

Michigan State University
Department of Physics and Astronomy
East Lansing, Michigan 48824

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This report covers the Astronomy and Astrophysics group from October 1996 through September 1997.

1. INTRODUCTION

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. Suzanne Hawley was promoted to Associate Professor effective July 1. Kuhn was on leave at the National Solar Observatory until January 1997, and again from June to December, 1997.

2. RESEARCH

2.1 The SOAR Project

Michigan State University is participating in 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 take approximately five years. Kuhn devoted a significant fraction of the last year to modeling the optical advantages of a 4m off-axis telescope for purposes of the SOAR telescope consortium. For coronagraphic applications such a telescope surpasses the performance of conventional 8-m aperture telescopes.

2.2 Solar and Stellar Astrophysics

Beers continued his primary program of observations – the search for extremely metal-poor stars in the Galactic halo. Followup spectroscopy and photometry of some 5000 additional metal-poor candidates from the HK objective-prism survey are now complete, and a recalibration of methodology for the estimation of metal abundances is underway. Papers describing the data from the past five years of followup work are expected to be submitted for publication within the next 6-12 months. Plans for further study of metal-poor candidates are being explored at present.

In fall 1996, graduate student Ronald Wilhelm, working under the direction of Beers, completed his thesis work on the nature of Field Horizontal Branch and other A-Type stars discovered as part of the HK survey followup. Wilhelm is presently a computer specialist at the University of Texas McDonald Observatory. Beers continued work with graduate student Jaehyon Rhee on the development of new techniques for the identification of metal-poor stars in the Galaxy.

Capriotti is studying the dynamical evolution of planetary nebulae. He has developed techniques for determination of nebular structure and its dependence on the luminosity, temperature, and wind-strength of the central star.

Hawley, George Fisher (Space Sciences Lab) and collaborators finished their study of a flare on AD Leo observed with EUVE and several optical telescopes. The differential

emission measure analysis provided new evidence on the differences between flaring and quiescent coronal loops.

Hawley, Chris Johns-Krull (Univ. Colorado) and collaborators completed their analysis of a solar flare observed at Lick Observatory with the Coude Auxiliary Telescope. The results allow, for the first time, a direct comparison with stellar data and with solar models. Graduate student Bill Abbett is continuing his work on solar flare models, incorporating dynamics into the radiative transfer code.

Hawley, John Fernley (IUE-Vilspa), Tom Barnes (U. Texas) and other collaborators completed a new statistical parallax investigation of the galactic RR Lyrae stars using the Hipparcos proper motions. As in previous studies, 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 recent globular cluster results, including results using subdwarf data from Hipparcos. The cause of the discrepancy is a subject of some controversy. Graduate student Chris Hanley continued his development of the statistical parallax code to incorporate metallicity effects.

Kuhn spent summer and fall terms at the National Solar Observatory in Sunspot, NM. The research program there has focused on infrared polarimetry and magnetometry and precise differential photometry. In collaboration with the MSU electronics and mechanical shops a new infrared instrument has been developed for 1-5 micron high dynamic range imaging. The instrument uses a new detector technology developed by Rockwell. Two infrared instruments (a near IR spectrograph and the 1-5 micron imaging system) will be used on a C130 aircraft experiment. This program involves collaborators from the High Altitude Observatory, NSO, Max Planck (Lindau), and Rhodes college. In February the unpressurized aircraft and a specially designed pointing platform that looks through a hole in the airplane roof, will chase the moon's shadow during a solar eclipse near the Galapagos Islands. Kuhn (with NSO) has also completed and will deploy the second solar telescope in a network of two instruments that are optimised for very high precision differential photometry. This semi-automated 15cm aperture, tip-tilt image corrected instrument will operate from near the summit of M. Loa in Hawaii.

Working with a graduate student and post-doc Kuhn has completed analysis of satellite photometry data from the SoHO experiment. These results confirm and refine earlier measurements of the solar oblateness and latitudinal temperature structure of the sun.

In collaboration with P. Etzel, I. Hubeny, and E.C. Olson, Linnell has completed a photometric and spectrophotometric analysis of MR Cygni. The analysis used an accurate mass ratio from new spectroscopic data obtained at Mt. Laguna Observatory. The new study shows that MR Cygni is a member of the class of hot Algols identified by Popper, in striking contrast to prior analyses that derived near main sequence

locations for the binary components. The photometric analysis applied a synthetic photometry algorithm. This procedure has been used to generate synthetic colors of single stars by Buser and Kuruucz. The synthetic spectra package developed by Linnell and Hubeny produced synthetic spectra that gave excellent fits to the Mt. Laguna spectra at all orbital phases. Synthetic spectrum fits to IUE spectra established the effective temperature of the primary component.

In collaboration with P. Szkody and D. Hoard (Univ. Washington), Linnell used the accretion disk option in the synthetic photometry package to model the rim bright spot in the PG0859+415 system. The B light curve by Grauer can be fit with excellent accuracy. The synthetic spectra option for accretion disk systems produced a precise fit to IUE spectra of the same system.

In collaboration with P. Harmanec and I. Hubeny, Linnell is analyzing multicolor light curves of β Lyrae with the accretion disk package. Preliminary indications are that a good fit to the photometry can be achieved with a disk that has appreciable extent perpendicular to the orbital plane. Linnell participated by invitation in the minisymposium on "Binary Stars: New Generation Modeling Developments and Results" at the Winston-Salem AAS Meeting.

Smith, Ruth Peterson (Lick), and Bruce Carney (UNC) continued a study of ultraviolet spectra of the star RR Lyrae which were obtained with the Hubble Space Telescope.

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 (Texas), Alistair Walker (CTIO), graduate student Barton Pritzl, and summer REU student Michele Stark in a study of variables in the Small Magellanic Cloud.

Smith and undergraduate student Cathy Simon completed a reanalysis of the correlation between metallicity and period change among field RRab stars. The more metal-rich RRab stars tend to have small rates of period change, consistent with their being near their zero-age horizontal branch locations in the HR diagram.

Graduate students David Bercik and Dali Georgobiani together with Stein initiated simulations of magnetoconvection near the solar surface. Two topologies are being investigated: (1) an initially vertical unipolar field and (2) a horizontal field carried in with the fluid entering at the base of the computational domain which forms flux loops. The equations of mass, momentum and energy conservation, and the induction equation are solved in a region 6 x 6 Mm horizontally and 3 Mm vertically, extending 2.5 Mm below the photosphere. Periodic boundary conditions are used in the horizontal directions, and the vertical boundary conditions are designed to be as transmitting as possible. We use a tabular equation of state that includes excitation and ionization of hydrogen and other abundant atoms, and the formation of H_2 molecules. The radiative energy exchange is calculated by solving the transfer equation for LTE radiation using a 4 bin opacity distribution function.

In both cases the magnetic field accumulates in the intergranule lanes and at the surface is compressed to a strength where the magnetic pressure is comparable to but slightly

smaller than the gas pressure. In the unipolar case, as the magnetic flux is increased it occupies an increasing fraction of the domain in which it suppresses the convection, producing broad dark lanes (somewhat reminiscent of pores) enclosing shrinking islands of bright granulation. In the flux loop case, the locations of strong surface fields appear as bright points in the intergranular lanes (as is observed for small flux tubes). As the strength of the horizontal field advected in from the bottom of the domain increases, magnetic buoyancy begins to play a role, so the rise time for the flux tubes through the convection region decreases. Also, the strength of the surface field slightly increases.

2.3 Galactic and Extragalactic Astronomy

In summer 1997, graduate student Jeffrey Kriessler, working under the direction of Beers, completed his thesis work on statistical issues of substructure in clusters of galaxies. Kriessler is presently a post-Doc at the University of Minnesota. Beers continues work with graduate student Lamya Saleh on theoretical aspects of galactic chemical evolution.

Nicole Homeier (undergraduate) and Loh measured the correlation function of the galaxies in the Hubble Deep Field using the photometric redshifts of Lanzetta et al. (1996, *Nature* **381**, 759). The correlation length r_0 at $z < 1$ is significantly lower than found by Loh (1988, in *Towards Understanding Galaxies at Large Redshift*, ed. Kron & Renzini, Kluwer, p. 197) for luminous galaxies. The correlation length at $3 < z < 5$ is comparable to that of nearby galaxies. A possible interpretation is that subluminescent galaxies have lower correlation, and the correlation for luminous galaxies formed before $z \approx 4$.

In collaboration with Charles H. Nelson, John W. Mackenty, and Richard E. Griffiths, Simkin has published results from a survey of Markarian Seyfert galaxies (using HST images), which show that the nuclei of type 1-1.5 Seyfert galaxies are dominated by strong point sources, while those of Seyfert 2 and non-Seyfert Markarian galaxies tend to be resolved, less distinguished, and similar in shape to normal galaxy luminosity profiles.

Working with B. I. Grimberg, Simkin has completed an analysis of the highly ionized gas in the outer regions of PKS0349-27 which shows that even at distances of more than 15 Kpc from the nucleus the gas displays excitation and ionization conditions which are similar to those found in AGN narrow line, nuclear gas clouds. (preprint available at <http://jabiru.pa.msu.edu>.)

Simkin has completed an essay for the AAS Centennial Year History dealing with the Committee on the Status of Women in Astronomy.

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H.A. Smith