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The following report covers the Department activities from Sept. 1, 1996 through Sept. 1, 1997.

1. PERSONNEL AND FACILITIES

William Herbst continues as Professor of Astronomy and Chairman of the Department of Astronomy. John Salzer was promoted to Associate Professor with tenure effective July 1, 1997. Edward Weis continues as Research Associate, Caryl Gronwall continues as a Post-Doctoral Fellow and Eric Williams continues as a Technical Assistant/Lab Instructor. The department has been authorized to hire an assistant professor to replace Arthur Upgren who left in January, 1997. Linda Shettleworth continues as Administrative Assistant for the department.

Katherine Rhode received an M.A. degree in Astronomy at the May commencement. She is continuing her education in the Astronomy Ph.D. program at Yale University. Kristin Kearns and Karen Kinemuchi continue as graduate students. Janice Lee and Jamison Maley joined the program in August, 1997. Four students received B. A. degrees in Astronomy at the May commencement: Scott Randall, Nick Harrison, Stuart Norton and Adam Heinlein. Norton received the degree with High Honors and the others with Honors. Norton was also the recipient of this year's Littell Prize for excellence in Astronomy, was selected to Phi Beta Kappa, and was a finalist for the Apker award given annually by the AIP in recognition of outstanding research by an undergraduate in physics. He is continuing his education in the Astronomy Ph.D. program at the University of California - Santa Cruz. Heinlein is also continuing his education in astronomy and physics at Indiana State University. Several of our continuing students held summer research positions in astronomy. Rising seniors Ben Holder and Anil Seth spent the summer at Maria Mitchell Observatory and Arecibo Observatory, respectively. Rising junior Eli Beckerman worked at the Colgate University Observatory. The department continued its active participation in the Keck Northeast Astronomy Consortium (KNAC), hosting four summer students - two from Vassar, and one each from Middlebury and Williams.

Salzer joined with astronomers from Vassar, Middlebury, BYU, and Williams and entered into an agreement with Case Western Reserve University which will provide access to the Burrell Schmidt telescope located at Kitt Peak, AZ. The Burrell Schmidt is the primary instrument being used for the KISS project. The agreement will provide the KISS group with 2.5 weeks of dark time each year for the next two years to continue the survey.

The Department, in collaboration with Wesleyan's Project to Increase Mastery of Mathematics and Science (PIMMS), was selected as an expansion site for Project ASTRO, serving the State of Connecticut. The goal of the program is to match volunteer professional and amateur astronomers with teachers in grades 4 - 9 to enhance the teaching of science in schools. Project ASTRO was initiated by the Astronomical Society of the Pacific in the San Francisco area and has been expanding across the country with the help of grants from the NSF and NASA. Wesleyan is the only expansion site on the east coast. The Project Director is William Herbst and Project Coordinator is Debra Herbst. PIMMS representatives are Dan Dolan and Wilma Toney. Eighteen teacher-astronomer partnerships were formed in Connecticut during this, the first year of operation.

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 continues. As in past years, fields in the Orion nebula cluster and in NGC 2264 are imaged in the I band on most clear nights. Rotation periods with false alarm probabilities of less than one percent are now known for more than 140 stars in the ONC and 29 stars in NGC 2264. The monte carlo method described in last year's report was applied by visiting summer student Becky Walldroff of Middlebury College to the complete ftp catalog on T Tauri stars maintained at Wesleyan. She found that a substantial fraction of the periods reported in the literature for Classical T Tauri stars were likely to be false alarms. She also discovered two new periods for CTTS. These results are being prepared for publication in the Astronomical Journal.

Kearns has analyzed an additional season's worth of data on NGC 2264. Many new rotation periods have been discovered for stars in that cluster, bringing the total to 29. The trend towards shorter periods (by about a factor of 2) in NGC 2264 compared to the ONC is corroborated by the larger data set. This is consistent with a picture in which very little braking occurs due to star-disk interactions for stars older than about one million years. This suggests that disk lifetimes may be of that order or shorter, constraining the amount of time available for planet formation. One very interesting star has been discovered that appears to be an eclipsing binary with a period near 47 days. The occulting object cannot be a normal star, however, since the depth of the eclipse is more than 3 magnitudes and there appears to be structure in the light curve during minimum. It is possible that we are seeing an occultation by a protoplanetary concentration in the circumstellar disk surrounding this star. Further study of this unique object is underway.

Rhode and Herbst are continuing a v sin i study of stars with known rotation periods in the ONC and in NGC 2264. This work is being done in collaboration with Bob Mathieu (Wisconsin) and involves the multi fiber spectrogaph on the WIYN telescope. In a preliminary study, v sin i measurements were obtained for about 30 stars. While some calibration issues need to be addressed, the results are very promising. WIYN time has been obtained for the fall of 1997 to

expand the data set to about 100 stars. Several possible spectroscopic binaries have been identified, in addition to the measured v sin i's.

A collaborative study of the light curves of T Tauri and Herbig Ae/Be stars between Van Vleck Observatory and Maidanak Observatory of Uzbekistan is underway. Herbst and Kearns visited Maidanak Observatory in August, 1997, and Valery Shevchenko of the Tashkent Astronomical Institute plans a return visit in 1998. The research is supported by a grant from the Civilian Research and Development Fund for States of the Fomer Soviet Union. The vast data bank of the Maidanak Observatory, including many thousands of UBVR observations of Herbig Ae/Be and T Tauri stars has been merged with the ftp data bank maintained at Wesleyan and is available over the net. Visit the Astronomy Department's home page (URL: http://www.astro.wesleyan.edu) for additional information.

The supernova monitoring program at Wesleyan is continuing. Most bright supernovae north of declination negative twenty are observed in BVRI with the 0.6 m telescope. Kinemuchi and Herbst are examining recent light curves and preparing older material for publication in the Astronomical Journal.

2.2 Extragalactic

A survey for emission-line galaxies was continued in 1997 by Salzer and Gronwall, along with collaborators A. Kniazev (Russia - SAO), T. Thuan (U. Virginia), T. Boroson (NOAO/KPNO), Y. Izotov (Ukraine), and J. Moody (BYU). Called KISS - KPNO International Spectroscopic Survey, the survey combines the advantages of using a CCD detector with the wide field survey capability of a Schmidt telescope + objective prism. The following students also participated in the project during the past year: Wesleyan graduate students Kristin Kearns, Karen Kinemuchi, and Katherine Rhode; KNAC-supported undergraduates Laura Brenneman (Williams), Erin Condy (Vassar), and Michael Santos (Vassar). In the spring of 1997 a total of 22 nights of time on the Burrell Schmidt were used to obtain new survey data. A new variation on the previous observing scheme was initiated this year, with spectral data being obtained in the red region, including H-alpha. Tests made in the previous semester suggested that far more emission-line sources were detectable via H-alpha compared to the older blue spectra.

The special software required to process the KISS data was completed in the summer of 1997, and the majority of the existing data were reduced and analyzed. Preliminary results of the emission-line selection process revealed that an average of 21 ELGs were detected per square degree, more than 200 times the surface density of the Markarian survey and roughly 40 times higher than the recent Gallego *et al.* survey. A preliminary report on the KISS project was given by Kniazev *et al.* (1997); more complete and up-to-date results from the survey can be found on the project web site: www.astro.wesleyan.edu/~kiss. The processing of the survey data continues, and the KISS team expects to produce the first ELG candidate lists in the coming year.

Two spin-off projects which utilize the KISS data for other projects were also started during the summer of 1997. Graduate student Karen Kinemuchi began a project with Salzer to search for Carbon Stars in the Galactic halo using the KISS blue spectra. Early results look promising, and a search of the 100 square degree survey strip is currently in progress. Graduate student Kristin Kearns is working with Gronwall and Salzer to utilize the KISS direct images to construct a deep galaxy catalog for the full strip (to B = 19-20), and to use the catalog to investigate the number counts of galaxies in the crucial range B = 15-20. The large areal coverage of the survey combined with the high quality photometry should provide an accurate sample for comparing with the deeper number counts available from a number of small area surveys.

Salzer continues to work on the long-term all-sky Tully-Fisher peculiar velocities project being carried out with R. Giovanelli, M. Haynes (Cornell U.), L. DaCosta, W. Freudling (ESO), and G. Wegner (Dartmouth). To date, over 2400 I-band images of Sc galaxies have been obtained by this group. These data are combined with existing HI profiles to allow us to derive velocity-independent distances to this large, homogeneous sample of galaxies, and thus determine their peculiar velocites and any bulk streaming motions of galaxies in the local universe (out to 7500 km/s). In a related project, the same group are also looking at clusters of galaxies at distances to 15,000 km/s. A number of papers were completed during the past year. These include two papers from the clusters project, presenting the observational data and the analysis which led to the development of the template Tully-Fisher relation used for the peculiar velocity analysis (Giovanelli *et al.*, 1997a,b), as well as a paper presenting HI data used for the project (Haynes, *et al.* 1997). A paper which uses the cluster data to derive a value for the Hubble Constant appearred (Giovanelli 1997c). The value obtained is $H_o = 69 \pm 5$ km/s/Mpc. Finally Borgani *et al.* (1997) present a comparison between the peculiar velocity field obtained from our data and that derived from other recent surveys. The agreement was excellent.

Undergraduate student Stuart Norton carried out an extensive investigation in collaboration with Salzer into the nature of the underlying host galaxies of Blue Compact Dwarfs (BCDs). These are dwarf stellar systems which are observed to be forming stars at an incredible rate. Using detailed analysis of the surface brightness distributions in BCDs and less active normal dwarf galaxies, Norton found that the host galaxies of BCDs appear to be fundametally different from the majority of dwarfs in that they have systematically higher central mass densities. This may explain why they are capable of hosting (and sustaining) the massive star-forming events observed. The host galaxies to BCDs may represent the high end of the range of central mass densities in dwarf galaxies. These results are consistent with previous photometric and modeling studies. This work represented the senior thesis research for Norton, who was selected as a finalist for the American Physical Society's 1997 Apker Award.

Graduate student Katherine Rhode and Salzer continued to work on a study of nearby dwarf galaxies which possess expanding HI holes. Recent HI mapping work by D. Westpfahl (NMIMT) and collaborators at the VLA has revealed that most dwarf galaxies, when mapped with sufficient spa-

tial and velocity resolution, show evidence for expanding HI holes. They suggest that the holes are being created by multiple supernovae explosions. We previously obtained and analyzed deep CCD images for several dwarf galaxies looking for direct evidence for the existence of remnant star clusters at the centers of the holes, as would be predicted if the supernovae hypothesis was correct. No indication of any stellar sources indicative of a cluster capable of creating the HI holes was found. This past summer Rhode used the published information regarding the ages and energetics of the holes in Holmberg II to model more precisely the expected brightnesses and colors of the remnant stellar populations associated with the HI holes. In many cases the predicted optical components were far brighter than our observational limits, and seem to rule out the supernovae hypothesis if the massive stars were part of a stellar population formed with a normal IMF. A paper detailing the results of this work is currently in preparation.

In another project related to dwarf galaxies, Salzer continued to collaborate with Liese van Zee (NRAO) and Martha Haynes (Cornell U) on an optical and HI study of dwarf galaxies with high HI mass to blue light ratios. Such systems exhibit very low surface brightness (LSB) in the optical, and have the potential of being relatively young (such as I Zw 18 and HI1225+01). Three papers were completed during the past year, all derived from van Zee's 1996 thesis. The first of these investigates the HI gas density levels in LSB dwarf galaxies, and attempts to correlate the gas density with star-formation activity. The data support the idea of a threshold level in the gas density necessary for star formation to proceed. The second paper presents the optical data - both imaging and spectroscopy - obtained and analyzed as part of this large project, while the third utilizes the data to estimate the evolutionary status of this sample of relatively quiescent dwarf galaxies. Based on colors and metal abundances, we conclude that these galaxies are not necessarily young galaxies, but rather have been extremely inefficient at turning their copious reserves of HI gas into stars.

Three projects concerning the HI characteristics of BCDs were carried out during the past year. First, VLA maps of the prototype BCD, I Zw 18, were obtained and analyzed by van Zee, Westpfahl, Haynes and Salzer. This galaxy is one of the very few which appears to be genuinely young, showing no evidence for stars older than a few hundred million years in age. The HI gas associated with the system is very extended and exhibits an unsettled appearance. Although the central region of the HI gas appears to be undergoing disk-like rotation, most of the outer parts of the HI cloud are kinematically distinct. It gives the unordered appearance of a galaxy in the process of forming. A paper detailing this study has been submitted. In collaboration with van Zee and E. Skillman (Minnesota), Salzer is also involved in a project to study the HI gas distributions of several other BCDs. Data were obtained with C and B array configurations of the VLA, and are currently being analyzed. Finally, substantial progress was made on bringing to publication the data and analysis from an HI survey of BCDs carried out at Arecibo by Salzer, J. Rosenberg (UMass), J. Mazzarella (IPAC), G. Bothun (Oregon), and E. Weisstein (Virginia).

Salzer, W. Baan (Arecibo), and former undergraduate R. LeWinter completed work on a paper detailing the spectral characteristics of OH Megamaser galaxies. This class of AGN are noted for their intense, mased 18-cm emission due to OH molecules in dense clouds near the central parts of active galaxies. It was found that a very large fraction of these objects (roughly 2/3rds) show evidence for some type of Seyfert activity. These results provide valuable clues to understanding the physical mechanisms and the evolutionary status of these galaxies.

Gronwall, in collaboration with D. Koo (UC Santa Cruz) and G. Bruzual (CIDA, Venezuela), continued her work on traditional luminosity evolution models of faint field galaxy data. We have applied our non-negative least squares fitting technique, which derives the best-fitting local luminosity function for various galaxy spectral types, to the data from the Hubble Deep Field in addition to current ground-based data (galaxy number counts, redshifts, and colors). We assume traditional luminosity evolution along with a small additional component of starbursting galaxies. We also assume that galaxy spectral energy distributions are reddened due to dust. We can fit both the Hubble Deep Field and ground-based data extremely well.The only exception is that we underpredict the B-band number counts from $B=26-28$ by $\sim 10\%$. The agreement between our conventional models and the data demonstrate that ''exotic'' forms of evolution (rapid merging, cosmological constant, etc.) are not needed to fit the data. This work was presented at the January 1997 AAS meeting and the 1997 May Symposium at the Space Telescope Science Institute.

Gronwall also continued her collaboration with the DEEP (Deep Extragalactic Evolutionary Probe) survey team at UC Santa Cruz. DEEP is a new spectroscopic survey of faint ($B>24$) field galaxies using the 10m Keck telescope. Preliminary results from a initial sample of 24 galaxies fainter than $I=22$ (Koo *et al.* 1997) showed a median redshift of 0.8. These faint galaxies had colors which fell well within the bounds of the colors of local, normal galaxies. While some of these galaxies showed hints of mergers on HST images, other $z\sim 1$ galaxies appeared normal indicating that $z\sim 1$ galaxies are not confined to late-type, peculiar systems. Another related project measured spatially resolved velocity profiles for 16 faint field galaxies with $z=0.1-1$ and $I=17.9-22.4$ (Vogt *et al.* 1997). These data provide a high-redshift Tully-Fisher relation. We find no indication of a change in the shape or slope of the relation with respect to the local Tully-Fisher relation. There is a small offset of $\leqslant 0.4$ mag in B with respect to the local relation which is presumably caused by luminosity evolution in the field galaxy population and does *not* correlate with galaxy mass. The DEEP team also obtained spectra of a sample of 24 galaxies having colors consistent with star-forming galaxies at redshifts of $2\leqslant z\leqslant 4.5$ in the Hubble Deep Field (Lowenthal *et al.* 1997). Eleven of these galaxies are confirmed to be a high redshift, one is at $z=0.5$, and the other 12 have uncertain redshifts but spectra consistent with their being at $z>2$. The galaxies are small but luminous with half-light radii $1.8<r_{1/2}<6.5\ \ h_{50}^{-1}$ kpc and absolute magnitudes $-21.5\geqslant M_B\geqslant -23$. Using rest-frame UV continuum fluxes

with *no* dust correction we calculate star formation rates in the range 7-24 $h_{50}^{-2} M_{\odot}$ yr^{-1} for $q_0 = 0.05$.

PUBLICATIONS

The publication list includes all papers published or submitted between Sept., 1996 and Sept, 1997 by the permanent staff.

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W. Herbst