

OPEN CLUSTERS AS LABORATORIES:

THE ANGULAR MOMENTUM EVOLUTION OF YOUNG STARS

Grant NAGW-2698

Annual Status Report No. 2

For the period 1 May 1993 through 30 April 1994

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This is the annual status report for the third year of our LTSA grant "Open Clusters as Laboratories." Because we have now had a few years to work on the project, we have started to produce and publish a large number of papers. We have been extremely successful in obtaining ROSAT observations of open clusters. With the demise of the PSPC on ROSAT, our main data source has come to an end and we will be able to concentrate on analyzing those data. We look forward to the planned launch of ISO in Fall 1995 since data from that mission should provide us with additional observational data needed to model the PMS angular momentum evolution of low mass stars.

Our main Pleiades ROSAT PSPC paper has now been published, and we are working on a second paper which will be devoted to analysis of the X-ray flares and long-term variability of Pleiades members. A set of ROSAT HRI observations are in progress that will provide us with high resolution X-ray images of selected regions in the Pleiades which we decided were necessary in order to separate a number of regions where several sources are blended together.

Our main HST WFPC Trapezium cluster luminosity function paper has been published recently, and we have just submitted two followup papers which estimate the fraction of Trapezium cluster members with protoplanetary circumstellar disks and provide near-infrared photometry for the Trapezium cluster members. A fourth paper where we will provide spectral types and reddening estimates and use those data to estimate the stellar mass function for the Trapezium cluster is in progress.

We have just submitted a paper on ROSAT HRI observations of the high mass stars in the Orion/Trapezium cluster whose purpose was to determine whether the late-B and early-A type stars there are intrinsic X-ray sources (as had been claimed in the literature) or if instead their X-ray emission is more likely attributable to low mass binary companions. We favor the latter interpretation in our paper. A long-awaited complete reanalysis of the EINSTEIN Orion observations has been written by one of us, with submission to the journal expected shortly.

Our collaborators in Germany (J. Schmitt and S. Randich) have completed analysis of the ROSAT raster-scan data for Praesepe; nearly completed analysis of the raster data for IC2602; and will soon start final analysis of the raster-scan data for the Alpha Per cluster. We have been working on obtaining optical data for the X-ray sources identified in the ROSAT data. In particular, we have obtained and analyzed an extremely large amount of CCD imaging data for IC2602, which has allowed us to provide optical ID's and photometry for about 30 of the IC2602 X-ray sources. An observing run to obtain spectra of the IC2602 low mass X-ray sources is scheduled for April 1994.

New pointed ROSAT PSPC observations of NGC6475 and the Alpha Persei cluster have been obtained and analyzed during this period. Basic analysis of both sets of data has been completed. We also obtained a large CCD mosaic of NGC6475, and have used those data to determine optical identifications of cluster member X-ray sources (in the same manner as was done for IC2602).

Analysis of the Hyades ROSAT X-ray data continues, with two more papers submitted during the period covered by this report: the first paper provides an analysis of the dK and dM

Hyades members detected in pointed ROSAT observations, and the second paper is devoted to an analysis of the complete ROSAT survey data for the Hyades. A paper on chromospheric activity of very low mass Hyades and Pleiades members was also submitted during the period.

A new set of spotted star light curve data for Pleiades, Hyades, and Alpha Persei members was obtained during the last observing season. A small amount of additional data is expected to be obtained during a March 1994 observing run. Initial analysis of the main dataset indicates that we should be able to derive new rotation periods for most of the stars we have observed.

K.B. MacGregor continued development of theoretical models of the angular momentum evolution of low mass stars. The latest version of the models (described in a paper just submitted to *Astronomy and Astrophysics*) incorporates disk-regulated PMS rotation – a newly predicted facet of the evolution of these stars that may provide the key to interpreting the distribution of rotational velocities and X-ray emission for stars in our young open clusters.

One of us (J.-P. Caillault) was the host to the 8th Cool Stars and Stellar Systems conference held in Athens, Georgia, in October 1993. Several members of the team attended the meeting and gave review talks. A team meeting was held during one evening at the meeting.

Our plans for the next year of the LTSA project remain essentially unchanged from our original proposal. Since we will have finished analysis of all the ROSAT PSPC data, we will be able to do correlation studies of X-ray activity vs. age and mass. We will also be involved in ground-based studies to determine the optical properties of the X-ray sources. The AO for U.S. participation in the ISO mission will be issued in the next few months, and we plan to submit one or more proposals to search for disks around low mass stars in our primary open clusters.

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