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1. INTRODUCTION

This report covers the Astronomy and Astrophysics group from October 1995 through September 1996. The group included Professors Jeffrey Kuhn, Susan Simkin, Horace Smith, and Robert Stein, Associate Professors Timothy Beers and Edwin Loh, Assistant Professor Suzanne Hawley, Visiting Professor Eugene Capriotti, and Emeritus Professor Albert Linnell. Kuhn was on leave at the National Solar Observatory until January 1995, and again from June to December, 1996.

2. RESEARCH

2.1 The SOAR Project

Michigan State University joined the SOAR project to build a four meter telescope in Chile in conjunction with the University of North Carolina, NOAO, and Brazil. Construction is expected to begin in 1997 and to take approximately five years.

2.2 Solar and Stellar Astrophysics

Beers is continuing his extensive investigation of the formation and evolution of the halo and thick disk of the Galaxy based on analysis of metal-deficient stars from the HK objective-prism/interference-filter survey. In this past year, Beers has completed the last of the visual scans for interesting candidates on the HK plates, and is initiating a computer scan of the 300 plates in collaboration with M. Irwin in Cambridge, England. A re-calibration of the method by which an estimate of [Fe/H] is obtained from medium-resolution spectroscopy is presently being carried out. A three-year campaign to substantially increase the numbers of known metal-deficient stars is coming to a close. A total of some 3000 medium-resolution spectra of candidates selected from the HK survey has been obtained. These should be published in the course of the next year. High-resolution spectroscopy of the most metal-deficient stars is presently being obtained using the NTT and 3.6m telescopes at ESO, the AAT, and the Herschel 4m telescope on the Canary Islands.

Beers and recent PhD recipient Ron Wilhelm have submitted for publication a paper describing methods to obtain estimates of temperature, surface gravity, and [Fe/H] for field horizontal-branch and other A-type stars. These methods will be applied to a large sample of some 1000 FHB/A stars in the near future.

Silvia Rossi (University of Sao Paulo) spent the year at MSU, collaborating with Beers in the acquisition, reduction, and analysis of spectroscopic data obtained as part of the follow-up to the HK survey.

Beers and graduate student Lamya Saleh are working with Grant Mathews (Notre Dame) in order to improve and refine theoretical models for the evolution of globular clusters and the Milky Way Galaxy.

Capriotti is investigating the temporal evolution of planetary nebulae based on the slow wind - fast wind model. One of the goals is to establish criteria for the formation and fragmentation of HI shells in evolving planetary nebulae. The radiation gas dynamics involved in the planetary nebulae study is being applied to diffuse nebulae in an attempt to understand the origin of star forming regions.

Hawley with Neill Reid and John Gizis (Caltech) completed the PMSU spectroscopic survey of 2000 nearby stars and the investigation of the magnetically active M dwarfs. Significant results included the identification of a break in the main sequence at spectral type M3, the observation of substructure in the photospheric TiO bands which correlated with the strength of the activity, and kinematic results which showed that magnetic activity lasts longer in the latest type stars. This last result provides a natural explanation for the observation that the incidence of acitvity increases with decreasing mass on the main sequence.

Hawley and collaborators finished their study of a flare on AD Leo observed with EUVE and several optical telescopes, and obtained new observations of flares with ASCA, EUVE, VLA, and optical telescopes. Graduate student Bill Abbett is continuing his work on solar flare models, incorporating dynamics into the radiative transfer code.

Hawley, Andrew Layden (McMaster), Bob Hansen (Lick), and collaborators completed a new statistical parallax investigation of the galactic RR Lyrae stars using NPM proper motions. An important part of the study was an extensive series of tests of the model which showed that the maximum likelihood method and the simplex implementation were both robust and reliable. The results indicate that the galactic RR Lyrae stars have an absolute V magnitude of about 0.76, in agreement with previous statistical parallax and Baade-Wesselink work, but in disagreement with some recent globular cluster results.

Kuhn continued to work upon problems involving the Sun, including analysis of data returned by the SOHO satellite.

Smith, Ruth Peterson (Lick), and Bruce Carney (UNC) began a study of ultraviolet spectra of the star RR Lyrae which were obtained with the Hubble Space Telescope. Smith and summer REU student Jason Lisle obtained B and V photometry of RR Lyrae with the MSU 60 cm reflector to assist in interpreting the spectra.

Smith and collaborators continued to work on photometry of pulsating variables in satellite systems of the Milky Way. Smith, Nancy Silbermann (JPL), and Hugh Harris (USNO) continued a study of variable stars in the Draco dwarf spheroidal galaxy, while Smith collaborated with Silbermann, Ron Wilhelm, and Alistair Walker (CTIO) in a study of variables in the Small Magellanic Cloud.

Undergraduate student Pamela Gay and Smith studied the period changes of RR Lyrae stars in seven globular clusters, finding that large positive and negative rates of period

change occurred more frequently for type RRab than for type RRc stars.

Realistic simulations of convection near the solar surface performed by Robert F. Stein in collaboration with A. Nordlund have shifted our paradigm for convection. Convection is non-local. It is driven from boundary layers which produce filaments of fluid that penetrate through the convection zone. This new paradigm replaces the older one of energy cascade from large scale driven eddies to smaller eddies. Solar convection is driven by radiative cooling at the surface on scales of granulation, which produces low entropy fluid that descends in the intergranule lanes and merges into filamentary downdrafts. Shear in these downflows creates turbulence. Ascending fluid is entropy neutral, with a very low level of fluctuations, because it diverges and overturns as it rises in order to conserve mass.

Stein, with graduate students David Bercik and Dali Georgobiani, has begun simulating magneto-convection near the solar surface. In one case, we evolve an initially uniform vertical magnetic field imposed on an existing hydrodynamic convection snapshot. Our lower boundary condition is that the field tend toward the vertical. In the other case, we evolve an initially uniform horizontal magnetic field imposed on the same snapshot. The lower boundary condition in this case is that incoming fluid carry in the initial magnetic flux. The upper boundary condition is that the field becomes potential.

Stein in collaboration with M. Carlsson has analyzed the formation of CaII H and K bright grains. We find that grains are produced by shocks that form around a megameter above continuum optical depth one. Their formation is determined entirely by the photospheric velocity field and is due primarily to acoustic waves with frequencies near the acoustic cutoff frequency.

Linnell is continuing development of combined binary star light synthesis and spectrum synthesis procedures. Synthetic photometry, using low resolution synthetic spectra, color filter transmission data, and phototube response data to simulate the actual observing process, is being added to the overall synthesis package. These procedures are being applied to both new and archival data for MR Cygni. The accretion disk simulation program has been extended to include a hot spot on the periphery of the accretion disk. The synthetic photometry procedure will automatically be applicable to the accretion disk program.

2.3 Galactic and Extragalactic Astronomy

Beers and graduate student Jeff Kriessler have recently submitted a paper describing the application of modern statistical methods for the detection of substructure in clusters of galaxies. As a part of his PhD thesis, Kriessler plans on applying these methods to a large sample of Abell clusters chosen from a volume-limited sample of the nearby universe.

Capriotti is investigating the flow of star clusters into the central regions of galaxies. A comparison of the rate of mass flow associated with stars to the mass flow associated with gas is made in order to see which would be more efficient in the mass concentrations observed in active galactic nuclei.

Capriotti and Hawley undertook a study of the dynamical evolution of the globular cluster system, including the effects of dynamical friction and tidal evaporation/disruption. Their results showed that the masses and concentrations of the current globular clusters are consistent with the rather narrow range that could have survived to the age of the Galaxy.

Hawley, Steve Majewski (U. Virginia), and J. Munn (USNO) continued their work on the motions of stars in the Galactic halo. They found additional evidence of halo streams, indicative of a halo that was at least partially formed from the disruption of galactic satellites. Graduate student Michael Hamlin is carrying out a theoretical study of this process of halo formation.

Kuhn, Hawley, and Smith analyzed photometry of the Carina dwarf spheroidal galaxy, finding evidence for extratidal stars along the major axis of the system. Though the surface density of the extratidal stars is low, they may account for a significant portion of the mass of the Carina system.

Simkin (with John Mackenty) has observed the extended HI surounding Markarian 315 and finds it is asymmetrically located with respect to the ionized gas and active nucleus in that object. Full details may be found at: http://jabiru.pa.msu.edu/pages/soar/sms.html.

3. INSTRUMENTATION

Hawley and graduate student Jeff Kriessler continued work on the MSU optical spectrograph for use at the Wyoming Infrared Observatory.

Loh has developed a new process to make charge-coupled detectors with a very low emissivity in the thermal infrared band. This will enable CCD's that need only a fifth as much cooling as conventional CCD's.

Kuhn studied problems related to off-axis telescope design for the CLEAR solar telescope and as a possible design alternative for the SOAR telescope.

H.A. Smith