Case Western Reserve University
Warner & Swasey Observatory
Department of Astronomy
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This report covers the period 1 July 1999-30 June 2000.

I. PERSONNEL

The academic staff consisted of George W. Collins, II, Adjunct Professor; R. Earle Luck, Worcester R. & Cornelia B. Warner Professor of Astronomy, Director and Chair; Heather Morrison, Assistant Professor, and Christopher Mihos, Assistant Professor. Emeritus Professor William P. Bidelman continues to be an active presence in the department. Lawrence M. Krauss, Ambrose Swasey Professor of Physics and Chairman of the Physics Department and Glenn Starkman, Associate Professor of Physics hold a secondary appointments in the Department of Astronomy.

The research and technical staff was comprised of Dr. Kelly Holley-Bockelmann, Research Associate (working with Prof. Mihos), Dr. Denise Hurley-Keller, Research Associate (working with Prof. Morrison) and Charles Knox, Technical Specialist. The part time staff consisted of William Claspy, Library Assistant and Linda Day, Departmental Assistant.

II. INSTRUMENTATION

The Case Western Reserve University Burrell Schmidt telescope located at Kitt Peak National Observatory continued to be used primarily by CWRU astronomers with some time used by NESTAC - the Northeast Schmidt Telescope Consortium.

Refurbishment of the 0.9 meter reflector at the Nassau Station of the Warner & Swasey Observatory continued during the year with direct imaging being routinely available since 1999 January. This multi-year project will culminate in 2001 in a robotic telescope with direct imaging and spectroscopic capabilities which will be accessible through the World-Wide Web.

III. RESEARCH

Publications which appeared during the report period are listed in Sec. V. The following is a summary of work in progress or unpublished.

A) Chemical Abundance Studies in Stellar Atmospheres (R. E. Luck)

In collaboration with Prof. Sergei Andrievsky and Dr. Valery Korotin (Odessa State University, Odessa, The Ukraine) Prof Luck continues a study involving Cepheid abundances and which deals with consistency, questions of stellar evolution, and the Period - Luminosity - Abundance Relation. From the derived stellar parameters and abundances answers to the following questions are sought: Can one obtain consistent abundances around the cycle of a Cepheid? Are differences in spectroscopic gravities phase dependent? Are the abundances of the non-variables consistent with those of the Cepheids? Are the derived CNO abundances consistent with the predictions of standard stellar evolution and assumed progenitor abundances? What is the current abundance level of the local region of the galaxy? What is the current value of the galactic metallicity gradient? Can one determine an empirical correction to Cepheid the period - luminosity relation due to differing metallicities? The first paper (on the open cluster M25) dealing with these questions appeared during the course of this year.

A large scale study of abundances of nearby stars has been initiated within the past year. This study will provide vital information on the spectral characteristics of these stars by obtaining high-resolution, high signal-to-noise spectroscopic data on a significant fraction of the stars within 15 parsecs, and by sampling the population within 100 parsecs. The parent sample for this program is those stars in the Hipparcos Parallax Catalog which are within 100 pc of the Sun. The subsets of interest for this project are the following: 1a) The stars with distances less than 15 parsecs with absolute magnitudes greater than 10.0 that are north of declination -30.0. 1b) Samples of stars with characteristics that make them of interest in regard to planets regardless of distance (but which are north of -30 declination) i.e.: a) Those stars which are known to have planets; b) Those stars ‘‘known’’ not to have planets; c) Stars which are metal-rich and hence according to the hypothesis of Gonzalez (1997, 1998) are likely to have planets; and d) A randomly selected control sample of stars of similar spectral type to those of a) and b). The second priority for this program is a sample of F/G/K dwarfs and giants from the Bright Star Catalog (and Supplement) which are within 100 parsecs of the Sun and that are north of declination -30. These objects are about equally divided between dwarfs and giants. To choose among these candidate objects the 100 parsec sphere centered on the Sun will be subdivided into approximately 200 equal volume regions and a pair of stars (preferably a dwarf and a giant) will be selected from each. Among these objects a higher priority will also be assigned to any visual physical binaries which consist of a giant and a dwarf or a pair of dwarfs.

These studies utilize high-resolution high-signal to noise data obtained at McDonald Observatory of the University of Texas, Austin.

B) Studies of Galaxy Structure and Evolution (H.L. Morrison)

In a study of the Milky Way halo (with Mateo and Dohm-Palmer [Michigan], Olszewski and Harding [Steward], Freeman and Norris [MSSSO)], Arabadjis [MIT], Helmi [Max Planck Garching], and Sun [CWRU Statistics]), photometric data which allows us to identify halo tracers including red giants and turnoff stars has been obtained to V=20 in 54 square degrees at high latitude. This project aims to answer the question ‘‘how much of the Milky Way halo was accreted’’ by searching for velocity substructure in the galactic halo. We have shown that we can detect halo giants out to ∼100 kpc, and have designed a new method of searching for substructure in our sparse giant sample, using cluster analysis techniques. We have evidence for substructure at the 2-sigma level from this analysis, and as our sample of giants grows we will be able to test this more extensively.

We (Morrison, Jacoby and Hurley-Keller) are studying the halos of M31 and M33 using planetary nebulae (Pne) as tracers. What we will learn about halo age and kinematics in these systems will help us understand the properties of the halos in the more distant edge-on disk galaxies that we are studying using both deep surface photometry and PN searches.

In collaboration with Mihos, Harding, Feldmeier and undergraduate student Rodney (CWRU) we are studying the properties of intracluster light in a sample of galaxy clusters at Z∼0.1. Deep imaging with the KPNO 2.1m quantifies the distribution and amount of intracluster light for clusters with a range of richness and concentration. Using dynamical modeling, we will be able to use our data to constrain the distribution of dark matter in the clusters and the evolution of the cluster galaxies. We have reached V=26.5 on the first two clusters in our sample, and analysis is continuing.

C) Galactic Dynamics and Galaxy Evolution (C. Mihos)

Studies of merger-driven galaxy evolution continue using both theoretical and observational approaches. With Dubinski (CITA) and Hernquist (Harvard), models of tidal tail morphology in merging galaxies have been used to constrain the distribution of dark matter in galaxies. Galaxies with extended, massive dark matter halos have difficulty producing the very long tidal tails seen in many observed interacting galaxies, arguing that some galaxies have more limited halos. Other studies involving tidal debris focus on the volution of extended, low density gas and the bifurcation of gaseous and stellar tidal tails in observed mergers. These structures can be explained naturally through the different angular momentum distribution of gas and stars in progenitor galaxies, and do not rely on complex hydrodynamic interactions between tidal gas and a hot starburst wind or intergalactic medium.

With van der Marel (STScI), Hernquist (Harvard), and Heckman (JHU), the formation of ellipticals through galaxy mergers is being studied using NICMOS data on a sample of young merger remnants. If merger remnants do evolve into ellipticals, these remnants should follow the same central parameter relationships as those of normal elliptical galaxies. Preliminary analysis shows that while the central parameter relationship for remnants and ellipticals is similar, several of the youngest remnants show marked deviations from the main relationship. These young remnants must evolve rapidly to become normal ellipticals, or else these types of mergers do not form the bulk of normal ellipticals.

The nuclear properties of merging galaxies is also being studied through HST imaging of the ultraluminous infrared galaxy NGC 6240. We have obtained broad band and Halpha WFPC imaging of the nuclear regions, and will be obtaining longslit STIS spectroscopic data in Cycle 8. These data will allow us to study the triggering of starburst winds, characterize the nuclear stellar populations and gas kinematics, and test for the presence of any central black hole.

With Holley-Bockelmann (CWRU), Sigurdsson (PSU), Hernquist (Harvard), and Norman (JHU), work continues on the dynamical evolution of elliptical galaxies harboring central massive black holes. New numerical techniques have been developed to allow for the self-consistent modeling of triaxial ellipticals on both the parsec and kiloparsec scales, studying both the scattering of stars by the central black hole and the subsequent global evolution in the structural and kinematic properties of the host galaxy. Orbital analysis of the models both with and without black holes is ongoing.

In collaboration with Bershady (Wisconsin), the evolution of the Tully-Fisher relationship at moderate redshift is being studied with a combination of ground-based spectroscopic data and Monte-Carlo modeling of artificial rotation curves. The artificial rotation curves are used to study the systematic errors in determining rotational velocity as a function of observing and source parameters.

Work has also begun on a project to study tidal debris in a variety of galaxy environments, from loose groups to rich clusters. With Morrison (CWRU), Harding (Arizona), and Feldmeier (Penn State), deep imaging is being used to quantify the spatial distribution and total amount of intracluster light as a function of environmental density and dynamical conditions in the cluster. Upgrades to the CWRU Burrell are in progress to enhance its capability to detect this intracluster light. Along with the dynamical modeling of tidal stripping and galaxy evolution in clusters, the data will provide constraints on the dynamical evolution of cluster galaxies and the distribution of dark matter in galaxy clusters.

On the educational front, a java-based dynamical ‘‘laboratory’’ is being constructed to allow students to study astrophysics using computer simulation. Projects include a galaxy collision simulator, the stability of galactic disks, the virialization of clusters, and accretion of small satellite companions. These javalabs are aimed both at non-science and technical majors, and are incorporated into a variety of astronomy curricula.

D) SS 433 (G.W. Collins)

During the past year Collins continued his research into SS433 and formulation the Minimal Dynamical Model with Robert Scher. The Model assumes that there is a resonance lock between the driven precession and Eularian Nutation. This results in a vastly simpler description of the system than the Full Dynamical Model. However, the justification of the assumptions relies on that early work. The increasing availability of data for the object and the new model allow for much tighter constraints to be placed on the constitutions of the binary system.

IV. MISCELLANEOUS

The series of free public lectures, ‘‘Frontiers of Astronomy’’, continued under the joint sponsorship of Case Western Reserve University, the Cleveland Museum of Natural History, and the Cleveland Astronomical Society. Visitors who spoke this year were Dr. Seth Shostak (SETI

Institute), Dr. Ann Zabludoff (Univ. Arizona), Dr. Glenn Starkman (CWRU), Dr. Doug Richstone (Univ. Michigan) and Dr. Eleanor Helin (California Institute of Technology). In addition, Collins delivered two lectures in the Harlow Shapley Lecture Series sponsored by the AAS during the 99-00 season.

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V. BIBLIOGRAPHY

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