

East Tennessee State University
Department of Physics and Astronomy
Johnson City, Tennessee 37614

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The following report covers the Department astronomical activities from August 2000 through July 2001. 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 and Astronomy at East Tennessee State University include Drs. M. Giroux, G. Henson, D. Luttermoser, and B. J. Smith. Dr. H. Powell retired from the full-time faculty in 1998; he is now a part-time faculty member. 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 telescope on Kitt Peak in Arizona. This telescope can be operated remotely from Tennessee, and has two CCDs and a spectrometer.

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. This telescope is operated from an adjacent control room. The observatory also has an outdoor area equipped with eight permanent pedestals for mounting telescopes. These pedestals have AC power and underground communication cables to link the telescope and CCD cameras to computers in the main room of the observatory building. The outdoor pedestals are used with eight 8" Meade LX-2000 telescopes. 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 astronomers in the department gives a short presentation.

In addition to the observatory, the department operates a 50 seat planetarium under the direction of G. Henson and R. Gardner. The planetarium houses a Spitz A3P projector under a 24 foot dome. The planetarium has been in continuous operation since 1962 as both an instructional aid for classes and as a science education resource for the local community. Monthly evening programs for the general public are offered during the academic year and an average of 1000 school children each year attend special educational programs. The planetarium has recently had its projection capabilities upgraded with the addition of a data/video projector, internet access, and stereo sound system.

3. RESEARCH

East Tennessee State University has research strengths in the study of the intergalactic medium, interstellar matter of galaxies, and Mira variable stars.

3.1 Extragalactic Research

B. J. Smith and C. Struck (Iowa State) published a survey of CO (1–0) observations of 11 extragalactic tails and bridges. Eight of these 11 features were undetected in CO to very low levels, with the most extreme case being the NGC 7714/5 bridge. Only one of the features was unambiguously detected, a luminous star formation region near an optical tail in the compact group Stephan's Quintet. Two distinct velocity components were found in this source, indicating that molecular gas was stripped from two different galaxies in the group. In order to better interpret these CO data, B. J. Smith has initiated a collaboration with J. Higdon (Kapteyn Institute, Holland) to measure chemical abundances in extragalactic tails and bridges using optical spectroscopy with the William Herschel 4.2 meter telescope. In addition, with C. Struck (Iowa State), B. J. Smith has been investigating the morphology of the prototype starburst galaxy NGC 7714 and its companion NGC 7715 via N-body hydrodynamical simulations. These simulations are able to reproduce all of the major morphology and kinematic features of this system with an off-center inclined collision between the galaxies.

In collaboration with G. F. Benedict (Texas) and his group, B. J. Smith has studied the star forming ring of the barred spiral NGC 4314 using Hubble Space Telescope U, B, V, I, and H α data. These data provided age estimates for the star clusters in this ring, and support the hypothesis that this ring is associated with an inner Inner Lindblad Resonance. In addition, B. J. Smith analyzed HI, CO, and optical data of the unusual radio galaxy NGC 4410A. These data suggest that distortions of this lobe were caused by an interaction of the lobe with interstellar matter, which was disturbed by the galaxy's gravitational interaction with nearby galaxies.

M. Giroux continued his collaboration with members of the Colorado Intergalactic Medium group (J. M. Shull, J. Stocke, J. Tumlinson, S. Penton, and A. Venkatesan), exploring observational and theoretical topics. As part of this collaboration M. Giroux was privileged to be an associate member of the FUSE GTO team. Using FUSE GTO data, in collaboration with the Colorado group and the FUSE Science team, the extent and strength of the Ly β lines corresponding to the well known Ly α forest of lines at low redshift were explored. In addition, under the leadership of G. Kriss (Space Tel. Sci. Inst.), M. Giroux was part of a team analyzing HST, FUSE, and groundbased spectra taken of the FUV-brightest known high redshift quasar. The comparison of He II Ly α absorption with the corresponding H I Ly α absorption suggested structure was present even in very low density regions. This analysis is being continued. In collaboration with T. Tripp (Princeton) and the Colorado IGM group, M. Giroux analyzed the gas associated with O VI absorption toward the AGN H1821+643, deciding that it is difficult to conclusively associate the absorber with hot collisionally ionized gas.

With J. Tumlinson and J. M. Shull, M. Giroux explored the theoretical possibility that some early star formation regions may contain metal free Population III stars. These stars have much harder spectra capable of doubly ionizing helium, and so have strong He II recombination lines from gas associated with this radiation. With A. Venkatesan and J. M. Shull, M. Giroux considered the theoretical consequences of an early X-Ray background on the thermodynamic evolution of the Intergalactic Medium.

In collaboration with B. Gibson (Swinburne University) and members of the Colorado group, M. Giroux analyzed HST spectra along lines of sight which probed gas associated with the Magellanic Stream and the High Velocity Cloud Complex C. This spectra provided constraints on the metallicity of this gas, the origin of which remains controversial.

3.2 Research on Mira Variable Stars

B. J. Smith, D. Leisawitz (Goddard Space Flight Center), M. Castelaz (PARI Observatory), and D. Luttermoser have used the COBE data to study infrared variability of 38 infrared-bright Mira stars. The amplitude of variability decreases with increasing wavelength, and for a few stars there is clear evidence for a near-infrared phase lag relative to the optical of $\sim 0.05-0.13$ phase. There is also evidence for a mid-infrared-to-near-infrared phase lag, with the mid-infrared peaking before the near-infrared but after the optical. Three examples of secondary maxima were detected, all of which have optical counterparts in the AAVSO data, supporting the hypothesis that these are due to shocks rather than dust formation.

G. D. Henson and H. Guenther (a SARA REU student from Biola University) searched for short-term variability in 4 Miras with suspected rapid variability during summer 2001. Several variations of at least 0.15 magnitude with a time scale of a few hours were observed in a near-infrared band for the star RR Boo. The most significant of these variations was an event with an amplitude of 0.8 magnitude over 3 hours. The amplitude of these variations is largest in a near-infrared band centered at 1.024 microns and small but detectable in the visual band. The variations in RR Boo were detected near phase 0.5 (time of minima) of the star's long-period pulsation cycle when such small brightness changes may be more evident. One other star with significant observations, SV And, showed no evidence of short-term variability, but it was near phase 0.1 (near maxima) of its pulsation cycle.

D. Luttermoser continues his work on modeling the atmospheres of red giant stars, calculating synthetic spectra from these models, and observing Mira variable stars with spectroscopic spacecraft. Luttermoser was Principle Investigator (with M. Castelaz of PARI as Co-Investigator) of a Cycle 2 Far Ultraviolet Spectroscopic Explorer (FUSE) observing program to study Mira stars at FUV wavelengths. A high radial velocity Mira star, S Car, was observed and a 3-sigma detection was made of the Lyman-beta line, red shifted from behind the geocoronal line. This flux was consistent with non-local thermodynamic equilibrium synthetic Lyman-beta generated from a Bowen (1988, *ApJ*, 329, 299) hydrodynamic model representative of S Car at the observed light-

curve phase of 0.35. The preliminary results of this work was reported at the 12th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun in Boulder in July 2001.

D. Luttermoser continued his work with Castelaz (PARI) on the optical spectra of Miras as well. Results of this work can be found in Castelaz, Luttermoser, and Piontek (2000) and Castelaz, Luttermoser, Caton, and Piontek (2000). Luttermoser's invited talk on the chromospheres of carbon stars, given at the IAU Symposium #177 in Antalya, Turkey in May 1996, appeared in print during the summer 2000.

D. Luttermoser also continued his development of software to model the evolutionary change of a planetary atmosphere in response to stellar evolutionary changes over the lifetime of a star. An undergraduate student laboratory based on this software has been developed as well during this time.

PUBLICATIONS

- G. F. Benedict, D. A. Howell, I. Jorgensen, B. J. Smith, and J. D. P. Kenney (2001), "NGC 4314. IV. Photometry of Star Clusters with Hubble Space Telescope—History of Star Formation in the Vicinity of a Nuclear Ring," submitted to *AJ*.
- M. W. Castelaz, D. G. Luttermoser, D. B. Caton, and R. A. Piontek (2000), "Phase Dependent Spectroscopy of Mira Variable Stars," *A.J.*, 120, 2627
- M. W. Castelaz, D. G. Luttermoser, and R. A. Piontek (2000), "Vanadium Oxide in the Spectra of Mira Variables," *ApJ*, 538, 341.
- B. K. Gibson, M. L. Giroux, S. V. Penton, M. E. Putman, J. T. Stocke, and J. M. Shull (2000), "Metal Abundances in the Magellanic Stream," *A.J.*, 120, 1830
- B. K. Gibson, M. L. Giroux, S. V. Penton, J. T. Stocke, J. M. Shull, and J. Tumlinson (2001), "High-Velocity Cloud Complex C: Galactic Fuel or Galactic Waste?" *A.J.*, in press
- B. K. Gibson, M. L. Giroux, J. T. Stocke, and J. M. Shull (2001), "Do High Velocity Clouds Really Fuel Galaxy Formation?" in *Gas and Galaxy Evolution*, ASP Conference Series, ed. J. E. Hibbard, M. P. Rupen, and J. H. van Gorkom, in press
- H. D. Guenther and G. D. Henson (2001), "Monitoring Select Mira Stars for Short-term Variability," submitted to I.A.P.P.P. Communications.
- G. A. Kriss, . . . , M. L. Giroux, . . . , (2001), "Resolving the Structure of Ionized Helium with the Far Ultraviolet Spectroscopic Explorer," *Science*, 293, 1112
- D. G. Luttermoser (2000), "The Chromospheres of Cool Carbon Stars," in *The Carbon Star Phenomenon*, ed. R. Wing, (Dordrecht: IAU/Kluwer), p. 105.
- D. G. Luttermoser and M. W. Castelaz (2001), "FUSE Observations of a Mira Variable Star," in 12th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, ed. T. Ayres and A. Brown, ASP Conf. Series, in press.
- J. M. Shull, M. L. Giroux, *et al.* (2000), "Far Ultraviolet Spectroscopic Explorer Observations of the Low Redshift Ly Beta Forest," *Ap.J.(Letters)*, 538, L13
- B. J. Smith (2000), "Interstellar Gas in the NGC 4410 Galaxy Group," *Ap.J.*, 541, 624.
- B. J. Smith and C. Struck (2001), "New Observations of

- Extra-Disk Molecular Gas in Interacting Galaxy Systems, Including a Two-Component System in Stephan's Quintet," *A.J.*, 121, 710.
- B. J. Smith, M. W. Castelaz, and D. G. Luttermoser (2001), 'Infrared Light Curves of Mira Variable Stars from COBE DIRBE Data', *Proceedings of the Galactic Structure, Stars, and the Interstellar Medium Conference (Fourth Tetons Conference)*.
- B. J. Smith, M. Donahue, and J. Stocke (2001), 'Interstellar Gas and Star Formation Near the Peculiar Radio Galaxy NGC 4410A', *Proceedings of the Gas and Galaxy Evolution Conference*.
- B. J. Smith, D. Leisawitz, M. W. Castelaz, and D. Luttermoser (2001), "Infrared Light Curves of Mira Variable Stars," submitted to *A.J.*
- J. T. Stocke, J. M. Shull, S. V. Penton, B. K. Gibson, M. L. Giroux, and K. M. McLin (2001), "The Local Ly Alpha Forest: HI in Nearby Intergalactic Space," in *Gas and Galaxy Evolution*, ASP Conference Series, ed. J. E. Hibbard, M. P. Rupen, and J. H. van Gorkom, in press
- T. L. Tripp, M. L. Giroux, *et al.* (2001), "The Ionization and Metallicity of the Intervening O VI Absorber at $z=0.1212$ in the Spectrum of H1821+643," *Ap.J.*, in press
- J. Tumlinson, M. L. Giroux, and J. M. Shull (2001), "Probing the First Stars with Hydrogen and Helium Recombination Emission," *Ap.J.(Letters)*, 550, L1
- A. Venkatesan, M. L. Giroux, and J. M. Shull (2001), "Heating and Ionization of the Intergalactic Medium by an Early X-Ray Background," *Ap.J.*, in press

B. J. Smith