The Johns Hopkins University  
Center for Astrophysical Sciences  
Department of Physics and Astronomy  
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I. INTRODUCTION

A massive building is under construction across the street from the Space Telescope Science Institute, which will house the Center for Astrophysical Sciences; the Department of Physics and Astronomy; the new Johns Hopkins Space Grant Consortium (see below); as well as several functions of the Space Telescope Science Institute itself. Occupancy of the building will be the late spring of 1990, which is about the same time that the Hopkins Ultraviolet Telescope will fly on the Space Shuttle (as part of the ASTRO mission), and Space Telescope will be launched. The Center for Astrophysical Sciences is therefore looking toward a year of culmination; but at the same time, with the success of the Lyman FUSE proposal, the continuing success of the Magellan 8-meter project, and our hopes for a future Small Explorer mission, a beginning.

II. PERSONNEL

Jeffrey Kruk has joined A. F. Davidsen in the HUT Project as an Associate Research Scientist, and Avery Meiksen is currently a Visiting Scholar in theoretical astrophysics to NASA funding; the Consortium at Johns Hopkins University and Space Telescope Science Institute. Other permanent staff members contributing to research in astronomy and astrophysics are: P. J. Dagdiggian, A. F. Davidsen, J. Doering, P. D. Feldman, H. Ford, R. Giacconi (Director, ST ScI), T. Heckman, R. C. Henry, B. Judd, C. Kim, H. W. Moos (Director, CAS), C. Norman, and D. F. Strobel, A. Szalay, Professors; J. Krollik, Associate Professor; R. F. G. Wyse, Assistant Professor; R. A. Brown, S. M. Fall and F. Paresce, Research Professors; S. Lubow, Assistant Research Professor; Wm. G. Fastie, Adjunct Research Professor; K. S. Long and S. T. Durrance, Research Scientists; W. P. Blair, C. W. Bowers, M. Clamphin, S. Friedman, R. A. Kimble, G. A. Kriss, S. McCandlish, M. D. Morrison and A. Uomoto, Associate Research Scientist; and H. A. Weaver, Assistant Astronomer (ST ScI).

III. THE JOHNS HOPKINS SPACE GRANT CONSORTIUM

On August 31, 1989, the National Aeronautics and Space Administration announced that the Johns Hopkins University had been selected to lead one of 17 National Space Grant Consortia. The Johns Hopkins University is now entitled to refer to itself as a "Space Grant College", in the spirit of the Land Grant Colleges that created and formed such a fundamental part of our American higher education system. The Johns Hopkins Space Grant Consortium consists of the Johns Hopkins Institutions, particularly the Homewood Campus (School of Arts and Sciences, and G. W. C. Whiting School of Engineering), and the Applied Physics Laboratory, located in Laurel, Maryland; Morgan State University, an independent historically-black university located a few miles from the Homewood Campus; and the Space Telescope Science Institute, which is operated by AURA, Inc., and is located on the Homewood Campus. In addition to NASA funding, the Consortium enjoys financial support from Martin Marietta, Computer Sciences Corporation, and Westinghouse. The Consortium will fund and/or carry out projects and programs aimed at fulfilling these objectives: to encourage cooperative programs among diverse institutions, locally and nationally; to encourage interdisciplinary training programs, research programs, and public service programs, related to aerospace; to recruit and train professionals, especially women and underrepresented minorities, for technical careers; and to promote a strong technical education base from elementary through university levels. Director of the Consortium is Richard C. Henry, Associate Director for Interdisciplinary Programs is Vincent Pisacane, Head of the Space Department at the Applied Physics Laboratory. George Peterson, a Vice-President of Morgan State University, is Associate Director for Undergraduate Programs, while Eric Chaisson, of the Space Telescope Science Institute, is Associate Director for Public Service. Central aims of the Consortium are increased minority and female involvement in aerospace, and increased synergism among the institutions that make up the Consortium.

IV. RESEARCH AND ACTIVITIES

William P. Blair continues his duties as science planning coordinator for the Hopkins Ultraviolet Telescope (HUT) and for the JHU portion of the Faint Object Spectrograph (FOS) Team. These duties have included detailed involvement in planning and executing the planned April 1990 launch of HUT as part of the Astro Observatory, as well as participation in ground system testing for FOS calibration and data reduction. In addition, he has continued research on galactic and extragalactic supernova remnants using both ground-based telescopes and the orbiting IUE observatory. A detailed study of a young, oxygen-rich supernova remnant in the Small Magellanic Cloud using IUE has been completed with J. C. Raymond (SAO) and J. Danziger and F. Matteucci (ESO). The same collaboration has successfully obtained long IUE integrations of two positions in the oxygen-rich remnant N132D in the Large Magellanic Cloud this year. A detailed study of the LMC remnant 0540-69.3 has also been carried out with R. P. Kirshner (Harvard), J. A. Morse (Harvard), and P. F. Winkler (Middlebury College). With R. S. Long (JHU/CAS), a combined CCD imaging and spectroscopy study has been carried out on supernova remnants in the Sculptor group spirals NGC 300 and NGC 7793, using the 2.5 m DuPont telescope at Las Campanas Observatory. Nearly 30 remnant candidates in each galaxy were identified from interference filter images and follow up spectroscopy at Las Campanas has confirmed many of the identifications. With Long, Kirshner, and Winkler, and imaging CCD survey of M33 to find remnants has been quite successful, and spectroscopic follow-up is continuing. These observations are being used to study supernova remnant evolution and the effect of remnants on the interstellar mediums of these galaxies. With Long and W. Krzeminski (LCO), optical emission from the remnant of SN1957D in M83 has been recovered and studied. A combined imaging and spectroscopic study of Kepler's supernova remnant has been accomplished with R. A. Fesen (Univ. of Colorado), R. H. Becker (Univ. of California, Davis) and Long. This investigation has identified nonradiative shock emission in this remnant for the first time. An on-going investigation with Long is extending this result to fainter emission in Kepler's remnant and to RCrB. The nonradiative emission has also been identified. Also with Fesen, interference filter CCD imagery of the Crab Nebula has been used to identify and study interstellar dust in the Crab Nebula. Archival data from the Voyager 2 Ultraviolet Spectrometer has been used to investigate the emission from
the Cygnus Loop supernova remnant in the 912-1200 Å region, with Long, O. Vancura (JHU/CAS), and J. B. Holberg (Univ. of Ariz./LPL). These data indicate strong emission at 1035 Å throughout the Cygnus Loop, probably due to emission from O VI λλ 1032,1037. Comparisons with X-ray optical and infrared data are continuing as is planning for higher resolution observations with HUT at selected locations in the Cygnus Loop.

Charles W. Bowers has continued pre-flight assembly, integration and testing work on the HUT project. Redesign of the HUT detector assembly has resulted in a more rugged detector for spacecraft flight and improvements in coating design and yield. Significant improvements have been made in the instrument efficiency. In addition, work on the design and specifications of a classically ruled and blazed diffraction grating has begun. The goal of this project is to obtain such a high efficiency grating for use with successive flights of HUT. Bowers has also continued work on an observing program of Type I planetary nebulae conducted at Las Campanas. These generally bipolar planetary nebulae are characterized by relatively high Hé and N abundances and are believed to have been formed from massive progenitor stars. Simultaneous strong emission from high and low ionization states is typically observed. Many are believed to have a torus of neutral matter and dust surrounding the central star. CCD images were taken through a variety of interference filters of several of these objects. Reduction of these images is nearly complete. Dust structure and excitation conditions in these nebulae as well as revealing their very extended and filamentary morphology. The hypothesized central disks have been revealed by two distinct methods. In some cases, O I imagery has revealed the disks directly. More generally, ratio maps of Hα/He have shown very large differential extinction in several of these objects. Analysis of the previously hypothesized dust disks can be used to infer properties of the dust itself. Long slit echelle spectroscopy of several Type I objects was also obtained by Knox Long and William Blair and analysis of this data is beginning. In conjunction with the imagery, this high resolution spectroscopy should permit the kinematic structure of these nebulae to be resolved as well as reveal the presence of any high velocity winds which have been observed in a few members of this group of particularly interesting planetary nebulae.

Mark Clampton is collaborating with Dr. S. T. Durrance in the development of the JHU adaptive optics coronagraph. The first stage of this program, a device compensating for atmospheric turbulence (wavefront tilts), has been completed and successfully tested. Development of a fully adaptive system based on a membrane and a wavefront curvature sensor is now in progress. Clampton also continues his work on the development of the RANICON photon counting detector in collaboration with Dr. F. Parese. The GaAs photocathode RANICON has been recently evaluated in the laboratory and development of a RANICON-based time-tagging system for high resolution imaging is nearing completion. The RANICON has recently been adopted by ESO for a high resolution study of AG Carina and is scheduled again for high resolution studies of SN 1987A.

Paul J. Dagdigian and his students are engaged in the study of instable and reactive collisions of small molecular free radicals. In these experiments, tunable laser fluorescence excitation is employed to measure populations of individual vibration-rotation states of the product molecule under investigation. During the past year relative integral cross sections for specific rotational transitions in collisions of several free radicals with a number of targets have been determined. These include NH₂(2⁻Ba)-He, NH(X-²E)-Ar, and NH(4⁺A) + with a number of molecules. The rovibrational state distribution of NH produced in ground X-²Σ⁺A electronic states in the reaction of hydrogen atoms with the N3 radical is currently under investigation. A time-of-flight mass spectrometer has also been constructed to allow the detection of individual states of the nitrogen molecule and other species by resonance enhanced multiphoton ionization. With this technique we have succeeded in observing the N₂ photofragments from the 283 nm photolysis of hydrazine (HN₃) and have shown that these fragments are born with considerable rotational excitation (ca. 0.8 eV). In related theoretical work, the inelastic scattering of ÆII molecules falling in the Hund's case (b) limit was investigated. It was shown that the Δ doublet propensities are opposite for molecules π vs. n° orbital occupancy (e.g. C₂H vs. OH). This has implications for an understanding of the pumping mechanisms in astronomical masers.

Arthur Davidsen continues to direct the Hopkins Ultraviolet Telescope project, with launch aboard the Astro-1 Mission now scheduled for April 26, 1990. A new spectrograph and detector system have been installed in HUT, which has remained at the Kennedy Space Center since the Challenger incident. Continued testing of the instrument and its interfaces with Spacelab, mission planning, and mission simulations continue to occupy the members of the HUT group nearly full time. Davidsen presented an invited talk on HUT at the 174th meeting of the AAS in Ann Arbor. Davidsen is also continuing his investigation of the 4000 Å break strength in elliptical galaxies in collaboration with Allan Sandage (MWPLO) and Randy Kimble (JHU), under whose paragraph in this report is a description of this work.

John Doering and graduate student, Luke Goembel, are continuing earlier investigations of electron impact excitation of the electronic states of NI. Work so far has been focused on the (6S²S-3p²P) (A 1200 Å) optically allowed transition. Difficulties arising in the laboratory measurement including the small percentage dissociation of N₂ (≈5%) in the NI source and the background of N₂ metastables produced by the source have largely been overcome. The excitation cross section has been measured, from 30 to 100 eV - the region which includes the 3 x 10⁻¹⁷ cm² peak. Further measurements of NI cross sections are underway.

S.M. Fall, in collaboration with H. Kang and P.R. Shapiro (University of Texas at Austin), and M.J. Rees (Institute of Astronomy, Cambridge), have examined in some detail the thermal history of metal-free gas overtaken by radiative shocks with velocities characteristic of gravitationally-induced motions inside a typical protogalaxy. This is relevant to suggestions by Fall and Rees that globular clusters formed in the compressed gas resulting from such shocks or from a thermal instability. Kang et al., solved the hydrodynamical equations, along with the rate equations for non-equilibrium ionization, recombination, molecular formation and dissociation and the equations of radiative transfer for steady-state shocks of velocity 300 km s⁻¹ in a gas of preshock density 0.1 to 1 cm⁻³. The calculations include external sources of UV and soft X-ray radiation such as might be present within a protogalaxy. In the absence of these sources, enough molecular hydrogen is produced behind the shocks to cool the compressed gas rapidly from 10⁴ to 10² K. However, when the total luminosity of the sources exceeds a few x 10⁴⁴ erg s⁻¹ in the case of AGN's or a few x 10⁴⁵ erg s⁻¹ in the case of early-type stars, the formation of H₂ behind the shocks is suppressed and the cooling time of the gas at 10⁴ K is longer than its internal free-fall time. This ensures that the radiatively-cooled postshock layer is of the same order of magnitude as the masses of globular clusters. Fall and Y.C. Pei, in collaboration with R.G. McMahon (Institute of Astronomy, Cambridge), find that quasars with damped Lyα systems in the foreground tend to appear redder than those without damped Lyα systems in the foreground. Their detection, at or above the 99% confidence level, is based on the spectra recently obtained by Sargent and collaborators. Fall, Pei, and McMahon estimate that the typical dust-to-gas...
ratio in the damped Ly\alpha systems is 1/20 to 1/4 of that in the Milky Way, with the exact value depending on the shape of the extinction curve. A comparison of their results with the upper limits from previous searches suggests that the 2200 Å feature may be weak or absent. This and the small dust-to-gas ratio is consistent with other evidence that the damped Ly\alpha systems are in an early phase of chemical evolution. The dust fall, Pei, and McMahon have detected is probably sufficient to extinguish a large fraction of any Ly\alpha photons emitted within the damped Ly\alpha systems. Pei and Fall have also estimated the contribution of damped Ly\alpha systems to the mean optical depth as a function of redshift along random lines of sight. Their calculations have included, one for the Ostriker-Heisler effect that absorbers with large quantities of dust may be underrepresented in magnitude limited samples of quasars and the other for the evolution effect that absorbers have lower abundances of dust at high redshifts than at the present epoch. Pei and Fall find that the mean optical depth in the B band of an observer on Earth caused by damped Ly\alpha systems with \z \leq 3 is only 0.3 or 0.1, depending on whether the extinction curve is assumed to have the same shape as that in the Milky Way or the Magellanic Clouds. This is not enough obscuration to cause an apparent turnover in the redshift distribution of quasars.

Paul D. Feldman directs the NASA supported sounding rocket program, which has as its main focus the development of instrumentation for far- and extreme-ultraviolet astronomy. A rocket launch to obtain long-slit ultraviolet spectra of the Io torus in January 1989 was unsuccessful due to a malfunction of an inertial guidance system and will be repeated later this year. This work is being carried out with Associate Research Scientist Stephen McCandless and graduate students David Sahnow and Mel Martinez. Feldman also continued his IUE comet program (with graduate student Elizabeth Rochford) in collaboration with M. F. A'Hearn of the University of Maryland and M. C. Festou of the Observatorio de Besancon with observations of periodic comets Tempel-2 and Borresen-Metcalf, and has continued as a member of the Imaging System Science Team for NASA's Comet Rendezvous/Asteroid Flyby mission and as member of the imaging instrument definition science team for the Cassini mission. He currently serves as a Trustee of the Universities Space Research Association.

H. Ford, X. Hui, K. Freeman, M. Dopita, S. Meatheringham, and R. Ciardullo have detected 800 PN in α Cen A survey which is complete from 2 kpc to 20 kpc. Subsequently they measured velocities of ~300 PN using the [OIII] \lambda5007 emission line. This unprecedented number of stellar velocities in another galaxy has enabled them to investigate stellar dynamics out to 20 kpc in Cen A's halo. The velocities of the PN show indisputably that the halo is rotating about the photometric minor axis (NE approaching, SW receding). The rotation curve rises from the center of the galaxy and then flattens to a value of ~100 km s^{-1} between 10 and 20 kpc. Combining the velocity dispersion and rotation along the major axis with the Boltzman equation shows that M/L increases from a value of approximately 2 in the center to 10 in the halo, and shows that Cen A has a dim or dark halo. Surprisingly, the galaxy also rotates about the photometric major axis (SE approaching, NW receding) at a rate of ~50 km s^{-1} between 2 and 10 kpc. The velocity dispersion appears to be indistinguishable between the two axes, but the halo to disk ratio is 4:1. The minor axis rotation shows that the galaxy is most likely triaxial. In contrast to the rotationally supported stellar halo, the globular cluster system is rotating very slowly, if at all. This shows that the halo stars and clusters are different populations which most likely formed at different times. Ford, in collaboration with R. Ciardullo, A. Shafter, D. Neill, M. Swaters, and Tomany light curves for 11 M3 novae, four of which were well observed near maximum. These data, along with the Hα light curves of two Galactic novae, demonstrate that a nova's maximum Hα flux occurs days or weeks after its continuum maximum at a monochromatic intensity one to two magnitudes above its peak flux in B. Moreover, after this maximum is achieved, a typical nova will radiate a third as many photons in Hα as in the entire B bandpass. The most interesting part of a nova's Hα light curve, however, is its decline. They find that, regardless of a nova's speed, its Hα decay rate after maximum is almost identical to its decay rate in B. Because the effective temperature of the central source is most likely increasing during this time, this behavior suggests that most of a nova's optical luminosity during early decline is continuous emission from the central source rather than direct radiation from the central source. Although the data are limited, they find no correlation of maximum Hα magnitude with nova speed, and no evidence that an Hα maximum magnitude--rate of decline relation exists. However, the Hα emission is still a useful tool for studying the underlying population of nova progenitors. To facilitate such probes, they present the mean Hα light function for novae for a set of limiting magnitudes. These values will enable extragalactic nova rates to be derived from multi-epoch Hα surveys. Ford, in collaboration with R. Ciardullo, J. Jacoby, and J. Booth, used the planetary nebula luminosity function (PNLF) to measure a distance of 3.50 ± 0.34 Mpc to M81. The starting point was the identification of 183 planetary nebula candidates from a CCD survey of M81 with the KPNO 4 m telescope. A statistically homogenous and complete sample of 88 nebulae representing the brightest 1.2 mag of the luminosity function was fit to the PNLF in M31. M81 provides an excellent test case for comparing the distances determined from the PNLF with estimates from other techniques. The derived distance compares well with the distance determined from Cepheid (3.3 Mpc) and the infrared Tully-Fisher relation (3.7 Mpc), and shows that the PNLF will be an accurate standard candle which can be used at large distances (~15 Mpc) in early type galaxies devoid of Cepheids and HI. Ford, R. Ciardullo, and J. Jacoby tested the internal consistency of the PNLF standard candle by measuring the distances to three early type galaxies in the Leo I group. Altogether they found 249 nebulae in the top 1.5 mag of the PNLF, including M33 (1.8 mag), M31 (3.7 mag), and M81 (1.5 mag). Using Hubble types and metallicities demonstrates that the PNLF is an excellent and highly consistent standard candle for early type galaxies. Ford, I. Evans, and X. Hui applied the technique of maximum entropy image restoration to the problem of deconvolving the point spread function from a deep, high quality V-band image of the optical jet of 3C-273. The resulting maximum entropy image has an approximate spatial resolution of 0.6" and has been used to study the morphology of the optical jet. Four regularly spaced optical knots are clearly evident in the data, together with an optical "extension" at each end of the optical jet. The jet oscillates around its center of gravity, and the spatial scale of these oscillations is very similar to the spacing between the optical knots. The jet is marginally resolved in the transverse direction, and has an asymmetric profile perpendicular to the jet axis. They present the distribution of V-band flux along the length of the jet, and accurate astrometry of the optical knot positions.

Riccardo Giacconi is pursuing a research program to study Clusters of Galaxies. Over the past year, working with R. Burg, W. Forman, and C. Jones, he has completed work on deriving the X-ray luminosity function of
Abell Clusters. With A. Cavaliere and R. Burg he has worked on the theoretical connection between initial density fluctuations and the x-ray properties of Clusters. New programs include an automated system to find optical counterparts to ROSAT All-Sky survey sources (in particular the development of algorithms to separate out high redshift clusters), and preparation for the ROSAT Deep Sculptor. Along with C. Burrows and R. Burg he has worked out designs for optimized wide field x-ray optics which have better than 3 arc-second spatial resolution with a one degree field of view. These designs can be used to develop telescopes that can efficiently discover and study clusters to redshifts of 2 or greater.

**Tim Heckman** and collaborators have conducted two investigations of molecular gas in Seyfert galaxies, as probed by their mm-wave CO emission. The first (with Armus, Blitz, Miley, and Wilson) was a survey with ~1 arcmin resolution of a large, optically-selected sample of Seyferts. Compared to normal galaxies, the type 2 Seyferts were systematically several times stronger CO (and far-IR continuum) emitters, while the type 1 Seyferts were normal. This implies that the two Seyfert types are intrinsically different, and suggests that the type 2 Seyferts have higher-than-normal rates of star formation and interstellar media that are unusually rich in molecular gas. This agrees with recent ideas concerning the evolutionary relationship between the two Seyfert types and starburst galaxies. The second program (with Blitz, Meixner, Puchalsky, and Wright) produced arc-sec-resolution images showing that the CO emission in two Seyferts (NGC 327 and NGC 7469) is strongly concentrated within a few hundred pc of the nucleus. The implied nuclear molecular masses are orders-of-magnitude higher than in typical normal spirals, and completely dominate the material studied optically (the Narrow-Line Region). If these results can be generalized, there will have major implications for the "care and feeding" of Seyfert nuclei. Collaborators (Armus and Miley) investigated the ionized gas and stellar populations in a large sample of far-IR-selected galaxies. The data clearly reveal the presence of a population of young, massive stars whose extinction-corrected bolometric luminosity is probably adequate to power the far-IR. The ionized gas in these galaxies is highly extended (typically by tens-of-kpc), and (as the first program) shows a complex distribution of molecular gas. There has a luminosity that correlates with that of the young stellar population. They find that the kinematics and physical conditions in the ionized gas strongly suggest that it consists of ambient interstellar matter immersed in a galaxy-scale wind (a "superwind"). The detailed properties of the gas are in excellent agreement with theoretical calculations of supernovae-driven superwind models. The superwind is associated with the starbursts. If all the starburst galaxies in the local universe drive supernovae with only a few thousand seconds of the current stellar mass, then the starburst is associated with the high supernova rate at the center of the galaxy NGC3628. These data provide evidence for outflowing hot gas along the minor axis of the galaxy (similar to that seen in the proto-typical IR/starburst galaxies M82 and NGC253). Heckman and collaborators (Smith and Illingworth) have continued their investigation of the properties of powerful radio galaxies (PRG's). They find that the class of PRG's having strong Seyfert/QSO-like optical emission-line spectra are frequently disturbed in optical morphology, have bluer colors and lower stellar velocity dispersions than normal giant ellipticals, and inhabit regions whose galaxy density is similar to that of radio-loud QSO's, but significantly lower than that of the class of PRG's with weak optical emission-lines. It is likely that significant fraction of these "strong-emission-line" PRG's are engendered by mergers or interactions involving at least one disk galaxy. In contrast, the PRG's with weak emission-lines most strongly resemble the brightest ellipticals in clusters of galaxies in terms of absolute magnitude, color, photometric structure, stellar dynamics, and local galaxy density. Heckman and collaborators (Franx and Illingworth) analyzed multi-object spectroscopy and stellar dynamical data for a large sample of normal elliptical galaxies. The most important conclusion was that a significant fraction showed detectable velocity gradients along the optical minor axis, implying that many (most) ellipticals probably have triaxial figures.

**Richard C. Henry** conducts research on the interstellar medium, cosmology, and ultraviolet background radiation. A second paper on the Johns Hopkins UVX cosmic background observations has been accepted, by Astronomy and Astrophysics. The UVX experiment on cosmic ultraviolet background radiation flew on the Space Shuttle in January 1986. A third paper is planned, the Berkeley UVX results have been published, coordinating with those results and presenting details of individual targets. Henry presented the Johns Hopkins UVX results at the June 1989 Heidelberg symposium (IAU #139) on cosmic diffuse background radiation. Johns Hopkins is attempting to pursue the study of the diffuse cosmic background through NASA's Small Explorer Program. Henry's study of the interstellar medium continues via two paths, IUE and IRAS. A paper has been submitted to the Astrophysical Journal analyzing IUE data on the lines-of-sight to α And and Capella. Results obtained are consistent with our previous Copernicus and IUE studies of the local interstellar medium, with one remarkable exception: for the present two lines of sight we find a significant overabundance of deuterium relative to hydrogen. This is not the first claim of such a dispersion in the D/H ratio among various short lines of sight, but our work has emphasized particularly careful analysis of errors, and we believe that our present results put the reality of such a dispersion on a considerably more secure footing. This is important, because a substantial dispersion in D/H ratio over such small (~10pc) regions of the galaxy is difficult to understand unless deuterium is manufactured locally, in which case the generally accepted cosmological interpretation of the D/H ratio is obviated. However, even with local recent manufacture, the results are still very difficult to understand. Further confirmation of the reality of the dispersion is therefore an obvious critical high-priority Space Telescope task, the HRS Space Telescope being ideally suited to the task. Henry's IRAS study, conducted with Murthy, Kimble, Werner, Walker, and Henry's graduate student, Jim Wofford, centers on probing the interstellar medium above the plane of the galaxy using bright stars, especially ultraviolet-bright stars, as local probes, heating the dust grains in their immediate vicinity. The galactic light contribution is removed, essentially by subtracting the average signal far from the star in question. What is left near the star is a) the effects of heating of dust by radiation from the star, plus b) the effects of heating by the interstellar radiation field if the density of dust along the line of sight to the star is significantly in excess of the average. (The second contribution will average to zero, if many stars are studied.) We thus set limits on the amount of dust present at the distance and in the direction (especially, distance above the galactic plane) of the star in question, as well as finding the filling factor of dust as a function of distance above the galactic plane. A paper is in preparation giving initial results.

**Randy Kimble** has continued his work as Deputy Project Scientist for the Hopkins Ultraviolet Telescope Project. He has been engaged this past year principally in the fabrication and calibration of an improved spectograph for the telescope, and in its installation and alignment to the telescope at the Kennedy Space Center. Numerous
additional activities in preparation for next year's launch of HUT continue. Kimble, Davidsen, Homewood Professor Allan Sandage, and Henry Ferguson have continued their spectrophotometric observations of elliptical galaxies in nearby clusters using the Lick 1.25m du Pont Telescope. They have obtained essentially complete samples of elliptical galaxy spectra to fainter than 16th magnitude in the Virgo and Fornax clusters. The particular emphasis has been on the relationship of the 4000 Å break strength to other fundamental galaxy parameters. They have demonstrated the sensitivity of this feature to both metallicity and recent star formation and have shown its unsuitability for use as a distance indicator. Also of interest was their confirmation that previously morphologically identified "M32-like" compact galaxies in Virgo are in fact low-luminosity cluster members and not background giants. Among these, they have identified a subset of compact galaxies whose spectral properties show clear effects of the proximity of a massive neighbor. Kimble, Henry, and student Jim Wofford, along with Jayant Murthy of GSFC and Mike Werner and Helen Walker of NASA Ames, have continued their investigation of the distribution of interstellar dust, using IRAS observations of infrared cirrus in the vicinity of luminous stars. Murthy has recently presented their results regarding the patchy distribution of this dust at IAU Symposium No. 139, "Galactic and Extragalactic Background Radiation". Along with Principal Investigators Richard Henry and Francesco Paresce, Kimble participated in developing two major proposals, to NASA's Small Explorer and Space Station programs, for a far ultraviolet diffuse background/point source all-sky survey mission. Kimble described the concept for this mission, the Hopkins Ultraviolet Background Explorer, also at IAU Symposium No. 139.

G. A. Kriss is continuing studies of the dynamics of clusters of galaxies in collaboration with E. Malumuth (STScI/CSC) and graduate students H. Ferguson and W. V. D. Dixon using the Nessie multi-fiber feed on the KPNO 4m telescope and the Argus multi-fiber instrument at the prime focus of the CTIO 4m. In 2 1/2 nights on the KPNO 4m, redshifts were obtained in the clusters A85 and A49. An additional 3 nights at CTIO produced 100 redshifts in A 496 and in DC0107-46. The primary objective of the investigation is to set limits on the distribution of galaxy orbits in the clusters. Mass constraints are first derived from HEAO A-2 and Einstein Observatory X-ray data. With this description of the gravitational potential, the maximally extended technique of Richstone and Tremaine is used to derive the internal distributions of radial and tangential velocity dispersions allowed by the projected velocity dispersion profile of the cluster. All the observed clusters have derived radial and tangential dispersion profiles consistent with an isotropic distribution of galaxy orbits. With 148 cluster members galaxies in A 496 interior to a radius of 20 Mpc ($H_0 = 50$ km/s), a limit on the average anisotropy parameter 

$$(\beta = 1 - \sigma_r^2/\sigma_z^2) \text{ of } < 0.4$$

can be set at the 90% confidence level. Kriss is also investigating the utility of the He II λ1640/Ly α line ratio as a spectral diagnostic for the 10 - 100 eV continuum of quasars and Seyfert galaxies. Quasars with large blue bumps and strong soft X-ray excesses like PG1211+143 have λ1640/Ly α ratios of ~0.10, much higher than the typical value of ~0.05 often seen in other AGN. He is beginning a study of a large sample of objects to see if the λ1640/Ly α ratio correlates with the strength of the blue bump or with the presence or absence of a soft X-ray excess.

Knox S. Long is a Co-Investigator and the Project Scientist for the Hopkins Ultraviolet Telescope, now scheduled for launch on the Shuttle in 1990. Long continues to be active in the development of a design for an 8-m telescope at Las Campanas. He is a member of the science working group for that project and, in conjunction with it, is an Adjunct Associate of the Carnegie Institution. While the Shuttle was inactive, he has pursued his research interests in supernova remnants from the ground and, in collaboration with R. P. Kirshner (Harvard U.) and P. F. Winkler (Middlebury College) have been conducting an interference filter survey of M33 using the Kitt Peak 4-m in order to significantly increase the sample of ~20 SNRs known in that galaxy. Thirty new candidates have been identified on the basis of strong [SII] emission relative to Hx and no evidence of continuum emission in a portion of M33 where only 10 supernova remnants were known previously. The new candidates in M33 tend to be somewhat larger and of lower surface brightness than the previously known supernova remnants. The cumulative number-diameter relation (N<vs D) relationship for all the supernova remnants and candidates in M33 are old--has a slope of ~2.1 which provides evidence that supernova remnants have been strongly decelerated by the interstellar medium of M33. Long and Blair have also been studying more distant Sculptor group spirals NGC300 and NGC7793 using a TI CCD and the CHUEI on the DuPont telescope. They have identified 27 nebulae in NGC300 and 31 nebulae in NGC7793 which appear to be supernova remnants. Spectroscopic confirmation of one of the candidates in M33 and in the Sculptor group spirals has now been obtained. Long and Blair, using data obtained from the Swope and DuPont telescopes at Las Campanas, are also compiling a catalog of optical images of galactic supernova remnants in the field of Hx, [SII], and [OIII]. This catalogue will be useful in characterizing the optical properties of supernova remnants. As part of our ongoing analysis of this survey, they have identified nonradiative filaments in Kepler's SNR (Fesen, et al. 1989) and the RCW86. Thus nonradiative optical filaments have now been identified in all remnants of historical type Ia supernovae. Long, Blair, and Charles W. Bowers (JHU) have used the new cross-dispersed echelle spectrograph at Las Campanas to simultaneously observe the density sensitive doublet of [OIII] λλ3727, 3729 and [SII] λλ6717, 6731 at several positions in six supernova remnants (and a similar number of planetary nebulae). The data are being analyzed to determine the degree to which both line ratios indicate the same density in the recombing plasma which dominates emission from radiative shocks. Since the [OIII] line producing region is about a factor of two higher than the [SII] producing region, one might anticipate the density in the [OIII] zone would be a factor of two lower than in the [SII] zone if thermal gas dominates the total pressure of the gas and if the two zones are in pressure equilibrium.

Steve Balbus (U Va) and Steve Lubow have begun a study of possible stochasticity of spiral waves as a means to explain irregular spiral structure. Graduate student Pawel Aryniewicz and Steve Lubow have been investigating mildly nonlinear flows induced by spiral potentials in thin disks. Nonlinear effects cause the generation of torques by wave excitation at the ultraharmonic resonances. Conditions for the generation of a mass flux have been investigated. Steve Lubow has begun investigating the possible origin of magnetic fields in galaxies by a dynamo. The effects of spiral shocks on dynamo activity are being analyzed.

The NASA Phase A study of the Lyman Far Ultraviolet Spectroscopic Explorer astronomy satellite mission, under the leadership of Principal Investigator, Warren Moos, was completed in 1989 and was selected for Phase B, which will be begin in 1990. Warren Moos and Scott Friedman are also participating in NASA's Space Telescope Imaging Spectrograph definition study. Moos, P. Feldman, M. McGrath, D. Strobel and T. Livengood continue their studies of the outer planets using the IUE satellite.

Daniel Morrison has been using the nightglow observations from the Johns Hopkins UVX experiment
which flew on the Space Shuttle in January 1986 to set upper limits on spacecraft induced ultraviolet emissions. This work has concentrated on searching for nocturnal N2 Lyman-Birge-Hopfield (LBH) emissions which have been seen from low altitude satellites and other lower altitude Shuttle experiments. These emissions are expected to have an [N2] or an [N2] [O] altitude dependence and are thus very strongly dependent on the spacecraft altitude. This upper limit can be used to put constraints on the different surface chemistry models which are used to explain the source of these emissions. Recent measurements of sodium in the lunar atmosphere have prompted a reexamination of the Apollo 10 sodium observations by Morrison. This was a Johns Hopkins experiment with Bill Fastie as the principal investigator which flew on Apollo 17 and searched for a lunar atmosphere and made measurements of the cosmic sky background. They will be attempting to lower the limits which has been set on various lunar atmospheric constituents in the original analysis. This will lead to a better understanding of the atmospheric source and loss processes on the Moon and how they differ from those of Mercury which has similar surface composition and where a tenuous atmosphere has been observed. Morrison is also designing a fast speed EUV spectrometer for Paul Feldman which will cover the 800 to 1600Å wavelength range and be similar in design to the HST spectrometer. This experiment will fly on a series of rocket flights as part of the Atmospheric Response in Aurora (ARIA) project. Data from this spectrometer will be used to address the controversy over atomic oxygen measurements in the thermosphere and to provide measurements of total energy input by auroral particles.

Colin Norman and Satoru Ikeuchi have been working for several years now on a model of the interstellar medium. The model stresses the importance of the disk-halo connection. Mass, energy, momentum, cosmic rays, magnetic fields, etc., all flow into the halo via superhelves generated by many supernovae explosions that burst through the disk into the halo. It is this process and the subsequent cooling and infall that regulates the interstellar medium. There is not an all pervading hot gas component in the disk. In our model the filling factor of hot gas in the disk is very much less than unity. The whole process of dynamo action to generate magnetic fields in spiral galaxies is changed as are many other points such as cosmic ray diffusion, high energy cosmic rays, etc.

Colin Norman and Nick Kylafis have continued to work on interstellar masers. With respect to their H2O maser models a beautiful experiment has been done by the Bonn group who have detected Zeeman splitting in H2O and found fields weaker than we predicted but still large, as they thought. This has now been confirmed by the CFA group. Recently they have concentrated on the Type II OH masers in starforming regions and have solved one aspect of this problem associated with collisional pumping. Many interesting details remain to be studied. If the physics is now understood we can use masers to infer physical conditions in star forming regions. Observers in both Europe and the US are gearing up to test the model.

Norman and Jean Heyvaerts are studying the shape of axisymmetric magnetohydrodynamic flows with fairly general boundary conditions appropriate to winds. The result is that most MHD winds generally collimate along the symmetry axis and the conjecture is that this is the reason why the jet and bipolar flow phenomenon is so ubiquitous.

In the area of star formation Norman learned much last year about the relationship of protostellar disks to planetary formation and with Francesco Paresce has published some thoughts in the STSCI Workshop proceedings on Formation of Planetary Systems.

Colin Norman and Nick Scoville considered the relationship between AGN and starbursts. Their ideas started from a consideration of the nature of the broad emission line regions of active galactic nuclei and quasars. All the current models are very dubious. Their interpretation is that red giants illuminated from the outside by a central source would have all the correct properties. This naturally led to consideration of a dense central star cluster formed in a burst and furthermore its relation to the growth of a massive central black hole. The discovery of almost self-gravitating masses of gas ~10^10 M☉ within 500 pc in ultra-luminous systems and the discovery of powerful point source quasars embedded in these sources seem to be quite consistent with our model. Observed conditions relevant to the formation of AGN may here be seen at last. Starbursts also are very interesting for their effects on the environment and the process of galaxy building that may be occurring.

Scoville and Norman reported on their very recent work that addresses the Broad Absorption Line regions in the context of this model at the Wyoming meeting.

Norman is preparing an Annual Reviews article on starbursts.

Jean Heyvaerts, Colin Norman and Ralph Pudritz have published their detailed model of the whole Galactic Centre region with the concept that it is a turbulent corona about some central object. Many details of the loop structures, arcs and filaments fell into place and the low-β coronal concept really does have a lot of merit. This was presented as an invited review at the IAU meeting on the Galactic Center last summer. However, new data over a range of wavelengths indicates that another massive paper on the subject should be undertaken.

Barred galaxies currently defy analytic study. With Hashima Hasan, Colin Norman has begun a careful study of the orbits in barred galaxies. They have almost finished a paper on the interaction of inner barred systems with central mass concentrations such as black holes. The orbits exhibit a most interesting chaotic behaviour and we are using this relatively simple problem to see if a better description of chaos in these systems can be found.

With Daniel Pfenniger, Colin Norman has found a most exciting result on the behaviour of orbits of slightly dissipative particles in chaotic Hamiltonian systems. This is of general interest but with specific applications to gas flow in galactic nuclei and the formation of AGN. They presented the results at the Heidelberg meeting and are preparing a comprehensive version paper.

Norman, Ikeuchi and collaborators are involved in the project of trying to put quasar absorption line together with galaxy formation which is now a central issue. Norman's Varenna lectures on the subject will appear soon. The Quasar Absorption Line book has come out.

Colin Norman has been fascinated by the high redshift objects that Miley has found. With Ikeuchi he has studied the interaction of an expanding radio lobe propagating out into an infalling protogalactic cloud. The central result at present is that above a redshift of about 2 the dense protogalactic cloud can cool and produce the observed line emission in the lobes. This is like a vast supernova remnant. This has led them to a detailed study of feedback effects in the process of aglaxy formation.

An exciting development is the tentative observation of large magnetic fields at high redshift. A primordial field inferred from the observations of ~10^2 G would significantly affect galaxy formation and fluctuation theory. If not primordial it is very hard to see how such fields could have been generated sufficiently rapidly in ~10^9 years.

With Bill Fastie, Chris Burrows and Sam Durrance, Colin Norman and Jim Pringle have a major adapts program initially concerning circumstellar material using the Las Campanas 40 inch.

Francesco Paresce and Pawel Arnyłowicz continued their theoretical investigation of the Beta Pictoris circumstellar disk. From a study of its observed properties and deduced physical characteristics obtained from a detailed analysis of existing IR and optical data, they reject the
hypothesis that the observed feature is a bipolar nebula surrounding an evolved star. They show, instead, that the nebula is most likely a flattened disk of orbiting particles making up a planetary system in its clearing out phase as small grains collide, erode, and are swept out by radiation pressure.

Francesco Paresce and Christopher Burrows used the STScI coronograph on the ESO 2.2 m telescope with broad-band B and R filters to image a region 23' x 36' in size centered on SN 1987A at 0.8 resolution ~ 300 days after eruption for evidence of a light echo from circumstellar dust. All the identifiable sources of radiation in these bands in the region are objects related to the SN, e.g., the eruption including star 2 of the SK-69 202 complex located at 2°.8, 32°.0 p.a. of magnitude B = 15.1 ± 0.2 and R = 15.6 ± 0.3. The data allow a stringent upper limit of 22.5 mag arcsec^-2 to be set on the B-band brightness of an echo-like, largely azimuthally symmetric feature located anywhere between 2' from the SN out to the edge of the observed field. This limit implies an upper bound of 10^{18} hydrogen atoms cm^{-3} to the column density of any circumstellar shell of gas of average galactic properties located on the ellipsoid of equal delay points between ~2 and 20 pc from the SN. An echo from a uniformly distributed gas of this type around the SN of this limiting brightness would be obtained only if the average hydrogen density is between 2.5 x 10^{-3} and 10^{-2} cm^{-3}, indicating that SN 1987A may be located in a cavity of very low gas density.

The SN1987A was observed again by Bill Sparks, Francesco Paresce and Duccio Macchetto in February, 1989 with the ESO Faint Object Spectrograph and Camera (EFOSC) operating in the coronographic mode on the 3.6-m telescope with a broad-band V filter and four linear polarizers oriented at position angles 0°, 45°, 90°, and 135°. To measure the linear polarization scattered from circumstellar material around SN 1987A. A faint arc of V-band emission with a sharp inner and outer boundary centered on the supernova and of radius ~ 8.3 arcsec and width ~ 2.5 arcsec is clearly discernible above background, most prominently in the Eastern quadrant between 45°, and 135° position angle. Its azimuthally averaged surface brightness in this position angle range is 21.8 ± 0.2 V mag arcsec^{-2}. In this region, the detected radiation is found to be partially linearly polarized with a degree of polarization 0.15 ± 0.04 and an electric vector orientation of ±0° position angle. These results indicate that the reflecting material is confined to a thin sheet or shell of column density 10^{16} to 10^{19} atoms cm^{-2} located at 3-5 parsecs from the SN which may have arisen from a previous red giant phase of the SN progenitor.

Francesco Paresce and Antonella Natale imaged the immediate surroundings of the galactic luminous blue variable AG Car at 0.8° resolution through broad band B, V, R, and I filters with the STScI coronograph on the ESO 2.2 m telescope. Highly anisotropic continuum emission in all these bands is clearly detected above sky background at intensity levels in the range m_B = 17.9-19.4 magnitudes/arcsec^2. Most of the signal is confined to a prominent bipolar structure elongated along the NE-SW direction extending from a few arcseconds out to ~15 arcsec corresponding to a projected linear distance of ~5.0 pc from the star. The morphology of the SW extension is peculiar in that it seems to consist of two ~1.5' thick outwardly spiraling features embedded in a diffuse, faint part of the gaseous ring nebula. Its essentially neutral color with respect to the star of Δ(V-I) = -0.07 suggests that the observed radiation is starlight scattered by grains of diameter ≥ 1 μm while the almost constant brightness of the filaments in all bands over the 5-15° angular size range implies a dust column density increasing with distance from the star. The observed brightness corresponds to a total mass of ~10^{-3} M_☉ consistent with recent IR measurements. The rest of the circumstellar dust around this object is strictly confined to the asymmetric gaseous nebula exhibiting a very sharp inner boundary reminiscent of the interaction region between a hot stellar wind and the remnants of previous ejecta. Both the bipolar and helical structures might be most naturally explained by an outflow from a small secondary component in a close binary system and the precession of an associated accretion disk.

Francesco Paresce used the STScI coronograph on the ESO 2.2m telescope with a broadband B and a narrow band filter centered on the [NII], 6584 Å line to image with subarcsec resolution a region 23' x 36' in size centered on the symbiotic Mira RX Pup for evidence of extended optical emission similar to R. The emission feature easily observable in both Hα and [NII] has the line ratio of at least 1.5° to 3.7° projected distance from the center of the star along the p.a. 15° axis. This jet is co-aligned with the semi-major axis of the extended 6cm radio emission nebula recently observed in the inner (<1") circumstellar region of RX Pup. The total flux emitted by the NE extension of the jet is 5 ± 2.10^{-13} and 4 ± 2.10^{-14} ergs cm^{-2} s^{-1} in the Hα and [NII] 6584 Å lines respectively. The observed [NII]/Hα ratio is consistent with the emission being due to a plasma photoionized by a hot white dwarf or subdwarf companion. At a canonical plasma temperature of 10^{4}K, the emission measure of the nebula is 3.10^{6} cm^6 pc corresponding to n_e ~ 9.10^{5} cm^{-3}. Such a long (projected length ≥ 6.10^{5} cm) thin extended feature implies the existence of a very effective mass cooling mechanism possibly associated with a dense equatorial disk.

Francesco Paresce, Mark Clampin at JHU and Jim Crocker performed laboratory evaluations of the first Gallium-Arsenide high red response (Red) RANICON for astronomical high resolution imaging applications. Detector resolution is determined to be 76 μm FWHM with the possibility to improve this performance by factoring in system parameters and design constraints. The detector exhibits negligible dark noise at temperatures of less than -35° C and is otherwise similar in operating characteristics to multi-alkali photocathode RANICONs. The GaAs/RANICON is particularly suited to applications requiring good temporal performance such as high resolution imaging. The Red-RANICON has the highest R.R.E. of any photino counting detector in the wavelength region 6000 - 9000 Å and it is uniform over the whole wavelength response, in marked contrast to S20 and bi-alkali photocathodes. Optimization of the proximity focusing stage gives an overall efficiency of ≥ 60% of the photocathode R.R.E., a high figure in comparison to other photon counting systems. An extension of the photocathode red response to 1.1 μm should be available in the near future, with the possibility of a red limit at ~1.6 - 1.8 μm as field assisted photocathode technology develops. A reduction in the blue response cutoff from 6000 Å to 4000 Å should also be possible by changing the Al composition of the GaAlAs window layer.

Francesco Paresce, Jim Crocker, Marc Rafal, Amit Sen, Colin Cox, Knute Ray together with Mark Clampin at JHU have continued to vigorously pursue imaging applications of the RANICON detector. The significant factors which determine the performance of these detectors are found to be the proximity focusing stage, the microchannel-plate stack (MCP), and the signal processing electronics. For applications in optical astronomy, the low photon counting efficiency typically found with optical MCP-based detectors, due to ion barrier films, presents an additional consideration. A new approach to the signal processing electronics reduces nonlinearity, while achieving increased processing speeds and a position error corresponding to < 21 μm FWHM. A significant improvement in detector performance is achieved with an advanced Rancion incorporating a reduced proximity focusing gap and an improved MCP stack. The theoretical spatial resolution of both standard and advanced Rancion designs is derived and compared to the
experimentally determined values. For the advanced Ranicon, this spatial resolution is shown to be typically 40 \( \mu \)m FWHM at \( \sim 650\)nm. The point spread function of the Ranicon system is shown to be stationary over the active imaging area, principally due to the removal of nonlinearities and noise sources from the signal processing electronics.

This same group with Keith Horne has also been developing the RANICON for high time resolution applications. For this, one adds a time tag to each photon and records each set of \( x, y, t \) on tape. The tape is processed retrospectively in several ways. For time resolved spectroscopy, a valuable real-time function is to accumulate the counts in a small interval of time and present an intensity versus time plot. Performing a Fourier transform on this data immediately displays any periodicity in the object brightness. For speckle imaging, the data stream is binned into time intervals of 10 to 50 ms. The actual interval chosen depends on the counting rate and the seeing conditions. Each bin of data constitutes a frame. The data are processed in several ways. This data is used to determine the atmospheric blurring effect and the seeing conditions.

Darrell Strobel has devoted most of his effort the past year to the study of the upper atmosphere of Uranus. In collaboration with Roger Yelle, Jack McConnell, and Lyn Doose, he analyzed the Voyager 2 UV spectrum of Uranus between 1250 to 1700 A as primarily solar reflected light from an \( H_2 \) Rayleigh and Raman scattering atmosphere with small but measurable absorption by hydrocarbons. We inferred strong latitudinal variations in the hydrocarbon abundances, with substantial depletion in the subsolar, polar stratosphere. In collaboration with Michael Summers, Yuk Yung, John Trauger, and Frank Mills, he investigated the escape of species from Io's atmosphere using a steady-state model of Io's exospheric corona and its interaction with the Io plasma torus. Atmospheric sputtering was found to be the major escape mechanism for models in which the plasma flow reached the critical level. In collaboration with Michael Summers, he studied the photochemistry of hydrocarbons in the atmosphere of Uranus with explicit treatment of condensation processes. The calculated condensation rate of hydrocarbons is in agreement with the upper range of stratospheric haze inferred from Voyager data. As one of the original Co-Investigators on the Voyager Ultraviolet Spectrometer Experiment, Darrell Strobel spent two months at JPL during the Voyager Encounter with Neptune and Triton and is currently working on is research time to the analysis and interpretation of the Triton data.

Alex Szalay's recent interests have been very deep redshift surveys, with D. Koo (Lick Obs.) and R. Kron (U of Chicago). They have found excess clustering on scales \( > 100 \)Mpc, significant on the 5\( \sigma \) level. Dr. Szalay is also working on theoretical implications of this correlation. Calculated N-point correlations of galaxies with I Szapudi (ST Sc/IJHU) and P. Boschan (Univ. Duisburg, Germany) in the Lick catalog. They found the amplitudes up to \( N = 8 \) to be roughly constant. Another interest is in applications of the biased CDM scenario to explain morphological differences of galaxies as a function of local density (with J. Silk and A. Evrard, UC Berkeley). With J. R. Bond (CITA, Toronto) they are working on the alignment of clusters towards their nearest neighbors. This seems to be an extremely sensitive tracer of large scale power in the fluctuation spectrum.

Alan Uomoto continued work on supernovae in Population I environments using KPNO facilities and began new observations of star formation in collaboration with G. MacAlpine (University of Michigan) using the Rutgers Fabry-Perot imager at CTIO. He also continues work with Arlo Landolt (Jehovah State University) calibrating standard stars for broadband photometry for use with the Hubble Space Telescope at Las Campanas.

Rosemary Wyse continued to work in observational and theoretical aspects of galaxy formation. She and G. Gilmore (Cambridge) have continued the data acquisition for their spectral survey of spheroid stars, and we are making sense of the data. Wyse and T. Smecker (JHU) have observing time at Kitt Peak to use a similar approach with fainter stars to measure the \textit{in situ} abundance gradient in the halo. Wyse, with Gilmore, used IUE to obtain spectra of NGC 1666, a giant elliptical galaxy with an apparently regular young stellar population (based on previous IUE spectra); these data are being analyzed. Wyse, with Gilmore and K. Kuijken (CITA) completed a large manuscript on the kinematics, chemistry and structure of the Galaxy, which will be published in Annual Review of Astronomy and Astrophysics. She continued her collaboration with J. Silk (UC Berkeley) developing a model of star formation that describes both the relatively efficient star formation in proto-Ellipticals, and the inefficient processes in spiral disks.

V. REFERENCES


