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I. INTRODUCTION

When it was founded in 1876 our Department was known as the Department of Physics, but during the brief periods 1907-08 and 1917-18 we carried the title listed above, to which we now revert (we expect) permanently.

A university department is not a rose, and the name, we think, matters: it signals the increased importance of that special area of physics that we call astronomy, both world-wide, and in Johns Hopkins perspective. The local perspective of course heavily involves the now massive presence of our campus guest, the Space Telescope Science Institute (ST ScI), but is not dominated by it: a vigorous program in astrophysical theory (linked to ST ScI) joins a sharply enlarged experimental program that involves not only sounding-rocket experiments, but also Space Shuttle missions. The Hopkins faculty are also active observers, particularly with IUE, and will surely be general observers on Space Telescope; guaranteed Space Telescope observing time is also held by Hopkins Faculty. Our mixture of hands-on experiments, theory, and observing, provides a very attractive environment for graduate students.

II. PERSONNEL

Lennox L. Cowie has been appointed Professor. He is also Head of the Academic Affairs Branch of the ST ScI. Colin A. Norman has been appointed Professor, also joint with ST ScI. Julian H. Krolik has been appointed Assistant Professor. Stephen Lubow (ST ScI) has been appointed Assistant Research Professor. Randy A. Kimble and Harold A. Weaver have been appointed Associate Research Scientists, working on the Hopkins Ultraviolet Telescope (HUT) project. William P. Blair has also been appointed an Associate Research Scientist, working primarily on the Faint Object Spectrograph programs. Other permanent staff members contributing to research in astronomy and astrophysics are: A. F. Davidsen, P. D. Feldman, R. Giacconi (Director, ST ScI), R. C. Henry, C. W. Kim, and H. W. Moos, Professors; K. S. Long, Jr., Research Scientist; S. T. Durrance, Associate Research Scientist; and W. G. Fastie, Adjunct Research Professor. P. D. Tennyson and T. E. Skinner are post-doctoral fellows. We also note that Dr. S. T. Durrance has been accepted for the flight crew on the ASTRO Space Shuttle project.

III. THE UVX PROJECT

The UVX project is a joint venture between the Johns Hopkins University Department of Physics and Astronomy and the University of California, Berkeley, Space Astrophysics Group, with engineering support from the Goddard Space Flight Center Applied Engineering Division. The experiment will consist of observations of the diffuse ultraviolet background from within the space shuttle environment with the hope of resolving questions about the nature of the ultraviolet background and also the suitability of the shuttle environment for low light level ultraviolet observations. The cosmic background will be investigated with the aim of measuring the extragalactic component, the galactic halo component and also any contribution due to shocked interstellar matter and scattered starlight. The targets scheduled for the first mission of UVX cover a wide range of galactic latitudes and longitudes, but are regions chosen to minimize the contribution due to direct starlight.

The experiment will fly on the space shuttle as three contiguous "Get-Away-Special" containers, one for each organization involved. The JHU package consists of two scanning Ebert monochromators, our reliable workhorse of rocket astrophysics, covering the spectral range 1250 to 3200 Å with nominal 25 Å resolution. The package also contains an image intensified solid state array aspect camera to detect bright stars in the field of view. The UCB package consist of a single spectrometer covering the range 600 to 1700 Å with a film camera. The instruments have been built, calibrated and integrated to the flight electronics and await an early flight opportunity on the space shuttle.

Physics department personnel involved in this project include professors Paul D. Feldman and Richard C. Henry; post-doctoral fellow Peter D. Tennyson; project coordinator Russell S. Pelton; and graduate student Jayant Murthy.

IV. OTHER RESEARCH AND ACTIVITIES

W. P. Blair during the last year has continued to obtain and analyze optical and ultraviolet spectra of both galactic and extragalactic supernova remnants (SNRs). A very powerful young SNR in the irregular galaxy NGC 4449 has been scrutinized at X-ray, optical and ultraviolet wavelengths. Optical spectroscopic observations of 12 SNRs in M33 have been used to determine abundance gradients and study SNR evolution in this galaxy. Two of the brighter M33 SNRs have been successfully observed with the IUE satellite. The galactic object CTB 80 has been extensively studied using CCD images, interference filter photographs and spectroscopy. Ultraviolet and optical work has continued on the Cygnus Loop, and an optical spectrographic survey of optically faint galactic SNRs is in progress. Ultraviolet observations of faint cataclysmic variables with the IUE satellite have continued as part of a broad program to determine the accretion disk parameters in these systems.

Arthur F. Davidsen conducts a research program in space astronomy, currently focused on ultraviolet spectrophotometry of extragalactic objects and development of new instrumentation applicable to such studies. He is a Co-Investigator on the Faint Object Spectrograph (FOS) for Space Telescope, and is P.I. for the Hopkins Ultraviolet Telescope (HUT) Project, which involves a 36-in. telescope to be flown aboard the Space Shuttle as part of an instrument package called the Astro Observatory. The HUT has evolved from an Aries rocket design. Astro-1 is expected to fly in March 1986. The HUT will obtain spectra at ~2-A resolution on flat-spectrum objects as faint as $V \sim 17$, primarily in the 900-1200 Å range, but with some capability from 500 to 1800 Å. The initial flight will include a significant program

of observations of Halley's Comet, although a broad range of observations, including quasars and other active galactic nuclei, planets, stars, nebulae, and galaxies, is also planned. Davidsen continues to serve on the AURA Board of Directors and the Space Telescope Institute Council (STIC). He recently completed a term as AAS Councilor, and continues as a member of the U.S. National Committee for the IAU. He has been appointed Co-Chairman, with Riccardo Giacconi, of the Local Organizing Committee for the IAU General Assembly to be held in Baltimore in 1988. Davidsen has recently served on the Shuttle Science Working Group and continues as a member of the Space Science Working Group and its Steering Committee. He was recently elected a Fellow of the American Association for the Advancement of Science.

Samuel T. Durrance is currently concentrating his efforts on completing the construction of the Hopkins Ultraviolet Telescope (HUT). He was recently selected as Payload Specialist for a series of astronomy missions to be flown on the space shuttle in 1986 and 1987 of which HUT is a major component. This program is now called "the Astro missions", and he has begun training for this activity. He also continues to observe the outer planets with the IUE satellite. Most recently, along with H. W. Moos, J. T. Clarke and M. C. Festou, he has been studying the temporal variability of the Ly α aurora on Uranus.

William G. Fastie continued application of physical optics, particularly the Ebert spectrometer, to a wide variety of problems in auroral and planetary physics, and astrophysics. In addition to his work concerning Space Telescope (he is a Telescope Scientist), he continued his work on evaluation of optical components, particularly gratings, and played his usual substantial role in the Johns Hopkins sounding-rocket and Space Shuttle ultraviolet astronomy program.

Paul D. Feldman directs the NASA-supported sounding rocket program (including the UVX project, see above) which has as its main focus the development of new instrumentation for far- and exteme-ultraviolet astronomy. He and Tom N. Woods have obtained new absolute stellar flux data in the wavelength region 912-1600 Å for six hot stars from a successful Black Brant V rocket launch on 2 March 1984. Feldman has continued his program of ultraviolet spectroscopy of comets (with M. F. A'Hearn of the University of Maryland) with *IUE* observation of periodic comet Encke in April and May 1984. This is the first comet to be observed on successive apparition by the *IUE*, and it was found that, contrary to the visible emissions, the OH light curve for this comet is nearly symmetrical about perihelion. Feldman is serving on NASA's Comet Rendezvous Science Working Group and Management and Operations Working Group for Astronomy/Relativity and is currently an Associate Editor of Journal of Geophysical Research - Space Physics.

Holland Ford does research on active galaxies, large scale structure, and stellar populations. He is an instrument scientist for the Faint Object Spectrograph (FOS) at the Space Telescope Science Institute, and a co-investigator on the FOS. Ford was a member of the organizing committee for the Santa Cruz Workshop on active galaxies, and gave an invited paper on the bubbles and jets in the center of M51. Ford, P. Crane (NRAO), G. Jacoby (KPNO), D. Lawrie (OSU), and van der Hulst (NFRA) investigated the nuclear activity in M51 by using optical-and-radio images and spectroscopy. Their monochromatic H-alpha+ [NII] images and high resolution VLA 6 cm and 20 cm radiographs show that a bright cloud and a large ring are paired across M51's nucleus. They used spectrophotometry to show that the cloud has a spectrum similar to the shocked gas in some supernova remnants, and a 2000 km/s full width at zero intensity velocity dispersion, which is larger than in the nucleus. They used optical and radio data to derive the sizes, ages, masses, filling factors, and minimum energies of the ring, nucleus, and cloud. The ring and cloud exceed galactic supernova remnants by factors of 100 to 1000. They emphasize that the sites of maximum nuclear activity are outside the nucleus, and conclude that the active nucleus has created a pair of bubbles which are inflating and interacting with the disk. Their observations show at least one way a forbidden line region can form in the nucleus of a galaxy. G. Jacoby, H. Ford, and R. Ciardullo (UCLA and ST ScI) used H-alpha+ [NII] on-band and off-band CCD pictures of M31 to find a striking spiral distribution of ionized gas extending to within a few parsecs of the nucleus. Because of its low surfact brightness, this system of gas had not been seen previously. The mass of ionized gas is approximately 1500 solar masses. The filamentary appearance, small filling factor, and the strength of the [SII] lines suggest that some of the gas is heated by shocks. Interestingly, the geometry of the apparent spiral arms implies that much of the gas is in a plane which is tipped with respect to M31's disk. G. Jacoby and H. Ford measured chemical abundances in M31's disk and halo by observing three planetary nebulae and an HII region at projected distances of 3.5 kpc, 18 kpc, and 33 kpc from the center. Their data show that M31 experienced considerably more enrichment of its interstellar medium during its early life than did the galaxy. Their observations show that 7 of 52 planetaries with measured radial velocities are in retrograde orbits, and thus have a strong kinship with the globular cluster system, which has 35% retrograde orbits. They find evidence for a chemically hetergeneous halo, and conclude that there is little evidence for a relationship between kinematics and metallicity in M31's halo. Ford, R. Ciardullo, and G. Jacoby are continuing their H-alpha survey of M31's nuclear bulge for novae. Their long range goals are to establish the suitablity of H-alpha nova magnitudes as standard candles, and to investigate possible changes in the nova frequency through the bulge. W. Romanishin (GSFC), H. Ford, R. Ciardullo, and G. Jacoby used narrow band CCD H-alpha+ [NII] images to resolve the shell of Nova Cygnus 1975. They analyzed the emission line profile with expanding prolate spheroids, and combined the geometrical model with the maximum apparent magnitude and the model of the resolved image to derive the nova's parallax. R. Nolthenius (UCLA) and H. Ford used a new analysis of variance technique on the radial velocities of 13 planetary nebulae in M32 to show that the stellar velocity distribution is almost certainly isotropic, and that the global M/L is approximately 2. Papers describing these investigations in detail have been submitted to the Astrophysical Journal.

Riccardo Giacconi, the director of the Space Telescope Science Institute (ST ScI) which is located on the Homewood Campus of the Johns

Hopkins University, is also professor of astrophysics in the Hopkins Department of Physics and Astronomy. Giacconi led the group of scientist who were first to make astronomical observations using the X-ray part of the spectrum, thereby establishing X-ray astronomy as a significant field of astrophysical research. In 1970, the UHURU satellite, conceived by Giacconi and developed under his direction, became the first orbiting X-ray observatory. In 1978 the launch of the Einstein Satellite permitted the extension of X-ray observation to all classes of objects of greatest astrophysical interest. His main field of current interests are the nature of the X-ray background, the origin and dynamical evolution of clusters and the early structures in the universe. He is co-author of a book entitled A Face of Extremes: The X-ray Universe, which is currently in press. Giacconi's most recent awards include the 1982 Gold Medal of the Royal Astronomical Society and the 1982 A. Cressy Morrison Award in Natural Sciences from the New York Academy of Sciences. In May 1983 he was awarded an honorary degree from the University of Chicago, and most recently in February 1984, he received an honorary degree from the University of Padua.

Richard C. Henry conducts research on the interstellar medium, cosmology, and ultraviolet background radiation. The past year included observation of α Cen B with the IUE observatory (with Landsman, Linsky, Murthy, and Moos) in an effort to understand as much as possible about the interstellar medium over a very short line of sight. Our previous work on α Cen A is "in press" in the Astrophysical Journal. We compare two previous *Copernicus* observations of the α Cen A Lα profile with that we have obtained using IUE. Interstellar deuterium is detected, and a lower limit is set on the deuterium-to-hydrogen ratio of $n_D/n_H > 8.5 \times 10^{-6}$. Furthermore, the deuterium bulk velocity appears blueshifted by 7 ± 2 km s^{-1} from interstellar hydrogen, suggesting a non-uniform medium along the line of sight. Henry also acted as local Co-chair for the Baltimore AAS meeting, with Cowie. Henry continued as Editor-in-Chief of the journal *Astrophysical Letters*, with Davidsen (JHU), Pounds (Leicester), and Jugaku (Tokyo) as Editors. Submissions to *Astrophysical Letters* maintain their high quality, and color illustrations are now available at no charge to authors. Henry has been elected Secretary-Treasurer of the Astrophysics Division of the American Physical Society.

Chung W. Kim has been interested in applications of grand unification and supersymmetric theories, and supergravity to cosmology. He is currently investigating symmetry-breaking patterns which are crucial for the success of the inflationary scenario of the very early universe. He is also working on the origin and evolution of density fluctuations in the inflationary model.

Knox S. Long is the Project Scientist for the Hopkins Ultraviolet Telescope (discussed above), which is now undergoing integration prior to delivery to Kennedy Space Center. He remains actively interested in the X-ray properties of normal galaxies and supernova remnants. Two reviews, one on the "X-ray Properties of Supernova Remnants in the Large Magellanic Cloud" and the other on "X-ray Emission in Normal Galaxies" (with L. P. Van Speybroeck) were published during the year. An atlas of X-ray and optical imagery of large Magellanic Cloud SNR's by Long and collaborators at Mt. Stromlo and Columbia University was also published. This study indicates that the Sedov-based number-diameter relationship is not representative of observed LMC remnants. Long with graduate student Y. Matsui and collaborators J. R. Dickel (Univ. of Ill.) and E. W. Greisen (NRAO) made a detailed comparison of the X-ray and radio properties of Kepler's SNR which provides the first direct estimate of the magnetic field in a young SNR (not based on the assumption of equipartition). Long with D. A. Leahy and D. Venkatesan (Univ of Calgary) and S. Naranan (Tata Institute) has also investigated the properties of HB3, and old SNR whose X-ray image reveals a ring of emission 30 pc in diameter, possibly due to hot ejected material, inside the 84 pc diameter radio shell.

Stephen Lubow has been working on several dynamical problems in astronomy. He has recently investigated the influence of orbital eccentricity on the dynamics of mass transfer in close binary star systems. Together with L. Cowie, Steven Balbus (Princeton), and Y. C. Pie, he has begun a long range project on spiral galaxies. The project aims to provide an understanding of the role of viscosity and self-gravity of the interstellar medium in the dynamics of density-wave induced shocks.

H. Warren Moos is using the IUE satellite to study the outer planets with S. T. Durrance, P. D. Feldman, and T. E. Skinner. Studies have been performed on the stability of the hot central part of the Io torus, the longitudinal location of the Jovian aurorae, and auroral emissions from Uranus. Moos serves as a member of the Far Ultraviolet Spectroscopic Explorer Working Group and the Committee on Planetary and Lunar Exploration. Recent laboratory work is concerned with the development of pulse-counting intensified two-dimensional solid-state arrays for space astronomy. Moos is using ultraviolet diagnostics to study high-temperature-tokamak plasmas; the physics of the highly ionized atoms studies in this program is of direct relevance to astrophysics.

Colin A. Norman is continuing his studies of the dynamics of galactic nuclei with central holes, this time using detailed N-body techniques on a Cray-1 supercomputer in collaboration with T. S. van Albada and A. May. Further studies with these collaborators involve long-term secular evolution and oscillations of triaxial galaxies. Studies of disk evolution and the collapse of the Galaxy have been commenced in collaboration with R. Carlberg. Detailed calculations of magnetic processes during star formation have been completed in collaboration with J. Heyverts, and with R. Pudritz a number of projects concerning protostellar flows have been initiated.

Harold A. Weaver, Jr. recently completed an NAS/NRC Research Associateship at the NASA Goddard Space Flight Center and has rejoined the Hopkins program as an Associate Research Scientist and Assistant Project Scientist on HUT. While at Goddard, he continued his research on comets; *not* in the UV, as he had previously pursued at Hopkins, but in the relatively unexplored, and potentially promising area of IR spectroscopy. In collaboration with M. J. Mumma (GSFC) and H. P. Larson (U. of Ariz.), he is planning to make IR observations of comet Halley from the Kuiper Airborne Observatory in 1986. Since HUT will observe Halley in the UV at the same time, important new information of this most famous of comets can be expected.

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