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The following report covers the Department in terms of personnel and facilities from Sept. 1, 1998 (the effective date of our last report) through Sept. 1, 2002 and includes the publications over that time. Discussion of research, however, is limited to activities over the past year.

1. PERSONNEL AND FACILITIES

William Herbst was appointed John Monroe Van Vleck Professor of Astronomy as of July 1, 2000. John Salzer continues as Associate Professor and replaced Herbst as Chairman of the Department of Astronomy and Director of Van Vleck Observatory on July 1, 1999. Kathryn Johnston was appointed Assistant Professor of Astronomy, also on July 1, 1999. Ata Sarajedini resigned his position as Assistant Professor in 2000 to take a faculty position at the University of Florida. Vicki Sarajedini, who was a post-doctoral fellow with Salzer, also left at that time for a faculty position at the University of Florida. Edward Moran was appointed Assistant Professor of Astronomy as of July 1, 2001. Edward Weis retired from his Research Associate position on July 1, 2000. Caryl Gronwall left her position as a Post-Doctoral Fellow in 1999 to join the staff of the Space Telescope Science Institute. Anna Jangren joined the staff as a Post-Doctoral Fellow with Salzer in July, 2001. Eric Williams continues as Systems and Facilities Manager and Linda Shettleworth continues as Administrative Assistant for the department. Debra Herbst retired as the Coordinator of Project ASTRO effective June, 2002, but continues as Associate Director of the project on a volunteer basis.

Janice Lee received an M.A. degree in Astronomy in 1999 and is currently a graduate student at the U. of Arizona. Matt Pappas received an M.A. degree in 2000 and is employed teaching astronomy at Suffolk County Community College in NY. Jeff Van Duyne and Jason Melbourne received M.A. degrees in 2001. Van Duyne is currently a graduate student at Yale and and Melbourne is a graduate student at the University of California - Santa Cruz. Christine Thurl and Blake Likins received M.A. degrees in 2002. Thurl is currently a graduate student at Mt. Stromlo Observatory in Australia and Likins is working at NASA Headquarters in the Earth and Planetary Sciences Division.

The department continued its strong record of graduating students with a B.A. degree in Astronomy. We were recognized by Research Corporation in its seminal study ‘‘Academic Excellence: The Source Book.’’ as the primarily undergraduate institution which produced more astronomy majors than any other during the period 1985-1997. From 1999 to 2002 we graduated eleven students, many of whom continue in astronomy as graduate students or research assistants. Students receiving Wesleyan’s B.A. degree in Astronomy during this period are: Eli Beckerman (1999), Emily Lu, Hugh Crowl, Lael Hebert and Frank Muscara (2000), Arianne Donar, David Olsen and Martin Medina (2001), Andrew Rhodes, Sun Mi Chung and Li Wei Lin (2002). The department has also continued its active participation in the Keck Northeast Astronomy Consortium, hosting many summer students during the period covered by this report.

Wesleyan has become a partner in the consortium (an expanded version of the original WIYN group) now operating the 0.9m telescope on Kitt Peak National Observatory. Several of our students and faculty have already observed with this instrument. We have also upgraded one campus facility by replacing the Fiducia telescope (a 10-inch) with a 16-inch Meade. The Department, in collaboration with Wesleyan’s Project to Increase Mastery of Mathematics and Science (PIMMS), has continued to serve as an expansion site for Project ASTRO in the State of Connecticut. The goal of this Astronomical Society of the Pacific sponsored program is to match volunteer professional and amateur astronomers with teachers in grades 4 - 9 to enhance the teaching of science in the schools. Over the years, nearly one hundred such partnerships have been formed in the state. We continue to make available to Project ASTRO teachers or astronomers a Starlab Portable Planetarium purchased with the assistance of an IDEAS grant from NASA. We estimate that more than ten thousand children around the state have had planetarium programs in their schools as a result of this effort. We have, furthermore, joined forces with the Greater Hartford Amateur Astronomy Association to make the 20-inch refractor of the Van Vleck Observatory open to visitors on a regular basis. In association with that group we have continued to host StarConn, a gathering of New England area amateur astronomers, on an annual basis.

2. RESEARCH

2.1 Stellar and Galactic

The long-running T Tauri star monitoring program directed by Herbst, which employs the 0.6 m telescope of Van Vleck Observatory is continuing. Recent program objects include the Orion Nebula Cluster, NGC 2264, IC 348, NGC 1333, MBM 12, CB34V, FU Ori and some other fields. Monitoring is done every clear night in the I band of the Cousins system. We typically obtain 30-40 images per observing season of each field. Integrations are five minutes in duration but broken into five one-minute segments to improve dynamic range. We are most sensitive to variations of stars in the magnitude range I = 11-16 but can obtain data on stars as faint as I = 18. The main scientific focus has been on determining rotation periods of young stars by detecting periodic variations and studying the irregular variations of stars caused by accretion or occultation events.

The most exciting discovery from this program is arguably KH 15D, an object which undergoes a deep eclipse ($\sim$3.5 mag) every 48.36 days. It is discussed in detail by Herbst *et al.* (2002a) and has its own Web site (www.astro.wesleyan.edu/kh15d/). The most recent data indicate that the duration of the eclipse is continuing to increase at an astonishing rate. In September of 2002 the length of an eclipse has reached nearly 24 days, or half the orbital period. When first discovered, in 1995/96, the dura-

tion was much less - no more than 16 days. Our models of the system continue to be challenged by these data and the rapid time evolution. The star will continue to be a primary focus of the stellar component of the research carried out here. Collaborating on this work are Reinhard Mundt and Coryn Bailer-Jones of the Max-Planck-Instute for Astronomy (MPIA) - Heidelberg, Germany, Mansur Ibrahimov of the Tashkent Astronomical Institute, Fred Vrba of the U.S. Naval Observatory and others. Physics graduate student Catrina Hamilton is continuing to work on the object as part of her Ph.D. thesis dissertation under the direction of Herbst. In addition, we have been searching for other examples of the KH 15D phenomenon. A possible such object, CB34V has been studied in detail and a rotation period determined for it.

Another part of Hamilton's thesis work involves a v sin i study of NGC 2264 which is in progress, in association with R. Mathieu of Wisconsin and K. Rhode of Yale. Approximately 150 stars in that young cluster with known rotation periods from our photometric surveys (and that of Markus Lamm at the MPIA) have had their v sin i's measured with the multi-fiber spectrograph on the 3.5 m WIYN telescope. We are particularly interested to learn whether the low value of $<$sin i$>$ discovered in the ONC by Rhode, Herbst & Mathieu (2001) will be replicated in this cluster. We also wish to determine whether the photometric evidence for more rapid rotation in NGC 2264, when compared with the ONC, is mirrored in the spectroscopy.

Johnston is continuing her research program of understanding signatures of satellite accretion and galaxy formation. In collaboration with David Spergel (Princeton University) and Christian Haydn (a former Wesleyan undergraduate student) she has recently completed a study of how dark matter lumps in the Milky Way's potential could disturb cold streams of stars from satellite galaxies and globular clusters. They have found that although the level of substructure predicted within a standard λCDM model of structure formation will scatter stars in streams significantly, this effect is unlikely to be detectable with the current data sets (for example, the carbon star sample associated with the Sagittarius dwarf galaxy). Such an experiment to limit the degree of dark matter substructure in our halo may be feasible with future larger or more accurate data sets.

As part of her contribution to the Space Interferometry Mission's Key Project on Galactic Dynamics (PI Steven R Majewski, University of Virginia) she has worked on interpreting early data from the Grid Giant Star Survey of the Galactic halo. In addition to its primary purpose of providing candidates for SIM's reference frame, this survey will yield a wealth of information about the stellar halo's structure and substructure. Two students have completed masters theses under Johnston's supervision. Christine Thurl worked on calculating the likelihood that the globular cluster ω Cen could have formed from a merger within the Milky Way environment. Blake Likins performed and analyzed numerical simulations of the disruption of the Ursa Minor dwarf spheroidal galaxy.

2.2 Extragalactic and Cosmology

Moving beyond the Galaxy, Johnston has an ongoing collaboration with Penny Sackett (Mount Stromlo Observatory) and James Bullock (Harvard-Smithsonian Center for Astrophysics) whose goal is to estimate the frequency of faint features from accretion events detectable around other galaxies with a variety of cosmological models of galaxy formation. This work is in conjunction with an observing program of surveying disk galaxies for just such features with the VLT.

Salzer continues to work on the KPNO International Spectroscopic Survey (KISS), an international collaboration to carry out a major survey for active galaxies. It is being done in collaboration with V. Lipovetsky (d. 20 Sept 1996) and A. Kniazev (Russia), Y. Izotov (Ukraine), T. Thuan (U. Virginia), T. Boroson (NOAO), J. Moody (BYU), present and former postdocs A. Jangren, C. Gronwall and V. Sarajedini, and many students at Wesleyan. It is an objective-prism survey for emission-line galaxies using the Burrell Schmidt telescope at Kitt Peak with a sensitive CCD detector. This project represents the state-of-the-art survey for active and star-forming galaxies. Much work during the past year focused on writing papers presenting some of the survey data and describing results derived from the analysis of the data. The third survey paper and first analysis paper appeared in print during this time (see publication list below); two additional KISS-related papers are in press at the time of this writing.

Follow-up spectroscopy of KISS ELG candidates was a major focus this past year. Several telescope proposals were submitted in the fall of 2001 for time this spring, and most were successful. We were awarded time on the following telescopes: 3 nights on the 2.4-meter telescope at MDM Observatory (in collaboration with Dr. Gary Wegner, Dartmouth); 2 nights on the ARC 3.5-m telescope at Sac Peak, NM; 3 nights on the 3.0-m telescope at Lick Observatory, CA; parts of 12 nights on the 10-m Hobby-Eberly Telescope which is located in Texas; and parts of 2 nights on the 3.5-m WIYN telescope on Kitt Peak. This huge number of nights of telescope time have yielded over 150 high-quality spectra which will be used to understand the properties of the active galaxies discovered by the survey.

Salzer continued work on a new initiative related to the KISS project involving observations at radio wavelengths. With collaborators J. Lee and C. Impey (U. Arizona) plus C. Gronwall and T. Thuan, he completed a project using the Arecibo Observatory radio telescope in Puerto Rico to observe a sample of KISS galaxies at 21-cm. These observations have allowed us to make a direct determination of the amount of cool neutral gas present in these star-forming galaxies. A paper detailing the results is in press (Lee, *et al.* 2002, AJ).

Salzer also carried out projects with student collaborators (both current and former). In addition to the radio project mentioned above, he worked with former student Janice Lee ('99) on a paper analyzing the spatial distributions of dwarf galaxies in the local universe. This paper is the second to come from Lee's thesis work, and should be completed by the end of 2002. Jason Melbourne ('01), who carried out his

M.A. thesis research under Salzer's supervision, completed an analysis of the chemical elemental abundances in star-forming galaxies from the KISS survey. One paper from this project has already appeared in print (Melbourne & Salzer 2002), and a second is currently in preparation. Another former M.A. student, Jeffrey Van Duyne ('01), is writing a paper on the radio continuum properties of the KISS emission-line galaxy sample. This paper is likely to be submitted in November, 2002. Current M.A. student Samantha Stevenson completed a study of the X-ray properties of KISS Seyfert galaxies, and submitted a paper this spring for publication. The paper is in press (Stevenson *et al.* 2002, AJ). Finally, he supervised a senior thesis project with Sun Mi Chung ('02), who carried out a ground-breaking study of the near-infrared properties of the KISS galaxies. This project was highlighted in a paper presented at the June 2002 AAS meeting by Ms. Chung. The completion of this project must await the release of the full 2MASS NIR database in the Fall of 2002.

During the coming year, members of the KISS group will continue to publish results from the survey as well as from our extensive follow-up spectra of KISS ELGs. We are currently working on two papers that will present the spectral data for over 400 ELGs observed at MDM and Lick Observatories. In addition, the next installment of the KISS catalog, the 43-deg survey strip, will be completed and submitted this coming spring.

Other projects that Salzer worked on during the past year include an ongoing collaboration with L. van Zee (Indiana U.) on the study of gas-rich dwarf galaxies. We continue to have telescope time scheduled for our project at the Very Large Array radio telescope in NM. Our project involves studying the make-up of dwarf galaxies using the dynamics of their stars and gas as diagnostics. One paper appeared in print during the past year, and additional ones will be forthcoming. A new project was started this spring with former student J. Rosenberg ('93) and current M.A. student S. Stevenson using the 36-inch telescope that we are a partner with in Arizona (see above). The project involves imaging a large sample of galaxies observed as part of an unbiased HI survey carried out by Rosenberg. We will study the properties of these galaxies in the optical and compare their characteristics to those of optically-selected objects. Our first observing run in April, 2002 was very successful, and more observations are planned for the coming year. This project will constitute Ms. Stevenson's M.A. thesis. Finally, a paper presenting the results of a study of the HI gas content in compact dwarf galaxies was completed and appeared in print (paper with former students Rosenberg and Weisstein).

Edward Moran has continued investigations into the nature of the sources responsible for the cosmic X-ray background, focusing on the role of type 2 (narrow line) active galaxies. Based on broadband X-ray observations of a distance-limited sample of nearby Seyfert 2 galaxies, Moran and collaborators (L. Kay at Barnard College/Columbia U., M. Davis and A. Filippenko at U.C. Berkeley, and A. Barth at Caltech) obtained the first unbiased, composite Seyfert 2 X-ray spectrum. Integrating the volume emissivity derived from this spectrum over redshift, they demonstrated that type 2 AGNs have the X-ray spectral properties necessary to account for the observed intensity and spectrum of the background radiation in the 2–10 keV range.

Investigating the properties of faint sources in a deep Chandra image of the Lynx survey field, Moran and a team headed by D. Stern (JPL) reported the discovery of a type 2 quasar at a redshift of 3.3. The existence of such objects is expected in the context of AGN unification models, but to date they have remained elusive. The Chandra data of the Lynx object reveal a luminous but absorbed X-ray source; optical and near-IR spectroscopy obtained at the Keck Observatory indicate the absence of broad emission lines in the rest-frame UV and optical spectrum, which is consistent with a type 2 classification.

Spurred by reports of a large population of ''normal'' galaxies in the deep Chandra surveys, Moran and Berkeley collaborators Filippenko and R. Chornock have explored the possibility that many such objects are in fact type 2 AGNs whose nuclear emission lines are overwhelmed by host-galaxy light. The deep survey sources are at high enough redshifts that the angular sizes of their host galaxies are comparable to the apertures used in ground-based spectroscopic follow-up observations. We obtained integrated optical spectra of nearby Seyfert 2 galaxies, demonstrating that a large fraction of these objects do indeed appear to be ''normal'' in the analysis of their integrated light. This suggests Seyfert 2 galaxies may well be the primary source of the hard X-ray background, as prior research has indicated.

PUBLICATIONS

The publication list includes all papers published between Sept., 1998 and Sept, 2002 by the permanent staff.

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