OPTICAL SPECTROSCOPY OF COOL STARS DETECTED BY EXOSAT

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ABSTRACT Optical spectroscopy of southern serendipitous X-ray stars detected by EXOSAT are presented. We detected the Hα line in emission or filled-in in more than 50% of our stars. Strong Ca II H & K emission lines were detected in almost all sources. We also detected the 6707 Å Lithium line in 17 out of the 26 observed. In particular for 10 sources this line was stronger than the nearby Ca I 6717 Å line; a clear indication of youth.

Keywords: Cool stars; X-ray; Spectroscopy; Lithium

INTRODUCTION

X-ray observations are a powerful tool for studying stellar surface activity, its variation with stellar evolution and the determination of the stellar contribution to the diffuse soft X-ray background (e.g. Rosner et al. 1985; Pallavicini 1989). By studying samples of sources serendipitously detected in the X-ray band, it is possible to investigate the high tail of the stellar X-ray luminosity function and the highest levels of activity among stars (Caillault et al. 1986; Favata et al. 1988; Fleming et al. 1988, 1989). The ROSAT full sky survey, in conjunction with optical studies, will fully exploit the potentials of this approach (e.g. Schmitt 1991).

About one hundred late-type stars have been detected with the Low Energy Telescope and CMA detector on board the EXOSAT satellite (Giommi et al. 1991). This sample includes many variable stars; to date, three new CVs (Beuermann et al. 1987, 1989; Osborne et al. 1988), a flaring PMS star

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(Tagliaferri et al. 1988) and a few flaring M dwarfs have been identified. Among the latter is the faint M dwarf VB 8 (=GL 644C, \( m_v \sim 17 \)), one of the coolest stars (Sp=dM7) so far detected at X-ray wavelengths (Tagliaferri et al. 1989). The nature of most stellar EXOSAT sources remains, however, to be determined.

RESULTS

In order to study the nature of X-ray selected cool stars in the EXOSAT sample, we started a campaign of optical observations. In March 1990 we obtained, at the European Southern Observatory at La Silla, Chile, moderate-resolution spectra both in H\( \alpha \) and in the Ca II H&K region, and high-resolution spectra of the Ca II H&K lines and of the Li I (6707 Å) line. UBVRI photometric observations were also obtained (Cutispoto et al. 1991). The H\( \alpha \) line was detected in emission or filled-in in more than 50\% of our stars (here we exclude the dMe stars which by definition have H\( \alpha \) in emission and constitute \( \sim 40\% \) of our sample), providing a sure indication of extremely high chromospheric activity. Strong Ca II H&K emission was also detected in almost all our sources.

Among PMS the Post T-Tauri stars (PTTS) are particularly interesting. The T-Tauri phase occupies only a small fraction (\( \approx 5 - 10\% \)) of the contraction time of a 1 \( M_\odot \) star towards the main sequence Herbig (1978). As a consequence,

![Graph](#)

**Fig. 1:** High resolution spectra of an EXOSAT serendipitous star in the Li I 6707 Å line region. Note that the Li line is stronger than the nearby Ca I 6717 Å line.
many more PTTS should exist than classical T-Tauri stars. But so far, only a handful of bona fide PTTS have been identified outside star-forming regions (see reviews by Herbig (1978) and Haro (1983)). However PTTS are expected to be vigorous X-ray coronal sources and X-ray surveys are the best way to identify them. One PTTS (HD 560B) has already been detected in the EXOSAT sample (Tagliaferri et al. 1988). Some of these elusive objects, whose study can provide crucial information on the evolution of stellar coronal activity during the pre-main sequence phase, could be present in our sample. To search for PTTS we took high resolution spectra of the 6707 Å lithium line region. The line was clearly detected in 17 stars out of the 26 observed. All these stars are of spectral type later than G. In particular for 10 sources this line was stronger than the nearby CaI 6717 Å line (fig. 1); a clear indication of youth. Unless extremely strong, the Li line, in fact, is not sufficient per se to classify a star as a young object, since this line has recently been detected in some RSCVn binaries (Pallavicini et al. 1990), which are evolved systems.

The high resolution spectra in the lithium region also revealed that many stars in our sample are very fast rotator, with a vsini between 15 and 50 Km s\(^{-1}\) (these are preliminary estimates from comparison with spectra of template stars obtained with the same telescope configuration).

In summary, our optical data show that a large fraction of the EXOSAT serendipitous sources are very active stars, a number of which are especially interesting objects such as pre-main sequence stars, RSCVn systems and BY Dracois type stars. Further study of this sample will provide important information on stellar coronal activity and its evolution.

REFERENCES

PART III

Convection
Figure 15 from "Magneto-Convection" by R.F. Stein, A. Brandenburg, and Å. Nordlund.