meter and Haystack 37–meter suggest a low deuterium abundance in the lensing galaxy located along the line–of–sight at a redshift of 0.9.

Thuan, in collaboration with Izotov (Kiev Observatory, Ukraine) has continued work on improving the determination of the primordial helium abundance Y_p. They have re-examined the helium abundance of IZw18, the most metal-deficient blue compact dwarf galaxy known (1/50 solar) which plays a key role in the determination of Y_p. They found that, of the 2 star-forming regions in IZw18, the NW and SE components, the NW component, which is usually used for Y_p determination, has its emission lines that are strongly affected by underlying stellar absorption. On the other hand, the SE component is much less affected by underlying He stellar absorption and is the component which should be used. The helium mass fraction derived for the SE component is $Y = 0.243 \pm 0.009$, larger than previous determinations for IZw18.

In order to determine Y_p with a precision better than 5%, Thuan and Izotov have used a sample of 45 low-metallicity HII regions in blue compact galaxies (BCGs). They have included many low-metallicity BCGs, including the two most metal-deficient galaxies known IZw18 and SBS 0335–052 ($Z_{\odot}/40$). They have carefully investigated the physical effects which may make the He I line intensities deviate from their recombination values such as collisional and fluorescent enhancements, underlying He I stellar absorption and absorption by Galactic interstellar Na I. By extrapolating the Y vs. O/H and Y vs. N/H linear regressions to O/H = N/H = 0, they obtain $Y_p = 0.244 \pm 0.002$ and 0.245 ± 0.001 respectively, in agreement with the study by Izotov, Thuan & Lipovetsky (1997), but higher than previous determinations ($Y_p = 0.230 - 0.234$). Part of the difference comes from the fact that previous investigators use the NW component of IZw18 in the determination of Y_p instead of the SE component. The mean Y of the two most metal-deficient BCGs, IZw18 and SBS 0335–052, is $\overline{Y} = 0.246 \pm 0.004$, in excellent agreement with the Y_p derived from the linear regressions.

Thuan and Izotov derive a slope of $dY/dZ = 2.3 \pm 1.0$, considerably smaller than those derived before. With this smaller slope and taking into account the errors, chemical evolution models with an outflow of well-mixed material can be built for star-forming dwarf galaxies which satisfy all the observational constraints. Their Y_p gives $\Omega_b h^2 = 0.058 \pm 0.007$, consistent with the lower limit set by dynamical measurements and X-ray observations of clusters of galaxies. It is also consistent, within the framework of standard big bang nucleosynthesis theory, with measurements of primordial ^7Li in galactic halo stars, and at the 2σ level with the D/H abundance measured in absorption systems toward quasars by Tytler, Fan & Burles (1996).

3.6 Astrometry

Dawson (WCSU) and Ianna have completed a study of 437 stars in the field of Cr110, an old open cluster at low galactic latitude toward the anticenter. Proper motions obtained from Lick Sky survey plates were used to eliminate 22 foreground stars. Photoelectric UBVRI photometry was obtained for 78 stars, along with photographic and CCD photometry for 437 stars. The cluster's distance is found to be about 2.3 kpc and its age is estimated to be approximately 1.5 Gyr.

Ianna continues to collaborate with T. Henry (STScI) and D. Kirkpatrick (UCLA) to identify new nearby star candidates in the southern hemisphere by means of JHK photometry and IR spectroscopy. Observing runs at CTIO have confirmed several likely nearby stars and revealed several new very late M dwarfs in the Wroblewski and Torres proper motion survey.

Ianna, Patterson, and Begam are continuing the

CCD parallax program at the Mount Stromlo and Siding Spring Observatories using the 1 m reflector (focal plane scale of 25.4 arcsec per mm). Emphasis is placed on brighter stars (m$\sim$13) from the Catalog of Nearby Stars and new nearby candidates from other sources. These objects are easily observed in R or I with very good S/N, and precisions of 1–2 mas are achieved. Current results include 14 parallaxes for new stars within the 20 pc sample.

Majewski and Cudworth (Yerkes Obs.) have continued their program to derive absolute proper motions with respect to galaxies for a sample of distant ($>$ 20 kpc) halo globular clusters and dwarf spheroidals. In the past year, in collaboration with A. Schweitzer (U. Wisconsin), they have derived the proper motion of the Ursa Minor galaxy. Siegel began his thesis project to determine the proper motions of the Leo II and Carina dSph galaxies. CCD observations of Leo II were begun on the Mayall telescope in April, and these will be combined with early Baade plates from the Palomar 200" telescope. Carina observations are scheduled for the Blanco telescope. A major part of this effort will be to pioneer techniques for combining archive plate material with new epoch CCD data.

Majewski has continued his program on the DuPont 100-in telescope at Las Campanas to repeat photographic observations of the mid-declination (-15° to +15°) Kapteyn Selected Areas. The goal is to match the original plates taken by Seares, Kapteyn and van Rhijn at the beginning of the century with the Mt. Wilson 60-in telescope, for proper motions of exquisite ($<$ 0.1 arcsec/century) precision to $V \approx 19$, tied to the extragalactic absolute reference frame. The 55 Selected Areas with $|b| > 20°$ will allow an assessment of the halo two-point correlation function in phase space as a means to search for and map large scale streaming motions in the halo.

Patterson and Ianna have begun a limited program to obtain parallaxes for a small sample of very low luminosity objects in the K band of the near infrared using CASPIR on the 2.3 m telescope at Siding Spring, in collaboration with Hugh Jones and M. Hawkins (ROE). Of special interest here is the brown dwarf candidate SERC 296A, shown to have Li in its spectrum.

Patterson, Ianna, and Begam, in connection with the parallax program, have also been doing VRI photometry of southern nearby star candidates. Particular results to date include 37 of the Wroblewski and Torres stars with proper motions exceeding 0.5 arcsec per year and no prior color information. All of the stars appear to be M dwarfs or subdwarfs; photometric parallaxes place eight of the stars nearer than 25 pc.

3.7 Space Astronomy

L. Fredrick (emeritus) continues as a member of the HST Astrometry Team.

R. Ohl (graduate student), H. W. Moos (JHU), S. Friedman (JHU), J. Kruk (JHU), D. Sahnow (JHU) are producing a photometric and wavelength calibration of the Lyman Far Ultraviolet Spectroscopic Explorer (FUSE) instrument. As part of this activity Ohl, Friedman, and Barkhouser (JHU) are experimentally determining the two-dimensional structure of the FUSE telescope point spread function as a function of wavelength in the laboratory. They are comparing those measurements to predictions based on primary mirror figure and surface roughness data. Ohl is also assisting S. Conard (JHU) in the preparation of the FUSE optical end-to-end test and laboratory calibration. Ohl and Kruk are selecting on-orbit calibration targets and are planning FUSE observations designed to improve models of the atmospheres of DA white dwarf stars.

O'Connell continues as a Co-Investigator for the Ultraviolet Imaging Telescope of the *Astro-2* Spacelab payload, which flew a 16-day Space Shuttle mission during March 1995. UIT obtained a total of 757 far-UV (1500Å) images of 193 different targets, ranging from the Moon to distant quasar fields. He is also a Co-Investigator on the Hopkins Ultraviolet Background Explorer project and the IRIS wide-field, UV imaging project, which is under conceptual study for a new NASA mission.

4 Miscellany

Balbus was a visitor at the Ecole Normale Superieure in Paris, France for May and June 1997. Chevalier gave the Derieux Lecture at North Carolina State University, began service on the NRC/NAS Committee on Astronomy and Astrophysics, and served on the scientific organizing committees for the Minnesota Centennial Workshop on Supernova Remnants and for the meeting "The Dynamics of the Galaxy: a Festschrift for J. P. Ostriker". Hawley served on the review panel for the NASA Origins of Solar Systems program. In October 1996, Hawley was a Scientific Visitor at the Japan Atomic Energy Research Institute, Advanced Science Research Center, in Naka, Japan. Ianna served as Vice-President of IAU Commission 24 (Photographic Astrometry), as chair of the Nominating and Handbook Committees of the Division on Dynamical Astronomy, on the HST Cycle Seven Cool Star Panel, as technical consultant to CSICOP; and as a member of the Board of Directors of the International Dark-Sky Association. Majewski was given a National Science Foundation CAREER Award for his Galactic structure research as well as his plan to develop McCormick Observatory into a teaching facility. Majewski also won a David and Lucile Packard Foundation Fellowship in Science and Engineering. O'Connell continued to serve as a member of the AAS Investments Advisory Committee. Richards served as a panel reviewer for the National Science Foundation Research Experiences for Undergraduates Program, was a reviewer for the Research Corporation, and was a member of the AAS Committee on Minorities in Astronomy. Sarazin was a member of the ASCA Users' Committee, the AXAF Users' Committee, the Heineman Prize Committee of the American Astronomical Society, and the scientific organizing committees of the ASCA "Cherry Blossom" Conference and the Tokyo Conference on X-ray Imag-

ing and Spectroscopy of Cosmic Hot Plasmas. Thuan with Mamon (Institut d'Astrophysique, Paris) organized the Moriond 97 meeting on "Extragalactic Astronomy in the Infrared" in March 1997 at les Arcs, France. He also organized with Brinks (Mexico) a Joint Discussion on "Dwarf Galaxies: Probes for Galaxy Formation and Evolution" at the IAU General Assembly in August 1997 in Kyoto, Japan. Whittle was a member of the Cycle 7 HST TAC.

As part of our public outreach program, approximately 2800 visitors toured the McCormick and Fan Mountain Observatories during the year, and special observing sessions were held at local schools and museums for the apparition of the bright comet Hale-Bopp.

We gratefully acknowledge the continuing research support offered, collectively and individually, to our staff by the Estate of Leander J. McCormick, the National Science Foundation, the National Aeronautics and Space Administration, the Air Force Office of Scientific Research, the Packard Foundation, and the University of Virginia.

PUBLICATIONS

Balbus, S. A. & Hawley, J. F. 1996, "Origin of Turbulent Viscosity," in Basic Physics of Accretion Disks, ed. by S. Kato et al. (Amsterdam: Gordan and Breach), 279

Balbus, S.A. & Hawley, J.F. 1997, "Instability, Turbulence, and Enhanced Transport in Accretion Disks," Rev. Mod. Phys., in press.

Balbus, S.A. & Hawley, J.F. 1997, "Instability, Turbulence, and Enhanced Transport in Accretion Disks," in Accretion Phenomena and Related Outflows, ed. by D. Wickramasinghe, L. Ferrario, & G. Bicknell (San Francisco: ASP), 90

Balser, D. S., Bania, T. M., Rood, R. T., & Wilson, T. L. 1997, "The ^{3}He Abundance in Planetary Nebulae," ApJ, 483, 320

Bania, T. M., Balser, D. S., Rood, R. T., Wilson, T. L., & Wilson, T. A. 1997, "^{3}He in the Milky Way Interstellar Medium: Summary of Relevant Observations," ApJS, in press

Bershady, M. A., Majewski, S. R., Koo, D. C., Kron, R. G. & Munn, J. A. 1997, "The Luminosity Function for $L > L^*$ Galaxies at $z > 3$," ApJ, in press

Blondin, J. M., Lundqvist, P., & Chevalier, R. A. 1996, "Axisymmetric Circumstellar Interaction in Supernovae," ApJ, 472, 257

Borkowski, K. J., Blondin, J. M., Szymkowiak, A. E., & Sarazin, C. L. 1996, "The Cassiopeia A Supernova Remnant: Dynamics and Chemical Abundances," in Cosmic Abundances, ed. by S. Holt & G. Sonneborn (San Francisco: ASP), 294

Bregman, J. N., Snider, B. A., Grego, L., & Cox, C. V., 1998 "Far-Infrared Emission from E and E/S0 Galaxies," ApJ, submitted.

Bregman, J. N. & Cox, C. V. 1998, "Far-Infrared Emission from Ellipticals and Clusters of Galaxies," in Extragalactic Astronomy in the Infrared, ed. by G. A. Mamon, T. X. Thuan, and J. T. Thanh Van (Gif-sur-Yvette: Editions Frontieres), in press.

Burkert, A., Hartmann, D. & Majewski, S. R. (eds.), 1997, "The History of the Milky Way and Its Satellite System," ASP Conf. Ser. Vol. 112, (San Francisco: ASP)

Chevalier, R. A. 1996, "The Evolution of Supernova Remnants, " in The Interplay between Massive Star Formation, the ISM and Galaxy Formation, ed. by D. Kunth, M. Heydari-Malayeri, T. X. Thuan, and J. T. Thanh Van (Paris: Ed. Frontieres), 151

Chevalier, R. A. 1996, "The Shaping of Planetary Nebulae and the Nebula Around SN 1987A," Ap&SS, 245, 255

Chevalier, R. A. 1997, "Type II Supernovae SN 1987A and SN 1993J," Science, 276, 1374

Chevalier, R. A. 1997, "Expansion of a Photoionized Stellar Wind," ApJ, in press

Chevalier, R. A. 1997, "Synchrotron Self-Absorption in Radio Supernovae," ApJ, submitted

Chevalier, R. A. 1997, "SN 1987A and Circumstellar Interaction," in SN 1987A: 10 Years Later, ed. by M. Phillips & N. Suntzeff (San Francisco: ASP), in press

Christodoulou, D. M., & Sarazin, C. L. 1997, "Tangled Magnetic Fields and Filaments in Cluster Cooling Flows," ApJ, submitted

Condon, J. J., Yin, Q. F., Thuan, T. X. & Boller, Th., 1997, "The ROSAT/IRAS Galaxy Sample Revisited," AJ, in press

Chugai, N. N., Chevalier, R. A., Kirshner, R. P., & Challis, P. M. 1997, "*HST* Spectrum of SN 1987A at an Age of 8 Years: Radioactive Luminescence of Cool Gas," ApJ, 483, 925

Dalton, W. W., & Sarazin, C. L. 1997, "High Mass X-ray Binary Modeling: The Magellanic Cloud Populations," ApJ, submitted

Dawson, D. W., & Ianna, P. A. 1997, "Collinder 110: An Old Open Cluster in Monoceros," AJ, submitted

D'Cruz, N. L., Dickens, R. J., Hatzidimitriou, D., Rood, R. T., & O'Connell, R. W. 1997, "Calcium Abundances of Blue Horizontal Branch Stars in ω Centauri," in Advances in Stellar Evolution, ed. by R. T. Rood & A. Renzini (Cambridge: CUP), 100

D'Cruz, N. L., Sarazin, C. L., & Dubau, J. 1997, "Excitation of the 3.071 mm Hyperfine Line in Li-like ^{57}Fe in Astrophysical Plasmas," ApJ, submitted

D'Cruz, N. L., & Sarazin, C. L. 1997, "Emission of the 3.071 mm ^{57}Fe Hyperfine Line from Clusters and Cooling Flows," ApJ, submitted

Dorman, B., & O'Connell, R. W. 1997, "Constraining the Abundances and Ages of Early-Type Galaxies,"

in The Ultraviolet Universe at Low and High Redshift, ed. by W. H. Waller (Washington: AIP Press), in press.

Dorman, B., Shah, R. Y., O'Connell, R. W., Landsman, W. B., Bohlin, R. C., Rood, R. T., Neff, S. G., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1997, "UIT Detection of Hot Stars in the Globular Cluster NGC 362," ApJ, 480, L31

Dwarkadas, V. V., & Chevalier, R. A. 1997, "Interaction of Type Ia Supernovae with their Surroundings," ApJ, submitted

Encrenaz, T., Serabyn, E., & Weisstein, E. W. 1996, "Millimeter Spectroscopy of Uranus and Neptune: Constraints on the CO and PH_3 Tropospheric Abundances," Icarus, 124, 616

Fanelli, M. N., Collins, N., Bohlin, R. C., Neff, S. G., O'Connell, R. W., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1997, "An Ultraviolet View of Massive Star Formation in Seyfert Host Galaxies," AJ, 114, 575

Fanelli, M. N., Waller, W. W., Smith, D. A., Freedman, W. L., Madore, B., Neff. S. G., O'Connell, R. W., Roberts, M. S., Bohlin, R. C., Smith, A. M., & Stecher, T. P. 1997, "An Ultraviolet and Near-Infrared View of NGC 4214: A Starbursting Core Embedded in a Low Surface Brightness Disk," ApJ, 481, 735

Fang, F., & Saslaw, W. C., 1996, "Effects of Galaxy Mergers on their Spatial Distribution and Luminosity Function," ApJ, 476, 534

Fang, F., & Saslaw, W. C., 1997, "Constraints on Galaxy Mergers at Moderate Redshifts from their Observed Luminosity and Spatial Distribution Functions," in HST and the High Redshift Universe, ed. by N. Tanvir, A. Aragon-Salamanca & J. V. Wall, (World Scientific Press), 135

Ferraro, F. R., Paltrinieri, B., Fusi Pecci, F., Cacciari, C., Dorman, B., & Rood, R. T. 1997, "HST UV Observations of the Cores of M3 and M13," ApJ, 484, L145

Ferraro, F. R., Paltrinieri, B., Fusi Pecci, F., Cacciari, C., Dorman, B., Rood, R. T. Buonanno, R., Corsi, C. E., Burgarella, D., & Laget, M. 1997, "HST Observations of Blue Straggler Stars in the Core of the Globular Cluster M3," A&A, 324, 915

Ferraro, F. R., Paltrinieri, B., Fusi Pecci, F., Dorman, B., & Rood, R. T. 1997, "Multimodal Distributions along the Horizontal Branch," ApJ, submitted

Ferraro, F. R., Paltrinieri, B., Fusi Pecci, F., Dorman, B., & Rood, R. T. 1997, "Optical counterpart to the X-ray source in M13," MNRAS, in press

Fomalont, E. B., Kellermann, K. I., Richards, E. A., Windhorst, R. A., & Partridge, R. B. 1997, "Radio Emission from Objects in the Hubble Deep Field", ApJ, 475, L5

Hamilton, A. J., Fesen, R. A., Wu, C.-C., Crenshaw, D. M., & Sarazin, C. L. 1997, "Interpretation of UV Absorption Lines in SN1006," ApJ, 481, 838

Hawley, J.F. & Balbus, S.A. 1997, "Three-Dimensional Simulations of Accretion Disks," in Accretion Phenomena and Related Outflows, ed. by D. Wickramasinghe, L. Ferrario, & G. Bicknell (San Francisco: ASP), 179

Hawley, J.F. & Balbus, S.A. 1996, "Numerical Simulations of Accretion Disks: Sources of Anomalous Viscosity," in Basic Physics of Accretion Disks, ed. by S. Kato et al (Amsterdam: Gordan and Breach), 273

Hawley, J. F. & Balbus, S. A. 1997, "Anomalous Viscosity in Accretion Disks," in the Proceedings of the $13^{\rm th}$ North American Workshop on CVs, ed. by S. Howell, E. Kuulkers, C. Woodward, in press

Hawley, J. F. & Holcomb, K. A. 1998, Foundations of Modern Cosmology, (New York: Oxford Press), in press

Henry, T. J., Ianna, P.A., Kirkpatrick, J. D., & Jahreiss, H. 1997, "The Solar Neighborhood. IV. Discovery of the Twentieth Nearest Star System," AJ, 114, 388

Hill, J. K., Waller, W. H., Cornett, R. H., Bohlin, R. C., Cheng, K.-P., Neff, S. G., O'Connell, R. W., Roberts, M. S., Smith, A. M., Hintzen, P. M. N., Smith, E. P., & Stecher, T. P. 1997, "UV Colors and Extinctions of H II Regions in the Whirlpool Galaxy (M51)," ApJ, 477, 673

Houck, J. C., Bregman, J. N., Chevalier, R. A., & Tomisaka, K. 1997, "Recent X-Ray Observations of SN1986J with *ASCA*, and *ROSAT*," ApJ, in press

Huang, Z., & Sarazin, C. L. 1997, "A High Resolution ROSAT X-Ray Study of Abell 4059," ApJ, submitted

Ianna, P. A. 1997, "Astrometric Applications of the Global Network of Automated Telescopes," IPPP, submitted

Irwin, J. A., Frayer, D. T., & Sarazin, C. L. 1997, "Is There Molecular Gas in the H I Cloud Between NGC 4472 and UGC 7636?," AJ, 113, 1580

Irwin, J. A., Frayer, D. T., & Sarazin, C. L. 1997, "The Search for Molecular Gas in the H I Cloud between UGC 7636 and the Cooling Flow Galaxy NGC 4472," in Galactic and Cluster Cooling Flows, ed. by N. Soker (San Francisco: ASP), 75

Irwin, J. A., & Sarazin, C. L. 1996, "X-Ray Evidence for the Interaction of the Giant Elliptical Galaxy NGC 4472 with its Virgo Cluster Environment," ApJ, 471, 683

Irwin, J. A., & Sarazin, C. L. 1997, "ROSAT X-ray Colors and Emission Mechanisms in Early-Type Galaxies," ApJ, submitted

Irwin, J. A., & Sarazin, C. L. 1997, "Low Mass X-ray Binaries As the Source of the Very Soft X-ray Emission in the X-ray Faintest Early-Type Galaxies," ApJ, submitted

Izotov, Yu. I., Foltz, C. B., Green, R. F., Guseva, N. G., & Thuan, T. X. 1997, "IZw18: A New Wolf-Rayet Galaxy," ApJ, 487, L37

Izotov, Yu. I., & Thuan, T. X. 1997, "A Re-examination of the Helium Abundance of IZw18," ApJ, in press

Izotov, Yu. I., & Thuan, T. X. 1997, "The Primordial Abundance of ^{4}He Revisited," ApJ, in press

Izotov, Yu. I., Thuan, T. X., & Lipovetsky, V. A., 1997, "The Primordial Helium Abundance: Systematic Effects and a New Determination," ApJS, 108, 1

Koekemoer, A. M., O'Dea, C. P., Baum, S. A., Sarazin, C. L., Owen, F. N., & Ledlow, M. J. 1997, "A Study of UV Absorption in the Intracluster Medium of Abell 1030," ApJ, submitted

Kunth, D., Guiderdoni, B., Malayeri-Heydari, M., Thuan, T. X., & Thanh Van, J. T. (eds.) 1996, "The Interplay Between Massive Star Formation, the ISM, and Galaxy Evolution," (Gif-sur-Yvettes: Ed. Frontieres)

Landsman, W. H., Sweigart, A. V., Bohlin, R. C., Neff, S. G., O'Connell, R. W., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1996, "Ultraviolet Imagery of NGC 6752: A Test of Extreme Horizontal Branch Models," ApJ, 472, L93

Leitherer, C. et al., including O'Connell, R. W. 1996, "A Database for Galaxy Evolution Modeling," PASP, 108, 996

Lufkin, E. A., White, R. E., & Sarazin, C. L. 1997, "Time-Dependence of the Mass Accretion Rate in Cluster Cooling Flows," ApJ, submitted

Majewski, S. R. 1997, "Formation and Evolution of the Milky Way," in IAU Symp. 179: Wide Field Surveys, ed. by B. Lasker, (Dordrecht: Reidel), in press

Majewski, S. R., Phelps, R. & Rich, R. M. 1997, "Observational Constraints on Chemodynamical Models of the Milky Way," in The History of the Milky Way and Its Satellite System, ed. by A. Burkert, D. Hartmann & S. R. Majewski, (San Francisco: ASP), 1

Markevitch, M. L., Sarazin, C. L., & Henriksen, M. J. 1997, "ASCA Atlas of the Cluster Temperatures," in X-ray Imaging and Spectroscopy of Cosmic Hot Plasmas, ed. by F. Makino & K. Mitsuda (Tokyo: Universal Academy Press), 91

Markevitch, M., Sarazin, C. L., & Irwin, J. A. 1996, "Heating of the Intracluster Gas in the Triangulum Australis Cluster," ApJ, 472, L17

McNamara, B. M., Jannuzi, B. T., Elston, R., Sarazin, C. L., & Wise, M. W. 1996, "U-band Polarimetry of the Radio-Aligned Optical Lobes in the Abell 1795 Cluster Central Galaxy," ApJ, 469, 66

Mendez, R. A., Rich, R. M., van Altena, W. F., Girard, T. M., van den Bergh, S., & Majewski, S. R. 1997, "Proper Motions in the Bulge: Looking Through Plaut's Low Extinction Window," in IAU Symp. 179: Wide Field Surveys, ed. by B. Lasker, (Dordrecht: Reidel), in press

Mendez, R. A., van Altena, W. F., Girard, T. M., Rich, R. M. & Majewski, S. R. 1996, "A Proper Motion Survey on Plaut's Low-Extinction Window," in Fourth ESO/CTIO Workshop on the Galactic Center, ed. by R. Gredel, (San Francisco: ASP), 345

Moss, C., Whittle, M., & Pesce, J. E., 1997, "Tidally-Induced Star Formation in Abell 1367", MNRAS, submitted.

Moss, C., Whittle, M., 1997, "Tidally-Induced Star Formation in Cluster Galaxies", Revista Mexicana de Astronomía y Astrofísica (Serie de Conferencias), 6, 145

Munn, J. A., Koo, D. C., Kron, R. G., Majewski, S. R., Bershady, M. A., & Smetanka, J. J. 1997, "The Kitt Peak Galaxy Redshift Survey (KPGRS) with Multicolor Photometry: Basic Data," ApJS, 109, 45

Nelson, C. H., Whittle, M., & MacKenty, J. W., 1996, "The Spheroidal Component of Seyfert Galaxies", in Barred Galaxies and Circumnuclear Activity, Nobel Symposium 98, ed. by Aa. Sandqvist & P. O. Lindblad (Berlin: Springer), 157

O'Connell, R. W. 1997, "The Star Formation History of Low Redshift Spiral Galaxies," in Star Formation, Near and Far, ed. by S. S. Holt and L. G. Mundy (Washington: AIP Press), 491

O'Connell, R. W. 1997, "The Ultraviolet Morphology of Galaxies", in The Ultraviolet Universe at Low and High Redshift, ed. by W. H. Waller (Washington: AIP Press), in press

O'Connell, R. W., Dorman, B., Shah, R. Y., Rood, R. T., Landsman, W. B., Bohlin, R. C., Neff, S. G., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1997, "Ultraviolet Imaging of the Globular Cluster 47 Tucanæ," AJ, in press

O'Connell, R. W., & Marcum, P. 1997, "The Ultraviolet Morphology of Galaxies," in HST and the High Redshift Universe (37$^{\rm th}$ Herstmonceux Conference), ed. by N. R. Tanvir, A. Aragon-Salamanca, J. V. Wall (World Scientific Press), 63

Ohl, R. G., O'Connell, R. W., Bohlin, R. C., Collins, N. R., Dorman, B., Fanelli, M. N., Neff, S. G., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1997, "Far-Ultraviolet Imaging of Early-Type Galaxies", in The Ultraviolet Universe at Low and High Redshift, ed. by W. H. Waller (Washington: AIP Press), in press

Papaderos, P., Loose, H. H., Fricke, K. J., & Thuan, T. X., 1996, "Optical Structure and Star Formation in Blue Compact Dwarf Galaxies II: Relations Among Photometric Components and Evolutionary Implications," A&A, 314, 59

Papaderos, P., Loose, H. H., Thuan, T. X., & Fricke, K. J., 1996, "Optical Structure and Star Formation in

Blue Compact Dwarf Galaxies I: Observations and Profile Decomposition," A&AS, 120, 207

Parker, J. W., Hill, J. K., Bohlin, R. C., O'Connell, R. W., Neff, S. G., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1996, "Ultraviolet Imaging Telescope Observations of OB Stars in the N 11 Region of the Large Magellanic Cloud," ApJ, 472, L29

Partridge, R. B., Richards, E. A., Fomalont, E. B., Kellermann, K. I., & Windhorst, R. A. 1997, "Small-Scale Cosmic Microwave Background Observations at 8.4 GHz," ApJ, 483, 38

Patterson, R. J., & Thuan, T. X., 1996, "Surface Photometry of Low-Surface- Brightness Dwarf Irregular Galaxies," ApJS, 107, 103

Pesce, J. E. et al., including Palma, C. 1997, "Multi-wavelength Monitoring of the BL Lacertae Object PKS 2155–304 in 1994 May. I. The Ground-based Campaign," ApJ, 486, 770

Pustilnik, S. A., Lipovetsky, V. A., Izotov, Yu. I., Brinks, E., Thuan, T. X., Kniazev, A. Yu., Neizvestny, S. I., & Ugryumov, A. V., 1997, "Detection of Another Optical Component in the H I Cloud Associated With the Young Dwarf Galaxy SBS0335–052: New Data From the 6-m Telescope," PAZh, 23, 350

Reid, I. Neill, Majewski, S. R. & Siegel, M. H. 1997, "Starcounts and the Galactic Halo," in Galactic Haloes, ed. by D. Zaritsky, (San Francisco: ASP), in press

Reid, I. N., Yan, L., Majewski, S. R., Thompson, I., & Smail, I. 1996, "Starcounts Redivivus. II: Deep Starcounts with Keck and HST and the Luminosity Function of the Halo," AJ, 112, 1472

Richards, E. A., Fomalont, E. B., Kellermann, K. I., Partridge, R. B., & Windhorst, R. A. 1997, "Detection of a Small Scale Cosmic Background Anisotropy at 3.6 cm," AJ, 113, 1475

Richards, M. T. & Ratliff, M. A. 1997, "Hydrodynamical Simulations of Hα Emission in Algol-type Binaries," ApJ, 493, in press

Richards, M. T. & Rosolowsky, E. W. 1997, "Doppler Tomography of Ultraviolet Spectra of HR 1099," in Tenth Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. by R. A. Donahue & J. A. Bookbinder, (San Francisco: ASP), in press

Richards, M. T. & Russell, S. E. 1997, "Dependence of Radio Flaring Activity on Orbital Phase in Archival Observations of Algol-type and RS CVn Binaries," in Tenth Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. by R. A. Donahue & J. A. Bookbinder, (San Francisco: ASP), in press

Richards, M. T., Waltman, E. W., Foster, R. S., & Ghigo, F. D. 1997, "Flaring Activity Cycles in β Per and HR 1099 from a Continuous 2GHz and 8GHz Radio Survey," in Tenth Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. by R. A. Donahue & J. A. Bookbinder, (San Francisco: ASP), in press

Ricker, P. M. 1997, "Off-Center Collisions between Clusters of Galaxies," ApJ, submitted

Rood, R. T., Bania, T. M., Balser, D. S., & Wilson, T. L. 1997, 3-Helium: Status and Prospects, in The Primordial Nuclei and Their Galactic Evolution, ed. by N. Prantzos, M. Tosi, & R. von Steiger (Dordrecht: Kluwer), in press

Rood, R. T. 1997, "Non-variable Horizontal-Branch Stars," in Fundamental Stellar Properties: The Interaction Between Theory and Observation, ed. by T. R. Bedding, A. J. Booth, & J. Davis (Dordrecht: Kluwer), 363

Rood, R. T. & Renzini, A. (eds.) 1997, "Advances in Stellar Evolution", (Cambridge: CUP)

Rood, R. T., Whitney, J. H., & D'Cruz, N. L. 1997, "Opisthodromism on the Horizontal Branch?", in Advances in Stellar Evolution, ed. by R. T. Rood & A. Renzini (Cambridge: CUP), 74

Sarajedini, A., Ostheimer, J. C., & Claver, C. 1997, "The Properties of the Antlia Dwarf Elliptical Galaxy," AJ, in press

Sarazin, C. L. 1996, "X-ray Spectra of Clusters of Galaxies and Cluster Cooling Flows," in The Eleventh Colloquium on UV and X-Ray Spectroscopy of Astrophysical and Laboratory Plasmas, ed. by K. Yamashita & T. Watanabe (Tokyo: Universal Academy), 9

Sarazin, C. L. 1997, "Cluster Cooling Flows: Recent Results and Outstanding Questions," in Galactic and Cluster Cooling Flows, ed. by N. Soker (San Francisco: ASP), 172

Sarazin, C. L. 1997, "High Resolution X-ray Spectra of Cluster Cooling Flows," in Proceedings of the Workshop on High Throughput X-ray Spectroscopy, ed. by H. Tananbaum, N. White, & P. Sullivan (Cambridge: SAO), 181

Sarazin, C. L. 1997, "X-Ray Emission from Elliptical Galaxies," in The Second Stromlo Symposium: The Nature of Elliptical Galaxies, ed. by M. Arnaboldi, G. Da Costa, & P. Saha (San Francisco: ASP), 375

Sarazin, C. L., & McNamara, B. R. 1997, "ROSAT X-Ray Observations of the Cooling Flow Cluster A2597," ApJ, 480, 203

Sarazin, C. L., Wise, M. W., Koekemoer, A. M., O'Dea, C. P., Baum, S. A., & Owen, F. N. 1997, "The X-ray Properties of B2 1028+313/A1030, a Quasar in an Abell Cluster," ApJ, submitted

Sarazin, C. L., Wise, M. W., & Markevitch, M. L. 1997, "X-ray Spectral Properties of the Cluster Abell 2029," ApJ, submitted

Saslaw, W. C., Maharaj, S. D., & Dadhich, N., 1996, "An Isothermal Universe," ApJ, 471, 571

Sauvage, M., Thuan, T. X., & Lagage, P. O., 1997, "10 Micron and HI Observations of the Blue Compact Dwarf Galaxy HE2-10," A&A, 325, 98

Schulman, E. & Cox, C. V. 1997, "Misconceptions about astronomical magnitudes," AmJPhys, 65, 1003

Schweitzer, A. E., Cudworth, K. M. & Majewski, S. R. 1997, "The Proper Motion of the Dwarf Spheroidal Galaxy Ursa Minor," in Proper Motion Surveys and Galactic Astronomy, ed. by R. Humphries, (San Francisco: ASP), 103

Schweitzer, A. E., Cudworth, K. M. & Majewski, S. R. 1997, "The Absolute Proper Motion and a Membership Study of the Ursa Minor Dwarf Spheroidal Galaxy," AJ, submitted

Shah, R. Y., Wootten, A., Carilli, C., Mangum, J., & Menten, K. 1997, "Deuterated Molecules at a Redshift of z=0.9," PASP, in press.

Sheth, R. K., & Saslaw, W. C., 1996, "Scale Dependence of Non-linear Gravitational Clustering in the Universe," ApJ, 470, 78

Siegel, M. H., Majewski, S. R., Reid, I. N. & Thompson, I. 1997, "First Results of a CCD Starcount Survey of Selected Areas with the Swope 1-m Telescope," in Proper Motion Surveys and Galactic Astronomy, ed. by R. Humphries, (San Francisco: ASP), 175

Smith, E. P., Bohlin, R. C., Bothun, G. D., O'Connell, R. W., Roberts, M. S., Neff, S. G., Smith, A. M., & Stecher, T. P. 1997, "Ultraviolet Imaging Observations of the cD Galaxy in Abell 1795: Further Evidence for Massive Star Formation in a Cooling Flow," ApJ, 478, 516

Smith, D. A., Neff, S. G., Bothun, G. D., Fanelli, M. N., Offenberg, J. D., Waller, W. H., Bohlin, R. C., O'Connell, R. W., Roberts., M. S., Smith, A. M., & Stecher, T. P. 1996, "Ultraviolet Imaging of NGC 3310: A Merger Driven Global Starburst," ApJ, 473, L21

Stecher, T. P., Cornett, R. H., Greason, M. H., Landsman, W. B., Hill, J. K., Hill, R. S., Bohlin, R. C., Chen, P. C., Collins, N. R., Fanelli, M. N., Hollis, J. I., Neff, S. G., O'Connell, R. W., Offenberg, J. D., Parise, R. A., Parker, J., Roberts, M. S., Smith, A. M., & Waller, W. H. 1997, "The Ultraviolet Imaging Telescope: Instrument and Data Characteristics," PASP, 109, 584

Thuan, T. X., Izotov, Yu. I., & Lipovetsky, V. A. 1997, "HST Observations of the Blue Compact Dwarf SBS 0335–052: A Probably Young Galaxy," ApJ, 477, 661

Thuan, T. X., & Izotov, Yu. I., 1997, "Nearby Young Dwarf Galaxies = Primordial Gas and Lyman-alpha Emission," ApJ, in press

Waller, W. H., Bohlin, R. C., Cornett, R. H., Fanelli, M. N., Freedman, W. L., Hill, J. K., Madore, B. F., Neff, S. G., Offenberg, J. D., O'Connell, R. W., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1997, "Ultraviolet Signatures of Tidal Interaction in the Giant Spiral Galaxy M101," ApJ, 481, 169

Weisstein, E. W., & Serabyn, E. 1996, "Submillimeter Line Search in Jupiter and Saturn," Icarus, 123, 23

Whitney, J. H., Rood, R. T., O'Connell, R. W., D'Cruz, N. L., Dorman, B., Landsman, W. B., Bohlin, R. C., Roberts, M. S., Smith, A. M., & Stecher, T. P. 1997, "Analysis of the Hot Stellar Population of the Globular Cluster ω Centauri," ApJ, in press

Wise, M. W., & Sarazin, C. L. 1997, "Internal Absorption in Cluster Cooling Flows," in X-ray Imaging and Spectroscopy of Cosmic Hot Plasmas, ed. by F. Makino & K. Mitsuda (Tokyo: Universal Academy Press), 133

Wu, C.-C., Crenshaw, D. M., Hamilton, A. J., Fesen, R. A., Leventhal, M., & Sarazin, C. L. 1997, "Far UV Absorption Lines in the Remnant of SN 1006," ApJ, 477, L53

Robert W. O'Connell, Chairman