

University of Georgia
Department of Physics and Astronomy
Athens, Georgia 30602

This report covers the period Oct. 1994 – Oct. 1995.

1. PERSONNEL

Department members participating in astrophysics or astronomy research or instruction were Associate Professors Jean-Pierre Caillault and J. Scott Shaw, Assistant Professor Loris Magnani, graduate students Fred Buls, Thomas Hearty, Michael James, Sangeeta Mysore, and Inseok Song and undergraduates Sharon Holcomb, Matthew Jester, J.D. Myers, Amy Seila, and Rebecca Turner. Undergraduate student Bryan Speck (Benedictine College) spent the summer as an NSF REU intern. Anna Varley (Cedar Shoals High School) was a summer intern.

2. FACILITIES

The Southeastern Association for Research in Astronomy (SARA), of which the University is a member, operates a 0.9-m telescope on Kitt Peak. This telescope is now completely functional with a dual-channel photometer and a CCD camera. The capability for robotic and remote operation is expected in spring 1996. The CCD camera was funded by a grant from the Research Corporation.

The astronomy group has five dedicated SUN Sparcstations and numerous smaller machines are also available for data processing and computation.

3. RESEARCH

Buls & Caillault have observed the NGC 3572 cluster with the *ROSAT* HRI. *Einstein* IPC observations indicated that this region (in the line-of-sight toward Car OB2) had significant unresolved extended X-ray emission. The HRI observations show that the emission has been resolved, primarily into sources whose optical counterparts are hot stars. Their search through the *ROSAT* archives for truly diffuse X-ray emission regions associated with OB associations continues, however, because Ser OB2 seems to have evidence of diffuse emission in both the *Einstein* and *ROSAT* observations.

Caillault, M. Gagné (JILA), J. Stauffer (CfA), R. Neuhauser (MPE-Garching), & J. Schmitt (MPE-Garching) are conducting a study of the variability of the X-ray sources detected in the Orion Nebula. They are using the *Einstein* data from the early 1980s, *ROSAT* All-Sky Survey data from 1990, archival *ROSAT* PSPC data from 1991, and *ROSAT* HRI data from 1992 in order to determine the degree of variability on timescales ranging from minutes (within one observation) to more than a decade. Ample evidence exists that flares occur frequently on the low-mass PMS stars, but a thorough study of longer-term X-ray variability in PMS stars has never been done.

Caillault, Gagné, & Stauffer have carried out a month-long monitoring campaign of the O7 star θ^1 Ori C with the *ROSAT* HRI. These observations will allow them to deter-

mine if the short-term periodic variability of θ^1 Ori C (seen in their previous HRI observations) is real and correlated with the 15.4-day periodic H α variations seen by Stahl *et al.* Also, combining these new data with their previous observations should allow for the study of long-term variability; the previous observations, separated by 11 months, show highly significant variation, not expected from theory.

Caillault & Stauffer have proposed to use the HST WFPC-2 to search for the companion to the highly-reddened WN8 Wolf-Rayet star AS431 which is both a hard, strong X-ray source and also a double radio source (separation = $0.58''$). Although the X-ray emission is best explained by capture of the WR-star's dense, equatorial wind by a neutron star companion, the true nature of the companion to AS431 is not known. High-spatial resolution *B*-, *V*- and *I*-band Planetary Camera observations of AS431 will allow for a high S/N search for the companion down to $V \sim 25$, enabling them to determine from its magnitude and *B-V* and *V-I* colors whether the companion is a faint PMS star, an early-type MS star, or a neutron star. If it is indeed a NS, then this would be only the third known NS with a MS companion - and it would be the first to be discovered by having investigated the hot star first.

Magnani & J. Onello (SUNY-Cortland) continue their study of the "X-factor," the ratio of the molecular hydrogen column density to the velocity-integrated CO(J=1-0) antenna temperature, in translucent molecular clouds. Their current effort focusses on the variation of the X-factor from position to position in a given translucent cloud. The two clouds which have been studied thus far, MBM40 and MBM16, show markedly different behaviour: The X-factor tends to vary significantly from position to position in MBM16 but not in MBM40. The next step in the project is to determine the physical processes responsible for this behavior.

Magnani, Hearty, & Caillault, along with Stauffer, Neuhauser, Schmitt, F. Verter (NASA/GSFC), & E. Dwek (NASA/GSFC), continue to seek evidence of star formation in low-extinction translucent molecular clouds. A recent, multiwavelength study of the cloud MBM40 reveals that this object harbors no discernible traces of pre-main sequence stellar candidates. Similar work on a more filamentary cloud, MBM55, and a more compact translucent cloud, MBM07, is in progress. The ultimate aim of this project is to determine the star-formation efficiency of translucent clouds and to identify the physical mechanism(s) responsible for initiating or inhibiting the star-forming process in these objects.

Magnani, D. Hartmann (CfA), & P. Thaddeus (Harvard/CfA) are continuing their survey of CO(J=1-0) emission at Galactic latitudes $|b| > 30$ deg. Using the CfA 1.2-m telescope, 44% of the high latitude sky visible from Boston has been sampled on a $1\text{deg} \times 1\text{deg}$ grid. They have made 53 detections of which some appear towards directions never before searched for CO(J=1-0) emission. Their detection

rate is 0.26%, a bit lower than previous work on high-latitude clouds. During the coming year, the survey will be extended to cover as much of the unsampled regions as possible and any new high latitude clouds will be mapped in detail.

Magnani, T.N. LaRosa (Kennesaw State), & S.N. Shore (Indiana-South Bend) continue their study of turbulence in translucent clouds. A coherent structure mapped in H₂CO in the cloud MBM16 has been mapped in ¹³CO in order to study in more detail the velocity structure of the region. Preliminary results seem to indicate that the observed superthermal velocities are truly turbulent and not due to a spectrum of Alfvén waves. The aim of this effort is to shed light on the probable hydrodynamic origin of MBM16 and translucent clouds in general.

Shaw, Caillault, & Schmitt have conducted a survey of near-contact binary systems observed during the ROSAT All-Sky Survey (RASS). The near-contact binaries have an A- or F-type primary, with a companion which is one to two spectral types cooler. The systems have periods less than one day and display strong tidal interaction, but are not in contact like the W UMa systems. Of the more than 150 such systems known to exist, all of those (58) within 400 pc were analyzed. Fourteen systems were detected, with X-ray count rates > 0.01 cts s⁻¹. The X-ray luminosity function for the NCBs is very similar to that for A-type W UMa systems, but appears to be significantly different from those of W-type W UMa systems and RS CVn binaries. This is consistent with the proposed scenario that the NCBs are evolutionary precursors to the A-type W UMa binaries. The mean X-ray luminosity of the NCBs is log L_x = 29.3 ± 0.1 ergs s⁻¹, less than that of the RS CVns, but greater than that of normal late-type main sequence stars. The detection of these systems may help to explain why many presumably single A-type stars were detected in the RASS; i.e., the "single" A-stars may, in fact, be binaries, like the NCBs, with late-type companions.

Shaw & Caillault have monitored V1010 Oph, a NCB system, with the ROSAT HRI. Their goal is to try to determine whether the system shows eclipses in its X-ray emission. Only a few stars (e.g., α CrB and FO Vir) have shown convincing evidence that X-ray eclipses occur, thereby demonstrating, at least in these two cases, that the X-ray emission almost certainly arises from the later type star in the system and that the A-star component has no detectable X-ray emission. Monitoring V1010 Oph through its secondary eclipse should produce more convincing evidence, because V1010 Oph is much brighter than FO Vir and because the phase coverage will be more complete.

Song & Caillault conducted a study of the X-ray spectral characteristics of late-type stars as derived from observations with the ROSAT PSPC. The fitting of these spectra to thermal models allows for an in-depth study of the stars' coronal parameters, e.g., temperature, size, density and emission measure. Unfortunately, they found no distinguishing characteristics among the different spectral types studied. All the field stars, from spectral types F through M, seem to have best-fit spectral parameters within the error bars of all of the other stars' measurements.

PUBLICATIONS

(1994):

- Caillault, J.-P., Editor, *Cool Stars, Stellar Systems, and the Sun*, ASP Conference Series, 64, 743 pages
- Caillault, J.-P., Gagné, M., & Stauffer, J.R., "ROSAT HRI Observations of Hot Stars in the Orion Nebula," **ApJ**, 432, 386
- Caillault, J.-P., Gagné, M., Stauffer, J.R., Prosser, C.F., & Hartmann, L.W., "ROSAT Observations of Young Stellar Clusters," in *Frontiers of Space and Ground-Based Astronomy*, eds. W. Wamsteker, M.S. Longair, & Y. Kondo, 629
- Caillault, J.-P., "Stellar Clusters and Star-Forming Regions," in *The Soft X-Ray Cosmos*, eds. E.M. Schlegel & R. Petre, 7
- Gagné, M. & Caillault, J.-P., "The Complete *Einstein* Observatory Survey of the Orion Nebula Region," **ApJ**, 437, 361
- Gir, B.-Y., Blitz, L., & Magnani, L., "The Association of High-Latitude Molecular Clouds with HI Gas," **ApJ**, 434, 162
- Magnani, L., "Molecular Line Surveys at High Galactic Latitudes," in *The First Symposium on the IR Cirrus and Diffuse Molecular Clouds*, eds. R.W. Cutry & W.B. Latter, ASP Conference Series, 58, 429
- Magnani, L., Caillault, J.-P., Hearty, T., & Buchalter, A., "Is L134N a Stellar Nursery?," in *Cool Stars, Stellar Systems, and the Sun*, ed. J.-P. Caillault, ASP Conference Series, 64, 720
- Shaw, J.S., "Near Contact Binaries," in *Evolutionary Links in the Zoo of Interacting Binaries*, eds. F. D'Antona *et al.*, Mem. Astr. Soc. Ital., 65, 95
- Stanford, J.M. & Caillault, J.-P., "An *Einstein* Survey of the 1 keV Soft X-Ray Background in the Galactic Plane," **ApJ**, 424, 671
- Stauffer, J.R., Caillault, J.-P., Gagné, M., Prosser, C.F., & Hartmann, L.W., "A Deep Imaging Survey of the Pleiades with ROSAT," **ApJS**, 91, 625 (1995):
- Caillault, J.-P., "ROSAT Observations of Open Clusters," presented at the *Röntgenstrahlung From the Universe* conference held in Würzburg, Germany, Sep. 1995
- Caillault, J.-P., "ROSAT Observations of Open Clusters," presented at The Ninth Cambridge Workshop on *Cool Stars, Stellar Systems, and the Sun*, held in Florence, Italy, Oct. 1995
- Caillault, J.-P., Magnani, L., & Fryer, C., "A Search for Pre-Main Sequence Stars in High-Latitude Molecular Clouds. III. A Survey of the *Einstein* Database," **ApJ**, 441, 261
- Gagné, M., Caillault, J.-P., & Stauffer, J.R., "Spectral and Temporal Characteristics of X-Ray Bright Stars in the Pleiades," **ApJ**, 450, 217
- Gagné, M., Caillault, J.-P., & Stauffer, J.R., "Deep ROSAT HRI Observations of the Orion Nebula Region," **ApJ**, 445, 280
- LaRosa, T.N., Shore, S.N., & Magnani, L., "On the Origin of the Velocity Field in a Non-Star Forming Translucent Molecular Cloud," **ApJ**, submitted
- Magnani, L., Caillault, J.-P., Buchalter, A., & Beichman, C.A., "A Search for T Tauri Stars in High-Latitude Mo-

- lecular Clouds. II. The IRAS Faint Source Survey Catalog.” **ApJS**, 96, 159
- Magnani, L. & Onello, J.S., “A New Method for Determining the CO to H₂ Conversion Factor for Translucent Molecular Clouds,” **ApJ**, 443, 119
- Magnani, L., Caillault, J.-P., Hearty, T., Stauffer, J., Schmitt, J.H.M.M., Neuhäuser, R., Verter, F., & Dwek, E., “A Search for Star Formation in High-Latitude Molecular Clouds. IV. The Translucent Cloud MBM40,” **ApJ**, submitted
- Prosser, C.F., Stauffer, J.R., Caillault, J.-P., Balachandran, S., Stern, R.A., & Randich, S., “An X-Ray Survey of the Open Cluster NGC 6475 (M7) with *ROSAT*,” **AJ**, 110, 1229
- Shaw, J.S., “X-Ray Observations of Non-Degenerate Close Binary Stars,” presented at the Third Pacific Rim Conference on *Recent Developments on Binary Star Research*, Chaing Mai, Thailand, Oct. 26 - Nov. 1, 1995
- Shaw, J.S., Caillault, J.-P., and Schmitt, J.H.M.M., “Near-Contact Binary Systems in the *ROSAT* All-Sky Survey,” **ApJ**, in press

J.-P. Caillault