East Tennessee State University
Department of Physics, Astronomy, and Geology
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The following report covers the Department astronomical activities from August 2002 through July 2003. For more information about the department, see our web pages at http://www.etsu.edu/physics.

1. PERSONNEL

The permanent teaching faculty that make up the astronomy group in the Department of Physics, Astronomy, and Geology at East Tennessee State University include Drs. M. Giroux, G. Henson, R. Ignace, D. Luttermoser, and B. J. Smith. Dr. R. Ignace joined the department in Fall 2003. Dr. R. Gardner, a tenured professor in the Mathematics Department, is an adjunct member.

2. FACILITIES AND INSTRUMENTATION

East Tennessee State University is a member of the Southeastern Association for Research in Astronomy (SARA) consortium, which operates a 0.9 meter optical telescope on Kitt Peak in Arizona. This telescope can be operated remotely from Tennessee. As part of the SARA consortium, ETSU participates in the SARA Research Experience for Undergraduates (REU) program.

On campus, the Harry D. Powell Observatory is used for teaching, research, and public outreach. It contains a 14″ Celestron telescope under a 14-foot AshDome, which can be operated from an adjacent control room. This telescope is equipped with an ST-9 CCD and a True Technologies filter wheel with BVRI and Wing filters. The observatory also has eight permanent pedestals outdoors for mounting 8-inch Meade LX-200 telescopes with Meade 416 XTE CCD cameras available for imaging. The telescopes and cameras can be controlled from computers in the observatory building. In addition, a 10-foot radio telescope was recently acquired for the Observatory. During the school year, public open houses are held at the observatory every two weeks. During these open houses, the telescopes are available for use, and one of the department astronomers gives a short presentation.

In addition to the observatory, the department operates a 50 seat planetarium with a Spitz A3P projector under a 24-foot dome and modern A/V capabilities. Monthly evening programs for the general public are offered during the academic year and an average of 1000 school children each year attend educational programs. The planetarium has been in operation since 1962.

3. RESEARCH

3.1 Extragalactic Research

M. L. Giroux, along with J. A. Collins and J. M. Shull (University of Colorado), used the Hubble Space Telescope (HST) and the Far-Ultraviolet Spectroscopic Explorer (FUSE) satellites to determine the metallicities and ionization structures of high velocity clouds by measuring ultraviolet silicon, oxygen, carbon, and hydrogen lines seen in absorption against the background quasars PKS 2155-304 and Markarian 509. Giroux and Shull, with J. Tumlinson (U. Chicago), and also with W. Zheng (John Hopkins) and his team, used FUSE and ground-based Very Large Telescope (VLT) observations to study intergalactic hydrogen and helium absorption in front of the quasar HE 2347-4342.

With J. T. Stocke (University of Colorado) and his team, Giroux identified the 1500 km/s Lyα absorber in the 3C 273 sightline with a dwarf post-starburst galaxy 70 kpc away from the sightline. This observation suggests that outflowing winds from dwarf galaxies may inject large quantities of metals and energy into the intergalactic medium. M. L. Giroux also worked with J. L. Rosenberg and J. T. Stocke (University of Colorado) and R. Ganguly (Space Telescope Science Institute) to investigate Lyα absorbers in the outskirts of the Virgo Cluster.

B. J. Smith, along with M. Nowak (M.I.T.), M. Donahue (Space Telescope Science Institute), and J. T. Stocke (University of Colorado), analyzed Chandra X-ray maps of the peculiar low luminosity radio galaxy NGC 4410A, which is part of a small group of galaxies. The nuclei of four galaxies in the inner group are clearly detected. In NGC 4410A, extended emission is observed, coincident with an arc of optical emission-line gas. This gas has optical line ratios indicative of shock ionization, thus it may be part of an expanding superbubble. Outside of the galaxies, diffuse intragroup gas is detected. This supports the hypothesis that this group is in the process of evolving from a spiral-dominated group, which typically have no X-ray-emitting intragroup gas, into an elliptical-dominated group.

With C. Struck (Iowa State), B. J. Smith has modeled the collision between the prototype starburst galaxy NGC 7714 and its companion NGC 7715, using an N-body hydrodynamical code. This model is able to reproduce all of the major morphology and kinematic features of this system with an off-center inclined collision between the galaxies. In a different approach to modeling interacting galaxies, B. J. Smith has incorporated a restricted 3-body galaxy interaction code into the PIKAIA genetic algorithm software, to automatically determine the interaction parameters using pattern-matching. During summer 2003, B. J. Smith, along with ETSU undergraduate Amanda Moffett, tested this software on NGC 7714/5, and obtained good matches to the morphology and line of nodes of the system.

3.2 Research on Asymptotic Giant Branch Stars

G. D. Henson worked with an ETSU undergraduate student (C. Huffman) and SARA REU program students (J. Reiff and W. Teets) to monitor Mira stars for microvariability. This is a continuing program supported by the Tennessee Space Grant Consortium to establish the presence and characteristics of suspected short-term variability in a select

group of Mira stars. Henson and his students carried out several sets of consecutive night observations in B, V, R, and I filters for a group of 6 stars over a two year period. With the exception of one event detected for RR Boo in 2001, they have found no significant short time-scale variations in any of the stars.

B. J. Smith extracted infrared light curves from the Cosmic Background Explorer (COBE) Diffuse Infrared Background Experiment (DIRBE) for a complete IRAS 12 micron-selected sample of 207 sources. These objects are mainly asymptotic giant branch (AGB) stars. In the time-averaged DIRBE color-color diagrams, slightly variable non-dusty red giants, semi-regulars, Mira variables, carbon stars, and OH/IR stars are clearly separated, with the DIRBE colors and variability increasing along the oxygen-rich sequence slightly-variable red giant → SRb/Lb → SRa → Mira → OH/IR and the carbon-rich SRb/Lb → Mira sequence. This supports the hypothesis that these are evolutionary sequences.

During the summer of 2003, B. J. Smith, along with ETSU undergraduate R. I. Baker, followed up on this study by investigating DIRBE variability in a sample of 89 additional sources with very red IRAS colors, in the range expected for very late AGB stars and post-AGB stars. The reddest object in this sample, OH 231.8+4.2 (QX Pup), was variable at 25 μm, with an amplitude of 0.29 $\pm$ 0.07 magnitudes. This source is a known bipolar nebula with an embedded M9III star, thus this is a very unusual source, in a brief and rarely observed stage of development: a pulsating AGB star embedded inside a proto-planetary nebula.

D. G. Luttermoser, in conjunction with ETSU undergraduate T. Smith, has been working on reductions and analysis of NEWSIPS IUE UV spectra and simultaneous optical spectra of the Mira variable R Leo (M8 IIIe) and a semi-regular variable, R Lyr (M6 III). The NEWSIPS reduction of RAW IUE spectra greatly reduces the background 'fixed-pattern' noise in the IUE cameras compared to the older IUESIPS reductions. For this work, D. Luttermoser wrote two procedures in the Interactive Data Language (IDL). These programs employ front-end GUIs to assist the user in IUE reduction and analysis. With the IUEREDUCE routine, the user takes the resampled NEWSIPS IUE raw low-resolution images, interactively subtracts blemishes (i.e., radiation hits and reseau marks), then carries out a Gaussian slit extraction to produce a final calibrated spectrum of energy flux versus wavelength. This procedure also performs interactive blemish subtraction for the high-resolution spectra. The user then runs the IUEANALYZE procedure to identify the emission features. For the low-resolution spectra, this procedure measures the emission line fluxes and 'continuum' regions. For the high-dispersion spectra, IUEANALYZE measures emission line fluxes, line centers, and line FWHM using Gaussian or Voigt profile functions. The UV Mg II lines were found to be brightest at visual light curve phase 0.3-0.4 (phase 0 = maximum visual brightness). This is coincident with the peak flux of the optical Fe I 4202 A and 4308 A lines, confirming that these optical lines are fluoresced from the Mg II lines. The visual flux varied by approximately 8% for the semiregular variable R Lyr as measured by the IUE FES camera while the Mg II flux varied by only 10% during this time period. R Leo had much larger flux variations. This strongly suggests that the outer atmospheric structure of the cool semiregular variable red giant stars is very different than that of the Mira-type variable red giant stars.

Luttermoser is also in the final stages of the analysis of his far-UV spectral observations of the high velocity Mira star S Car, obtained with the FUSE satellite. No secure detection was made of the Lyman-β line, which sets constraints on the hydrodynamic models representative of this star. Finally, Luttermoser is continuing his NLTE radiative transfer calculations with PANDORA of hydrodynamic models representative of Mira variables.

PUBLICATIONS

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B. J. Smith