This report covers the period 1 September 1993 to 31 August 1994.

I. PERSONNEL

During this time the departmental faculty consisted of Steven A. Balbus, Roger A. Chevalier, Laurence W. Fredrick, Samuel J. Goldstein, John F. Hawley, Philip A. Ianna, Shiv S. Kumar, 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. Goldstein retired with Emeritus status as the end of the 1993-1994 academic year. William W. Dalton was hired as a lecturer starting 1 September 1994.

The Virginia Institute for Theoretical Astronomy (VITA) continued operations during this period with support from the University of Virginia and a NASA Astrophysical Theory Program Grant. Postdoctoral fellows in the theory group were Dimitris Christodoulou, Ben Dorman, Charles Gammie, and Ding Luo. Shlomi Pistinner visited for this year as a Fulbright Fellow. Pamela Marcum arrived as a new postdoc at the end of this period. Giuseppe Bertin, Roger Blandford, Megan Donahue, Christopher McKee, Jeremiah Ostriker, and Mark Voit were VITA Visitors.

Jonathan V. Brinkmann continued as Research Scientist. A full-time astrometric support position was held by Michael C. Begam who spends most of the year at Mount Stromlo Observatory. Melanie Swain held a part-time position at McCormick Observatory from October through June. James Barr and Cliff Mawyer continued as electronics technician and instrument maker, respectively. Willie J. (Nick) Nichols is the resident caretaker at the Fan Mountain Station.

There were 21 graduate students in residence at the end of this period. Prudence Foster, Richard Gelderman, Charles Nelson, and Phil Plait completed their Ph.D.s during the year.

II. FACILITIES

The 67 cm Leander McCormick refractor on Mount Jefferson and the 1 m reflector on Fan Mountain were used during the year for our astrometric programs, and for student research and training. A new control system was built for the 30-inch reflector and installed in August replacing 20-year old electronics. The new system includes a digital coordinate display, and it permits operation from the new observing

room. In the southern hemisphere, the 66 cm Yale-Columbia refractor at Mount Stromlo Observatory continues to be available to the parallax program on a full time basis, although many of the photographic regions have been transferred to the CCD program at Siding Spring Observatory. During the year there were approximately 2160 visitors to the McCormick and Fan Mountain Observatories as part of our continuing public night programs. This is up about 25% from the previous year.

The Perkin-Elmer PDS 1010GM microdensitometer was used for scanning parallax program plates. David Stokes and Shi Dan of the UVA Medical School (Physiology) and Dan Pascu (U. S. Naval Observatory) visited during the year to use the machine.

III. RESEARCH

a. Stars and Stellar Evolution

G. Albright (graduate student) and Richards have continued their long-term program to obtain full-orbit Hα spectra of short-period Algols in which direct-impact accretion occurs. In June 1994, observations of short-period Algols U Sge, U CrB, SW Cyg, and CX Dra were obtained in 7 nights with the 0.9 m Coudé Feed Telescope at Kitt Peak National Observatory (KPNO). They now have full-orbit coverage of over 10 short-period Algols. The analysis of over 140 spectra of U Sge obtained in 1993 revealed evidence of weak emission components in the wings of the line profile which are rarely strong enough to extend above the continuum flux level. However, Balmer line emission with a strength of $\sim$ 2% of the continuum flux was seen above the continuum at one phase near mid-primary eclipse—the first such detection in over forty years. The Hα difference profiles of U Sge revealed the presence of double-peaked emission features at most phases outside of primary eclipse, and excess absorption at phases throughout primary eclipse. The strength of these absorption/emission features was typically within $\sim$ 16% of the quadrature continuum flux. The double-peaked emission features indicate the presence of a substantial transient accretion disk in U Sge. The radius of the trailing side of the disk was found to be $1.68 \pm 0.10 R_A$ with electron density $N_e \geq 8{\times}10^{10}\,\mathrm{cm}^{-3}$, and mass $M \leq 8{\times}10^{-12} M_\odot$. These measurements were made during an epoch of enhanced mass transfer. The gas distribution in the disk was found to be highly variable in just a few orbital cycles.

Albright and Richards coordinated an international multi-wavelength campaign to observe short-period Algols. The aim was to obtain simultaneous optical and ultraviolet spectra and radio continuum observations to discern the relative contributions of chromospheric emission associated with the magnetically-active secondary and the products of Roche-lobe overflow on the observed Hα line profile. The IUE spectra should arise primarily from the mass transfer process, but the Hα spectra could also arise from the chromosphere of the secondary, while the detection of a radio flare might signal increased chromospheric activity. From 1994 June 1–7, while Albright was collecting Hα spectra at KPNO, Richards observed U Sge and CX Dra from the European Space Agency IUE satellite tracking station in Madrid (Spain), P. Koubský (Ondřejov Observatory, Astronomical Institute, Academy of Sciences, Czech Republic) observed the Hα and He I lines of CX Dra, while D. Frayer and E. Murphy (graduate students) searched for radio flaring activity in about 20 Algols with the 140 foot radio telescope at Green Bank Observatory (NRAO). The simultaneous UV and Hα coverage was a success, but no radio flares were detected during the observing session. Another simultaneous Hα and radio continuum flare search is planned for December 1994.

Albright and G. Stringfellow (Penn State) collected high resolution Hα, Hβ, and Fe II spectra of Nova Ophiuchus 1994 with the 0.9 m Coudé Feed Telescope at KPNO. The spectra were obtained during the first 5 nights after the outburst was reported from 1994 June 4–8 UT. Broad castellated emission with FWZI $> 5000\,\mathrm{km s^{-1}}$ were detected in all the lines.

Balbus, Gammie, and Hawley have continued their investigation of the nonlinear behavior of the weak field magnetohydrodynamic (MHD) instability present in accretion disks. They have carried out extensive simulations of the instability in a Keplerian shearing-sheet system using a three-dimensional MHD computer code developed by Hawley. These simulations represent the first time that significant angular momentum transport is produced in a Keplerian disk entirely self-consistently and directly from the fundamental MHD equations. The simulations examined disks with either a purely vertical or purely azimuthal magnetic field. In all cases turbulence is initiated and sustained by the magnetic instability. The turbulence is anisotropic in a sense that implies an outward flux of angular momentum. The total stress is proportional to the magnetic energy density in the disk. The turbulent energy and angular momentum flux is dominated by magnetic stress rather than Reynolds stress. Most of the energy and angular momentum flux is concentrated

at the largest scales. The mean magnetic energy density in the saturated state depends on the product of the size of the simulation domain and the initial field strength and is independent of the sound speed.

Balbus, Gammie, and Hawley have shown that potentially observable correlated velocity fluctuations in turbulent accretion disks must be related in a simple way to the surface flux density emitted by the disk, and that the amplitude of the fluctuations must scale in a simple way with disk radius. By allowing velocity fields to be elucidated at high resolution, Doppler tomography and eclipse mapping techniques, combined with these findings, offer the promise of directly testing fundamental dynamical predictions of steady turbulent disk theory.

Chevalier is continuing to study neutron star accretion in dense environments, where neutrino losses carry off the gravitational energy of the accreting matter. Spherically symmetric calculations showed that there is a critical accretion rate, $\sim 10^{-4}\,M_\odot\ \mathrm{yr}^{-1}$, above which neutrino dominated accretion can occur. Angular momentum of the accreting matter can significantly raise this critical accretion rate and can lead to the formation of a neutrino cooled disk around the neutron star.

Chevalier investigated hydrodynamic instabilities that are associated with supernovae. With Luo, he calculated the nonlinear instability of a shock front accelerating down an exponential density gradient, as occurs when a shock front breaks out of a supernova atmosphere. When the unstable wavelength is comparable to the ambient density scale height, saturated oscillations of the shock front set in that create weak shock fronts in the downstream flow. The result is that density fluctuations of a factor of 2–3 become frozen into the expanding flow.

Chevalier and J. Blondin (NCSU) calculated the effects of radiative cooling on the Rayleigh-Taylor instabilities that occur when the outer parts of a supernova are decelerated by a surrounding wind. In the linear regime, they found that a thin-shell analysis leads to a dispersion relation that agrees well with a full stability analysis of the adiabatic flow in the long wavelength regime. In the short wavelength regime, the cooling case shows more rapid linear growth. In the nonlinear regime, the cooling case saturates at a level similar to the adiabatic case. The instability is potentially important for free-free absorption in radio supernovae and for structure in broad optical emission lines resulting from circumstellar interaction. Such structure may have recently been observed in spectra of SN 1993J.

Dalton and Sarazin are constructing models for the high mass X-ray binary (HMXRB) population of our Galaxy. These models are based on a grid of 5544 evolutionary histories for massive binaries. The binaries are combined assuming a rate of formation of massive stars, an initial mass function, a binary fraction, a binary mass distribution, and a binary separation distribution. The statistics of the resulting HMXRB population are compared to the observed populations of X-ray sources in our Galaxy. The observed populations can be reproduced in models in which mass transfer in the binaries is significantly nonconservative ($\approx$70% of the gas is lost), the initial masses of stars in massive binaries are correlated, and the high mass end of the IMF agrees with recent optical studies.

Dalton and Sarazin are extending their high mass binary population synthesis models to try and understand the population of high mass X-ray binary stars in the Magellanic Clouds, in M51, and in starburst galaxies.

Dalton and Sarazin are using their high mass binary star population techniques to synthesize the population of Wolf-Rayet stars in our Galaxy and in the Large and Small Magellanic Clouds. They find that mass transfer in binaries is a very important channel for the formation of Wolf-Rayet stars in our Galaxy, and is the dominant channel in the lower abundance Magellanic Clouds.

N. D'Cruz (graduate student), Dorman, Rood, and O'Connell are studying mass loss in red giant branch stars of mass $\leq 1 M_{\odot}$. Their goals are twofold: (1) Is it possible to find a mass loss law which can produce substantial extreme horizontal branch (EHB) populations without fine tuning? Dorman, O'Connell, & Rood (1995, ApJ, in press) suggest that the UV radiation from EHB stars and their progeny is responsible for the UVX phenomenon seen in elliptical galaxies and spiral bulges. (2) For high mass loss rates, red giant models "peel-off" the RGB. Under some circumstances they ignite helium while on the white dwarf cooling curve (Castellani & Castellani 1993, ApJ, 407,649). Such stars are being studied as a possible explanation for the EHB stars observed to lie below the theoretical zero-age horizontal branch (ZAHB) in the HR diagram of the globular cluster ω Cen (Whitney et al. 1994, AJ, 108, 1350).

Dorman continues his collaboration with M. Tripicco and R. Bell (U. Maryland) on population synthesis models for metal-rich galaxies and Galactic clusters. They have shown that the old open cluster NGC 6791 has [Fe/H] $\sim$ 0.3 and age 9–10 Gyr. This cluster is particularly interesting since it has been

found to contain hot subdwarfs as are posited for the nuclei of metal-rich elliptical galaxies.

Dorman, Rood, and O'Connell have recently completed a detailed study of the ultraviolet properties of evolved stellar populations. The object of this study was to identify the component responsible for the UV upturn in elliptical galaxies. They have reanalyzed the existing data from globular clusters and elliptical galaxy nuclei/spiral galaxy bulges. The UV properties are found to be different: the hot component of the galaxies is hotter, and the cluster UV spectra are flatter. They have constructed simple models of galactic stellar populations that are able to reproduce the observations with a very small number (1 or 2) of free parameters. The models show that the cluster UV spectra arise mainly from hot horizontal branch stars $T_{\rm eff} < 20000\,{\rm K}$, while in the galaxies, Extreme HB (EHB) stars and their post-HB phases are responsible. Key differences also arise from the fact the the background population in the clusters are metal-poor, so that earlier phases of evolution contribute about 50% of the flux in the mid-UV. This produces the flatter spectral energy distributions. The EHB stars in the galaxies are identified with the hot subdwarf population of the Galactic field. Somewhat less than 5% of the field population passes through the sub-dwarf phase, and a like fraction in elliptical galaxies can explain the UV upturn in all but the strongest cases. The most extreme manifestations of the UV upturn phenomenon require a larger production of EHB stars ($\sim 20\%$). The study also indicates that the strongest-lined galaxies as measured by the Mg_2 index may not be as strongly enhanced in [Fe/H] as previously thought ([Fe/H] ≤ 0.4). It also proposes mid-UV colors indices as a possible metallicity indicator for future integrated light studies of elliptical galaxies.

Gammie and Balbus have carried out a global stability analysis of a magnetized shearing sheet of finite vertical extent. This work confirmed the basic local character of the instability described by Balbus and Hawley, but also pointed to circumstances under which the vertical boundary conditions could also influence the stability of the sheet. This more general approach reconciled an apparent inconsistency between the local stability criterion found by Balbus and Hawley, and a global criterion obtained by other workers in the field.

Hawley and J. Stone (U. Maryland) continue investigating improvements to their numerical technique for multi-dimensional MHD. They have also developed a computer code suitable for the highly parallel Connection Machine architecture. Stone, Hawley, Gammie, and Balbus are extending the numerical simulations to stratified accretion disks. A variety of initial field

topologies and strengths have been examined as well as disks with isothermal and adiabatic equations of state. Buoyancy does not affect the linear growth of the instability. Nor does it seem to determine the saturation amplitudes; reconnection continues to play the major role in this regard.

Pistinner and G. Shaviv (Technion) are analyzing the form of the radiative transfer equation in an expanding envelope when a quasi-static approximation is applied. They find that the radiative transfer equation written in the fluid's rest frame must include the "advection" term.

Pistinner and Shaviv are also calculating formal analytic solutions of the radiative transfer equation for a grey moving atmosphere in a plane parallel geometry. A formal solution in the diffusion and the free streaming limit is also provided in the case of a spherically extended atmosphere. The formal solutions are written explicitly for a scattering atmospheres in which the density and the velocity fields are given by a power law. A self consistent temperature profile accurate to $O(\beta = v/c)$ is provided for the case in which the absorption or the scattering are temperature independent. The grey extinction temperature profile is considerably simplified in the case of a scattering atmosphere.

Pistinner, S. Shaviv, S. Starrfield, and P. Hauschildt (ASU) are using recent numerical models of synthetic spectra of expanding nova envelopes to explore the proper parameterization of a nova envelope. The numerical results show that certain regions of the continuum spectra are not sensitive to the input parameters. In certain cases, nova atmospheres have a continuum extinction coefficient that is dominated by scattering. The continuum scattering and the resulting continuum extinction in these cases are nearly gray. They are treating the case of a static extended atmosphere and the case of an extended atmosphere in motion. Using these solutions, they find the conditions that are required to obtain accurate results from the analysis of novae spectra.

P. Plait (graduate student), P. Lundqvist (Stockholm), Chevalier, and R. Kirshner (Harvard) analyzed 3 years of imaging data from the HST on SN 1987A. The data are consistent with observing the decaying emission from an irregular ring whose surface was heated and ionized by the flash from the supernova outburst. The gas density deduced from the rate of decline is consistent with that determined from emission line ratios. The decline rate is not correlated with the ring surface brightness, indicating that the variations in surface brightness are due to varying

column length. An A star in the LMC was found to be superposed on the ring.

M. Ratliff (graduate student) and Richards have begun to address some of the questions raised by the initial hydrodynamical results of J. Blondin (NCSU) and Richards. Since the interaction of the gas stream with the stellar surface may be the key to understanding the observed gas flows in the short-period Algols, Ratliff has been modelling the boundary at the surface of the accreting star by adding a model atmosphere to the mass accreting star.

Richards and G. Albright (graduate student) continued their study of magnetic activity on the cool components in short-period Algol-type binaries. During 10 nights in February 1994, they obtained JHK infrared photometry of δ Lib, β Per, RW Tau, and TX UMa with the 1.5 m Carlos Sanchez Telescope at Tenerife in the Canary Islands (Spain). This project will be continued on a long term basis to study starspot activity.

Richards and J. Blondin (NCSU) have modelled the mass transfer in the orbital plane of β Per (Algol) using a two-dimensional hydrodynamics code. The simulation was initialized with a pre-described tidal stream emanating from the tidal bulge of the mass-losing star. For the boundary conditions at the surface of the accreting star, they experimented with several possibilities, from total reflection to total absorption. They have found 3 main results. First, a significant stream/star interaction only occurs for incidence angles substantially smaller than predicted by Lubow and Shu. A transient disk appears only for a narrow range in stream density corresponding to moderate radiative cooling. Finally, the dynamics of the mass transfer is strongly modulated by the interaction of the gas coming back around the accreting star with the tidal stream coming from the mass-losing star. Under all but the most extreme conditions, there was always a significant amount of gas circling around to meet the tidal stream somewhere along the line of centers of the system. Thus, even for relatively small incidence angles the stream was continuously deflected away from the accreting star by the ram and gas pressure of this orbiting gas. Radiative cooling plays an important role in the dynamics of the mass transfer, and a sharp transition occurs from adiabatic flow to isothermal flow within a very narrow range of stream density ($10^{-9}\,\mathrm{g\,cm^{-3}} < \rho_s < 6 \times 10^{-9}\,\mathrm{g\,cm^{-3}}$). At high density the flow is effectively isothermal, and appears to always produce a permanent accretion disk. At low density cooling is relatively unimportant, but the flow again generally forms an accretion disk, albeit of much lower density. At intermediate densities, the flow is much

less steady, occasionally forming a transient accretion disk.

Richards and L. Bowles (undergraduate student) used the technique of Doppler Tomography to analyze the Hα difference profiles of β Per, U Sge, U CrB, RS Vul, and SW Cyg obtained by Albright. These tomograms display the first distinct "images" of gas streams in the Algols, and in the entire class of interacting binaries. A weaker emission source was associated with the chromosphere of the secondary star. The tomograms of RS Vul, U Sge, U CrB and Algol all show distinct elongated emission along the gas stream trajectory from the L_1 point towards the primary star. The collimation of the gas stream is more pronounced in U CrB than in the other systems, where a more diffuse flow along the gas stream is observed. An emission feature that partially encircles the primary star is also present in the tomograms of these systems. This disk-like feature is enhanced in the tomograms when the difference profiles are analyzed during the orbital phases where the gas stream is expected to be occulted by the primary star. It is strongest in U CrB, which also displays the strongest gas stream emission of all the Algols in the sample. The tomogram of SW Cyg displays a prominent, almost Keplerian disk which is similar to those found in the cataclysmic variables. The earlier 1993 observations of U Sge, apparently during an epoch of enhanced mass transfer, show a disk similar to that of SW Cyg. So it is apparent that the disk-like structures are dominant in the Doppler tomograms during epochs of enhanced mass transfer and in the longer period systems.

Rood continues his collaboration with F. Fusi Pecci and F. Ferraro (Bologna) on large sample studies of globular clusters. One goal is to check the "canonical assumptions" of stellar evolution and thus get a better estimate for the systematic error in derived quantities such as stellar ages.

J. Whitney (graduate student), O'Connell, Rood, and Dorman completed the data reduction of far-UV photometry of the globular cluster ω Cen, obtained with the UIT/Astro-1 instrument. They have determined fluxes for 1940 stars to a limiting magnitude at 1620Å of $\sim$ 16.9. This provides the largest sample of supra-HB stars available (140 objects over 1 mag brighter than the HB). Work now focuses on more detailed analysis. The radial distributions of stars with different colors are being derived. The preliminary result is that the blue objects are not concentrated in the cluster core, which is not necessarily surprising since ω Cen is not very evolved dynamically. The cooler HB stars ($T_e \lesssim 15,000$ K) fit theoretical tracks very well, but there is a conspicuous break in the density of

HB stars at $T_e \sim 16000\,\mathrm{K}$, and bluer than this most stars fall fainter than the predicted location of the HB. This may represent a special population of hot objects. There is also a surprising number of stars near to or hotter than the locus of zero envelope HB and post-HB tracks. Some could be on the white-dwarf cooling curve; for others, the unusual colors could be produced by strong line emission. A number of hot stars in the cluster are being pursued spectroscopically. With W. Landsman and T. Stecher (GSFC), IUE observations of two supra-HB stars have been obtained. Both show sdO spectra with $T_e > 40000\,\mathrm{K}$. IUE observations of 5 more hot stars in ω Cen are scheduled, and HST observations of others have been proposed.

Whitney, O'Connell, Rood, and Dorman are also analyzing the far-UV luminosity functions of the globular clusters M3 and M13 based on short-exposure images. In each cluster, the previously-identified post-AGB star is very UV-bright. 81 sources were detected in M3, including several new objects above the HB. The relatively small number of hot stars brighter than the HB is consistent with the lack of a blue tail for this cluster and with theoretical models. The photometry of M13 is less deep, with only 44 detections. Several of these match previously known "UV-Bright" stars in the cluster, but a significant number are new discoveries. Thirty of the 44 stars in the sample are significantly above the HB. Numerical simulations of the luminosity functions are underway based on the Dorman-Rood theoretical tracks.

b. Interstellar Medium

Brinkmann and A. Kutyrev (GSFC) are building an infra-red imaging Fabry-Perot camera to map the diffuse Brackett α emission in the Galaxy. It will, in conjunction with microwave instruments also being constructed, for the first time, allow a sensitive evaluation of the distribution of the ionized medium throughout the volume of the Galaxy.

V. Dwarkadas (graduate student), Chevalier and J. Blondin (NCSU) have modelled planetary nebulae (PNe) using the Interacting Stellar Winds model. If the two interacting winds have constant properties, and if the velocity of the fast wind is much higher than the expansion velocity of the shell, the interior of the hot shocked bubble becomes isobaric, the velocity of the PN shell becomes constant with time and the shape becomes self-similar. They have calculated the shapes of PNe assuming that they have reached the self-similar stage and taking an asymmetric density profile for the slow wind. The asymmetry is modelled using different functions, which depend on the degree

of asymmetry and the steepness of the density profile. An important part of their work is the inclusion of the effects of the ambient wind velocity, which has not received much attention since the work of Kahn & West (MNRAS, 212, 837, 1985). The fact that typical PN velocities (10–30 kms^{-1}) are only slightly greater than typical red giant wind velocities (5–20 kms^{-1}) indicates that this is an important parameter. The morphological appearance is a consequence of the density contrast, steepness of the density profile and velocity of the ambient medium; classification of PNe purely on the basis of increasing density contrast may be misleading. Moderate values of the density contrast result in a cusp at the equator. Higher density contrast coupled with a low velocity for the external medium gives rise to extremely bipolar nebulae. For large density contrasts and a finite value of the slow wind velocity, the surface density maximum of the shell shifts away from the equator, giving rise to peanut-shaped structures with pronounced equatorial bulges. If the external wind velocity is low, PNe tend to be correspondingly more bipolar, even if the density contrast is not very high. If the PN velocity is close to that of the external wind, the shape is relatively spherical. However a velocity asymmetry in the external wind can lead to a bipolar shape if the equatorial velocity is sufficiently low. Hydrodynamical simulations carried on till the self-similar stage appear to validate the semi-analytic conclusions.

Rood, T. Bania (BU), D. Balser (BU, NRAO), and T. Wilson (MPIfR) are continuing their project to determine the cosmic abundance of ^{3}He. The ^{3}He/H ratio cannot be calculated directly from the line and continuum intensities. This is because the hyperfine line depends on column density, while the broadband thermal continuum emission provides only an emission measure. Previously H II regions have been modelled as homogeneous spheres. Now high spatial resolution observations from the VLA and MPIfR 100 m and recombination line strengths obtained simultaneously with observations of the $^3\mathrm{He}^+$ hyperfine line are used for more realistic models. The abundances range from $^3\mathrm{He/H} = 1 - 5 \times 10^{-5}$. The observed distribution of ^{3}He in the Galaxy is in conflict with the predictions of chemical evolution models. Rood, K. Olive (UMn), et al. discuss the various options for the resolution of this problem.

K. Borkowski (U. Maryland), Sarazin, and J. Blondin (NCSU) are calculating the predicted X-ray images from their very detailed numerical hydrodynamic model for Kepler's supernova remnant.

c. Galaxies and Active Galactic Nuclei

Brinkmann and T. Stecher (GSFC) continued the study of the spatial distribution of near UV photons from the edge-on normal spiral galaxy NGC 891. These photons originated in hot stars in the disk. These photons were scattered dust grains by the interstellar medium of the disk and halo. They found that the scale height of the intensity of these scattered photons was similar to the scale height of the Hα emission in the disk. The UV scale height was about twice that of the Hα scale height in the bulge.

R. Gelderman (graduate student) completed his PhD thesis "An Optical Study of Compact Steep Spectrum (CSS) Radio Sources," working with Whittle. These galaxies and quasars have powerful sub-galactic radio structure, and constitute prime candidates for a strong interaction between radio jets and the interstellar medium of the host galaxy. The spectroscopic data have been published, and include detailed line strength and profile information for the sample of about 30 CSS and related objects. An interpretive paper supporting the picture of strong jet/gas interactions is being prepared for publication.

Hawley worked with G. Bicknell (ANU-MSO) to adapt the Virginia Institute for Theoretical Astronomy PPM hydrodynamics code VH1 to a problem involving jet-cloud collisions in AGN. A jet running obliquely into a dense cloud produces shock waves and filamentary structure due to shear layer instabilities. As part of a further development effort the VH1 code was extended to three dimensions.

C. Nelson (graduate student) completed his PhD thesis "Stellar and Gaseous Kinematics of Seyfert Galaxies" working with Whittle. Stellar velocity dispersions and emission line profile measurements for about 75 Seyfert galaxies have been presented in a paper accepted for publication. An interpretive paper is in preparation. A number of important results have emerged. The kinematics of the gas in the Narrow Line Region is principally determined by the depth of the bulge gravitational field, but with additional influences from the nuclear radio source, and perturbations from nearby galaxies. The Seyferts lie off the normal Faber Jackson correlation between bulge luminosity and nuclear stellar velocity dispersion, suggesting unusually low mass-to-light ratios. It also seems that the nuclear radio source depends on the bulge mass, possibly reflecting a link to the near nuclear ISM pressures.

O'Connell, with J. Gallagher (U. Wisconsin), D. Hunter (Lowell Observatory) and W. Colley (Princeton), completed an initial analysis of HST/PC imagery of the central regions of the prototype starburst galaxy M82. The deconvolved images reveal a remarkable complex of over 130 "super" star clusters,

with FWHM's of ∼3.5 pc, a large range of $(V - I)$ color, and mean absolute magnitudes $M_V \sim -11.6$, brighter than any cluster in the Local Group. They argue that some of these clusters lie in the starburst core, which is probably extended along a bar, and that part of M82's minor-axis wind originates in the visible regions.

O'Connell, with W. Jaffe (Leiden), H. Ford (JHU), F. van den Bosch (Leiden), and L. Ferrarese (JHU) completed an analysis of HST/PC V-band images (10 pc resolution) for a magnitude-limited sample of bright E galaxies in the Virgo Cluster. They find that the nuclear and near-nuclear morphologies confirm and strengthen the previously-recognized dichotomy of "E" galaxies into "true" and "disky" subtypes. The latter, usually classified E4 or later, often show a bright nuclear stellar disk of radius $\sim$ 100 pc. Essentially all the fainter galaxies are disky and have brightness profiles rising as power laws to the HST resolution limit. Most objects in the sample have dust in their nuclear regions, irrespective of classification or the level of nuclear activity. The three systems in the sample for which there is independent evidence for distinct kinematic components exhibit no photometric anomalies other than dust.

R. Patterson (graduate student) has obtained CCD B- and I-band surface photometry for a sample of 51 dwarf and low surface brightness galaxies in collaboration with Thuan. The sample was chosen based in part on their extremely narrow H I linewidths ($\Delta V_{20} < 100$ km s^{-1}), in order to examine the Tully-Fisher relation between linewidth and absolute magnitude at the low–luminosity/narrow linewidth end. In this regime, a substantial fraction of the linewidth is attributable to turbulent rather than rotational motion and the original Tully-Fisher relation does not hold. If we assume the linewidth is due to both turbulent and rotational motion, we are able to derive a mass for the dwarfs which is found to correlate with luminosity. However, the relation is distinct from the Tully-Fisher relation for spirals, and indicates the presence of an increasing amount of dark matter at low luminosities. They find that the locus of dwarf galaxies in the mass/luminosity plane is well fit by the theoretical prediction of Dekel & Silk (1986, ApJ, 303, 39), $M/L \propto L^{-0.37}$, while the spirals follow a relation in which M/L *increases* with L ($M/L \propto L^{0.2}$), which corresponds to the observed slope (~ 7) of the Tully-Fisher relation for spirals. The Dekel-Silk relation arises in low mass systems with massive dark halos which undergo extensive mass loss due to supernova driven winds. The dark halo allows the galaxy to

remain bound even as most (or all) of the gas is removed, drastically reducing the rate of star formation. The trend towards higher M/L at lower L is the result of the lower escape velocity of the less massive systems, allowing the gas to be removed more efficiently. The same relation has previously been seen to hold for dwarf Spheroidal galaxies, providing further evidence for a common evolutionary history of these two types of dwarf systems, radically different from "normal" early- and late-type galaxies. If the relation can be constrained by additional observations of galaxies at the extreme low-luminosity end, this relation may prove to be a reliable distance indicator for gas-rich dwarfs. The large number of H I observations of dwarfs which already exist would then enable them to use the dwarfs as test particles to examine deviations from the Hubble flow.

Sarazin and M. Wise (NOAO) are analyzing the ROSAT High Resolution Imager X-ray observations of a sample of elliptical galaxies. They will determine whether the X-ray emission originates from stars or diffuse gas. The density and temperature of the gas will be derived, and the roles of supernova heating and thermal conduction will be assessed. The dynamical state of the gas (steady or non-steady, inflow or wind) will be determined. The location and amounts of cooling gas will be derived. The possible role of stripping of gas from ellipticals will be studied. The distribution of the total mass of the galaxy will be determined, and the possible existence of halos of dark matter will be investigated. A comparison of the shapes of the X-ray and optical isophotes will allow limits to be placed of the shape of the mass distribution of the galaxy.

Thuan, in collaboration with Yu. Izotov (Kiev Observatory, Ukraine) and V. Lipovetsky (Special Astrophysical Observatory, Russia) have analyzed high quality spectrophotometric observations of 15 supergiant H II regions in 14 new low-metallicity blue compact galaxies (BCGs) selected mainly from the First and Second Byurakan Surveys and with oxygen abundance 12 + log O/H between 7.37 and 8.04 ($Z_\odot/35 < Z < Z_\odot/7$). They use the data to determine heavy element abundances, discuss their origin and constrain current nucleosynthesis stellar models. The main result is that *none* of the heavy element-to-oxygen abundance ratios studies (N/O, Ne/O, S/O, Ar/O, Fe/O) are correlated with oxygen abundance. They conclude that all these heavy elements are produced by the same massive ($M \geq 10M_\odot$) stars. The small dispersion of the N/O ratio (± 0.08 in the log) can only be understood if primary N is produced in massive stars, *not* in intermediate-mass ($4M_\odot < M < 9M_\odot$) stars as commonly thought. BCGs

show the same O/Fe overabundance with respect to the Sun ($\sim$ 0.34 in the log) as galactic halo stars, suggesting the same chemical enrichment history, and supporting the scenario of an early enrichment of the galactic halo by massive Population III stars. They have compared the observed heavy element abundance ratios with theoretical yields from current massive star nucleosynthesis models from Weaver & Woosley (1993). The best agreement is found for the single-mass $25M_{\odot}$ stellar model, suggesting a shallower IMF slope than the Salpeter slope, with a $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ nuclear reaction rate equal to 1.7 times the rate given by Caughlan & Fowler (1988) and with a "nominal" semiconvection rate of 0.1 times the thermal diffusion rate. The small dispersion in the heavy element abundance ratios suggests that there is *not* a large IMF variation between BCGs with different metallicities. The Fe/O abundance ratio in BCGs can be understood if the mass of the central collapsing core in explosive nucleosynthesis models is $\sim$ 10 percent larger than the mass of the iron core.

Thuan, in collaboration with P. Papaderos, K. Fricke, and H. Loose (University of Gottingen, Germany) has observed the blue compact dwarf (BCD) galaxy VII Zw403 with the PSPC camera onboard ROSAT. They found a total X-ray luminosity of $1.94 \times 10^{38}\,\mathrm{erg\,s^{-1}}$ distributed in a central core to which are connected three elongated structures. They interpret this X-ray morphology as the result of a hot gas outflow from the core of the dwarf galaxy powered by the present starburst. This is the first example of such a hot gas outflow from a BCD galaxy.

Thuan, in collaboration with M. Sauvage and P. Lagage (Saclay, France) has studied the Blue Compact Dwarf (BCD) galaxy He 2-10 in the mid-infrared (MIR) window using broad-band filters centered at $\lambda 10.5\,\mu$m and $\lambda 11.8\,\mu$m. In both filters only the galaxy's central regions were detected. An extranuclear UV emitting region is not detected, implying an older age. The central regions contain two resolved components which have the same MIR properties but different Hα fluxes. They interpret these properties in terms of differing star forming histories. They also present a new measurement of the H I content of He 2-10 which, combined to the MIR information, shows that the interstellar medium properties of He 2-10 are typical of that of BCDs. They study the energy sources for the MIR to FIR emission and show that the MIR emission is unambiguously associated with the young massive stars, but that the FIR emission requires in addition the heating contribution from a slightly more evolved stellar population.

Whittle, C. Mullis (undergraduate student), and R. Gelderman (GSFC) are analyzing the Extended Narrow Line Region (ENLR) of Markarian 78. Long slit spectra taken using the KPNO 4 m telescope, and images taken using the KPNO 2.1 m telescope provide a map of the ionization conditions across the ENLR. Data have now been reduced and the important diagnostic line ratios have been measured. Using the photoionization code CLOUDY written by Ferland, they intend to derive the continuum intensity and spectral shape as a function of angle from the primary radio axis. Such information provides insight into the various possible "beaming" mechanisms which force the radiation to emerge anisotropically.

Whittle, Mullis, Gelderman, G. Bower (STScI), A. Wilson (U. Maryland), and J. Mulchaey (Carnegie) are studying the Seyfert galaxy Markarian 1066, using emission line and continuum images taken with HST, long slit spectra taken with the CFHT, and radio images taken with the VLA. The galaxy is interesting because it harbors several gaseous components. The spectra show a rotating LINER like component, and a non-rotating but blueshifted Seyfert component. The multiple components show up as excitation gradients in the HST images, while the radio map suggests the presence of a collimated nuclear outflow. The combined data and its global interpretation are being prepared for publication.

J. Mulchaey (U. Maryland) et al. (including Whittle) have completed a multiwavelength study of the dusty torus model for Seyfert galaxies. Fluxes in a number of wavebands were measured or compiled for a sample of 116 Seyfert galaxies. Correlations between and distribution functions of these fluxes support the dusty torus model, and show that while [O III] λ5007, infrared, and hard X-ray emission is isotropic in Seyfert 1s and 2s, the ultraviolet and soft X-ray emission is anistropic, being significantly underluminous in the Seyfert 2s. The results have been accepted for publication in the Astrophysical Journal.

Whittle and A. Wilson (U. Maryland) have continued their study of the Seyfert galaxy Markarian 78 using HST and VLA images. There is evidence for a strong interaction between an inner jet and the most nuclear emission line cloud. At larger radii, the radio emission seems to fill the regions between the emission line knots. Although a simple model of a bow shock acceleration seems inadequate, a more general expansion driven by the radio source seems to be occurring. Spectra taken with the HST Faint Object Spectrograph are soon to be taken. These will provide important velocity and ionization information to help

understand better the interaction between the radio source and the line emitting gas.

d. Clusters of Galaxies

O'Connell, Sarazin, and B. McNamara (SAO) are comparing optical continuum images, optical line emission images, radio images, and X-ray images of the central regions of the galaxy NGC 1275 in the Perseus cluster. They find evidence for the interactions of the radio source with intracluster gas. Gas appears to be cooling preferentially and forming stars at the periphery of the strong radio source.

Sarazin, S. Baum, and C. O'Dea (STScI) have made high dynamic range VLA radio observations of the cooling flow cluster 2A0335+096. They have found radio emission associated with the central D galaxies, with the companion nucleus of the central D galaxies, with a cluster galaxy projected near the nucleus, with the very long NAT radio galaxy, and with several other sources. The central radio emission has an usually, disrupted jet structure with filaments of radio emission which coincide with filaments of X-ray and optical line emission which were discovered by Sarazin, O'Connell, and McNamara.

Sarazin, Baum, O'Dea, and F. Owen (NRAO) are studying the quasar B2 1028+313, which is located at the center of the Abell cluster A1030. They hope to use the quasar to detect cooler components in the intergalactic medium through UV or X-ray absorption.

Sarazin and J. Breen (graduate student) are analyzing the structure of the hot gas in the cooling flow cluster A1795. They have a deep ROSAT observation of this system.

Sarazin and Christodoulou are calculating numerical MHD models for cooling flow clusters with magnetic fields. These model confirm the simple self-similar solutions found previously.

Sarazin, H. Ford (JHU), S. Baum, and C. O'Dea (STScI) are using HST UV spectra of the nucleus and jet knots in M87 to search for absorption lines from cold gas in the Virgo cluster. This technique should reveal the nature of the cold gas which has been observed in X-ray absorption in this and other cooling flows clusters.

Sarazin and Z. Huang (graduate student) are studying the X-ray structure of the Hercules clusters, Abell 2151, using ROSAT and *Einstein* data. They find that the X-ray emission contains contributions from diffuse intracluster gas, individual galaxies, and a cluster-central cooling flow.

Sarazin and J. Irwin (graduate student) are analyzing the distribution of the hot gas, dark matter,

and cold gas in the cooling flow clusters 2A0335+096 using PSPC data from ROSAT.

Sarazin, W. Jaffe, M. Bremer (Leiden), B. McNamara (SAO), C. O'Dea, S. Baum (STScI), and M. Wise (NOAO) 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.

Sarazin, E. Lufkin (Hughes STX), 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, B. McNamara (SAO), J. Burns, and K. Roettiger (NMSU) are studying the optical, radio, and X-ray structure of the cD galaxy at the center of the cooling flow cluster A2597. This cluster shows elongated UV/blue continuum lobes, which are roughly aligned with the radio structure. This lobes may be due to either jet induced star formation in the cooling flow gas, or electron scattering of beamed emission from the active nucleus.

Sarazin, O'Connell, and McNamara are analyzing the ROSAT X-ray images of a sample of cooling flow clusters. Previous X-ray observations suggest that large quantities of gas are cooling at the centers of many clusters, although the final deposition of this gas is still uncertain. They clusters in which there is evidence for recent star formation and/or cooler gas. Evidence for star formation in these galaxies includes blue stellar continua or stellar absorption lines of O–F stars. Cool gas is detected through line emission from gas at 10^4 K, 21 cm line emission or absorption, molecular line emission, or far infrared emission. High resolution X-ray images will be compared to the star formation and cool gas tracers, and the rates of formation of cool gas and stars will be compared to the rates of cooling of the hot, X-ray emitting gas.

Sarazin, O'Connell, and McNamara are using high resolution ROSAT X-ray images to search for aligned radio, optical, and X-ray structures in the central galaxies of moderate redshift clusters. Similar structures have been seen in nearby and very distant clusters.

Sarazin and Pistinner are calculating the properties of the warm absorbing gas seen in X-ray absorption in the cluster of galaxies A2256. They show that this gas should produce very strong UV emission lines.

Sarazin and Pistinner are studying the hydrodynamical stability and structure of cold clouds immersed in cluster cooling flows. They hope to understand the origin of the excess soft X-ray absorption seen in the X-ray spectra of many clusters of galaxies.

Sarazin and Pistinner have shown that it is very difficult for highly tangled magnetic fields to effectively suppress thermal conduction in cluster cooling flows. In the limit where the field is highly tangled but simply connected, they have derived the transport coefficients by expanding the Boltzmann equation in drift variable. The alternative possibility that the magnetic field lines consist of a large number of very small loops is shown to be inconsistent with the observed Faraday rotation toward radio sources in many cooling flows.

Sarazin and Pistinner are calculating simple models for cluster cooling flows with relatively weak magnetic fields. They find that these fields will necessarily cause the gas to be at least moderately turbulent.

Sarazin and Pistinner have applied a complete kinetic, nonlocal treatment to heat conduction in cluster cooling flows. They find that nonlocal saturation effects cause the gas to be more thermally unstable than had previously been thought.

Sarazin, M. Voit (JHU), M. Donahue (STScI), and C. McKee (Berkeley) are calculating models for cold X-ray absorbing clouds in cluster cooling flows. They find that if is very difficult to produce the observed amount of X-ray absorption without violating the observed upper limits on the amount of H I and CO emission.

Sarazin and M. Wise (NOAO) are calculating the effects of optical depth and radiative transfer on X-ray emission from cluster cooling flows. Previous studies of X-ray emission from clusters have assumed the cluster to be optically thin; however, Sarazin and Wise find that resonance lines in clusters may be significantly optically thick. This opacity significantly effects the emergent spectrum.

Sarazin and Wise are measuring the X-ray spectra of the A2029 and 2A0335+096 clusters of galaxies with cooling flows using ASCA. They are particularly interested in studying the spectrum of the cooling gas, and the possible spectral effects of cold gas in these systems.

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, R. Gelderman (STScI), and Sarazin are using long slit spectra and narrow band image to map out the distribution and kinematics of the optical line emitting gas in the cooling flow cluster 2A0335+096. Hopefully, this may lead to an understanding of origin of the X-ray–radio–optical filaments in this system.

e. Cosmology

Saslaw and F. Fang (graduate student) have examined the effects of massive concentrations of dark matter in the cores of clusters of galaxies on the velocity distribution function of the galaxies. They do not agree very well with observations. A more uniform distribution of the dark matter in clusters may be more realistic.

Saslaw and S. Raychaudhury (CfA) have made the first determination of the observed peculiar radial velocity distribution function for a representative sample of galaxies which includes a wide range of clustering properties. The distribution is non-Gaussian. It agrees with an earlier prediction of gravitational clustering and with the spatial galaxy distribution function. In the simplest consistent model, most of the inhomogeneous mass of the Universe is in galaxies or their halos.

Raychaudhury and Saslaw have estimated the "Mach number" for the bulk flow of galaxies within $50h^{-1}$ Mpc from us. It is approximately 0.8, from a streaming velocity of about $600\,\mathrm{km\,s^{-1}}$ which is needed to make the peculiar radial velocity distribution symmetric around zero and from a velocity dispersion which includes a proportional sampling of field and cluster galaxies.

Saslaw and R. Sheth (Cambridge) have developed a new technique to synthesize the observed distribution of galaxies. It first populates space with a Poisson distribution of cluster centers. Then each cluster center is associated with a given number of galaxies drawn from a Borel distribution. These galaxies are arranged spherically with an r^{-2} density dependence around each cluster center, extending halfway to the nearest neighbor cluster center. Various statistical analyses—void distribution, two-point correlation function, counts-in-cells, and percolation—all show that this model is remarkably similar to the observed distribution of galaxies. It helps to guide and constrain many other proposed models of large scale structure.

Thuan, in collaboration with Yu. Izotov (Kiev Observatory, Ukraine) and V. Lipovetsky (Special

Astrophysical Observatory, Russia), use high quality spectrophotometric observations of 10 low-metallicity blue compact galaxies (BCGs) with oxygen abundance ranging from $12 + \log(O/H) = 7.37$ to 8.04 to determine the primordial helium abundance. They take special care into investigating the physical effects which may affect such a determination. They find that underlying stellar absorption, enhancement of helium lines due to self-absorption, and corrections for neutral and doubly ionized helium to be negligible. The main physical mechanism changing the He I line intensities from their recombination values is collisional excitation. To correct for it, they calculate the electron number density in the He^+ zone by a self-consistent procedure which constrains the He I $\lambda5876/\lambda4471$, $\lambda6678/\lambda4471$ and $\lambda7065/\lambda4471$ line ratios to have their recombination values, after correction for collisional enhancement. The density sensitive He I $\lambda7065$ line plays an important role in this respect. The usual practice of using the electron number density derived from the [S II] $\lambda6717/\lambda6731$ ratio underestimates the collisional enhancement correction and hence overestimates the helium abundance by $\sim$ 5 percent. They find that Brocklehurst's (1972) He I recombination emissivities give a smaller dispersion of the data points in the Y-O/H and Y-N/H planes and within the derived He abundances from different lines in a given galaxy than Smits' old (1991a,b) emissivities. The dispersion is comparable when Smits' new (1994) emissivities are used. By taking the mean of the intercepts of both Y vs. O/H and Y vs. N/H linear regressions at O/H = N/H = 0, they determine a primordial helium mass fraction $Y_p = 0.229 \pm 0.004$, with Brocklehurst's emissivities, and $Y_p = 0.240 \pm 0.005$ with Smits' new emissivities. Taking the mean Y of the 4 most metal-deficient BCGs ($Z < Z_\odot/15$) in their sample gives $Y_p = 0.233 \pm 0.003$ with Brocklehurst's emissivities. Adding the 4 known BCGs with $Z < Z_\odot/15$ from the literatures yields: $Y_p = 0.232 \pm 0.002$. These determinations are consistent with the lower limit of $Y_p = 0.236$ required by standard Big Bang nucleosynthesis theory. They obtain a slope $dY/dZ = 5.8 \pm 1.7$ with Brocklehurst's emissivities and $dY/dZ = 5.8 \pm 4.4$ with Smits' new emissivities, larger than the values predicted by closed-box models, but consistent with those given by chemical evolution models with differential galactic winds.

Thuan, in collaboration with S. Pustilnik, A. Ugryumov, V. Lipovetsky (Special Astrophysical Observatory, Russia) and N. Guseva (Kiev Observatory, Ukraine) has studied the spatial distribution relative to bright normal galaxies of a new large sample of Blue Compact Galaxies (BCGs) in the zone of the

Second Byurakan Survey (SBS): $7^{\rm h}40^{\rm m} < \alpha < 17^{\rm h}20^{\rm m}$, $49° < \delta < 61\overset{\circ}{.}2$, using as a statistic the distance D_{NN} to the nearest neighboring bright galaxy. They found that the majority ($\sim 80\%$) of BCGs have $D_{NN} < 5h^{-1}$ Mpc and follow generally the large-scale structure delineated by bright galaxies, but that a minority ($\sim$ 20%) have $D_{NN} > 5h^{-1}$ Mpc and are found in voids. The lack of BCGs with $D_{NN} \sim 2h^{-1}$ Mpc supports the hypothesis that the majority of dwarf galaxies originate as low-mass primordial density fluctuations, but not as debris resulting from tidal interactions between massive galaxies. The spatial distribution of BCGs is consistent with that found for low-surface-brightness dwarfs, supporting the idea that BCGs are LSB dwarfs undergoing intense bursts of star formation.

f. Astrometry

The southern CCD parallax program, under the direction of Ianna, has been given some emphasis during the past year. This work is carried out at the Mount Stromlo and Siding Spring Observatories. The observing list includes low luminosity stars and southern stars lacking parallaxes in the Catalog of Nearby Stars.

Ianna completed the analysis of the McCormick plate material of HR 6697, a star identified as probably nearby by H. McAlister (GSU) and Ianna. The star was found to be a spectroscopic binary by R. Culver (CSU) with component spectral types of G2 V and K4 V. The astrometry, radial velocities, and speckle observations have been combined for the determination of accurate masses for the pair. The 882 day period was seen in the astrometry as well.

Ianna has been using McCormick plates to re-investigate Barnard's star and test for the existence of an astrometric perturbation. In a preliminary analysis using half the plate material (499 images obtained between 1969 and 1993), periodogram analysis shows neither the 12 nor the 20 year Sproul periods, nor other periods of significance in either coordinate. Further analysis using the complete data set, which now has been measured, is under way.

Ianna and Fredrick have extended the observations of ESO 207-61 and improved the parallax for this, one of the lowest luminosity objects known. It lies near the termination of the main sequence in the HR diagram. Comparisons with theoretical models of low mass stars and brown dwarfs are seriously hindered by the large uncertainties in the effective temperature calibrations for stars as cool as ESO 207-61. The mass of this object may be as low as 0.07 solar masses.

Ianna and J. Martin (undergraduate student) are investigating the relative astrometric precision of plates versus Estar-based 4415 Tech Pan film. Since Kodak terminated the manufacture of most of their spectroscopic emulsions, we have been looking into alternatives. Preliminary results suggest a relative precision of $\pm 0.8\,\mu$m for the 4415 compared with $\pm 0.4\,\mu$m for IIIa-F glass plates measured on the PDS.

Ianna and Swain have completed scanning a number of McCormick parallax regions with the Observatory's PDS microdensitometer. For the most part these are dM stars found in the Vyssotsky survey. A parallax list is in preparation.

C. Mullis (undergraduate student), Begam, and Ianna reduced fourteen CCD frames of LHS 2067 and LHS 2068, a common proper motion pair with motions of 0.630 arcseconds per year in the Luyten Half Second Catalog. Spectroscopy from M. S. Bessell had shown LHS 2067 to be a Mira variable, and so it seemed unlikely to have a large proper motion. Our data show the large proper motions for both LHS 2067 and 2068 to be spurious.

g. Space Astronomy

O'Connell continues as a Co-Investigator for the Ultraviolet Imaging Telescope of the *Astro-2* Spacelab payload, currently planned for a 16-day mission during February 1995. The two most extensive UIT programs planned for the mission involve Galactic globular clusters and spiral galaxies.

IV. MISCELLANY

Balbus served on the peer review panel for the NASA Theory Program. Chevalier was Chair of the Scientific Advisory Committee for the Jubilee Gamow Seminar in St. Petersburg, Russia. Hawley was appointed a Departmental Visitor to the Astrophysics Theory Centre, School of Mathematical Sciences, Australian National University, July 1994. Ianna was elected Vice-Chair of the Division on Dynamical Astronomy of the AAS, and Vice-President of Commission 24 (Photographic Astrometry) of the IAU. O'Connell served as a member of the NASA Astrophysics Science Operations and Data Analysis working group and as chair of the search committee for the Director of Kitt Peak National Observatory. Richards served as a member of the NASA IUE and EUVE Guest Observer peer review committee. Rood served on the Hubble Fellowship selection committee. Rood was a Shapley Lecturer. Sarazin was a member

of the NASA Working Group on X-ray Astronomy and the NASA AXAF Users Committee. He was on the scientific organizing committees for the Moriond Astrophysics Conference on "Clusters of Galaxies" and the Aspen Astrophysics Workshop on "The Physics of Clusters of Galaxies." Thuan was on leave during this period at the Observatoire de Meudon and the Service d'Astrophysique at Saclay in France. Whittle has served on the NOAO dark time TAC. Tolbert continues to serve as Treasurer of the Society for Scientific Exploration. He is a lecturer in the AAS Shapley Lectureships Program. Tolbert served on a panel of the Geophysical Society of America on the Teaching of Earth Science in the U.S.

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