ACTIVE BINARIES IN STELLAR SOFT X-RAY SURVEYS

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ABSTRACT

We report on an ongoing program which aims at elucidate the nature and evolutionary status of about 1000 late-type stellar counterparts of ROSAT All-Sky Survey sources in the field by means of high-resolution optical spectroscopy. High resolution spectra will allow us to derive rotational and radial velocities, chromospheric activity, metallicity and Lithium abundance as well as to single out spectroscopic binaries. This large sample should allow to sort out activity as a function of stellar parameters. Other issues are galactic structure and evolution, kinematics and binarity fraction of young stars in the solar neighborhood.

Key words: Stars: binaries: spectroscopy - Stars: fundamental parameters - Stars: X-ray - Stars: activity.

1. INTRODUCTION

Although most of the Rosat-All-Sky-Survey sources cross-identified with Tycho stars (RasTyc) are expected to be the youngest stars in the solar neighborhood (Guillout et al., 1999) neither the contamination by older RS CVn systems nor the fraction of BY Dra binaries are actually known. The knowledge of the incidence of binaries in this sample is of paramount importance for studying the recent local star formation history using ROSAT and/or XMM-Newton data. We thus have started a spectroscopic observation campaign aimed at a deep characterization of a representative sub-sample of the RasTyc population.

2. OBSERVATIONS AND DATA REDUCTION

High (R $\approx$ 40 000) and medium (R $\approx$ 14 000) resolution spectroscopic observations are conducted at *Observatoire de Haute Provence* (OHP) and *Catania Observatory* (OAC) respectively. Photometric follow-up data were also acquired at OAC on a subsample of new SB1/SB2 systems identified on the basis of OHP spectra. The croos-correlation method and/or a synthetic approach are used to derive most of the stellar parameters. Synthetic or template spectra are computed at our spectral resolution and matched to the observed spectra by means of an automatic procedure of least-square fitting purposely developed by us. The code outputs several parameters among which abundance of elements of interest, projected rotational velocity, and wavelength shift relative to the laboratory rest frame.

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3. PRELIMINARY RESULTS

3.1. Statistics

Based on a sub-sample of about 350 stars with properly reduced Hα and Li OHP spectra, we derived a crude estimation of the fraction of very active (strong Hα emission, $>$ 5%), Li rich (Pleiades-like, $\geq$ 30%), rapid rotators (broad lines, $\geq$ 30%) and SB2 binary ($\geq$ 35%) stars in our sample. Variable radial velocity values derived from spectra acquired several days apart allows us to identify SB1 systems and may considerably enhance the fraction of known binary systems.

3.2. Active binaries in soft x-ray survey

We present below results from optical spectroscopic and photometric follow-up observations of a sample of six active binaries discovered in the RasTyc sample. Thanks to high resolution spectroscopy, we have obtained good radial velocity curves, whose solutions provided us with the mass of the components (see Table 1). For all but one systems, namely HD183957, we observed photometric modulations correlated with the orbital period ascribable to surface features at photospheric level, suggesting a synchronization between rotational and orbital periods.

The X-ray luminosities computed assuming a 0.9 keV Raymond-Smith emitting plasma and the Tycho paral-

Table 1. Main characteristics of new RS CVn/BY Dra systems discovered in the RasTyc sample.

Name	Sp.Type P/S	$M \sin^3 i$ ($M_\odot$) P/S	$P_{\rm orb}$ days	Log($L_{\rm X}$) erg s^{-1}
HD 183957	K0V/K1V	0.773/0.715	7.954	28.71
BD+15 4538	G8-K0V/K3-4V	0.007/0.001	1.748	30.21
BD+33 4462	K0III-IV/F7IV	0.908/0.892	1 0.12	–.-
HD 237215	K2III	SB1	12.67	31.84
HD 57267	G8III	SB1	36.20	31.23
BD+38 2140	K1IV	SB1	15.47	29.38

laxes are listed in the last column of table 1. Interestingly, the two binaries containing a giant component (namely HD 237215 and HD 57267) show coronal activity close to the upper end of the RS CVn X-ray luminosity distribution. These high values of Lx, in excess of 10^{31} erg s^{-1}, are additional clues to their RS CVn nature. On the other hand, HD 183957 shows only moderate coronal activity, in agreement with the small filling of the Hα profile of both components. Both it's low activity level (compatible with the *Hyades-like* field population predicted by X-ray population models) and the lack of photometric modulation correlated with orbital period leave some doubt on the synchonisation of the HD 183957 system. With X-ray luminosities in the range $10^{29.0}$ to $10^{30.5}$ erg s^{-1}, compatible with *Pleiades-like* field population, BD+15 4538 and BD+38 2140 display all the characteristics of new BY Dra system. We finally note that our Hα and X-ray diagnostics fully support the chromospheric/coronal activity connection (Frasca et al., 2005).

We also report on the discovery of some interesting objects like RasTyc 59 showing a puzzling symmetric triple-line pattern disappearing periodically. The system is tentatively explained as a triple system consisting of a close binary with an orbital period < 6 days plus a tertiary component orbiting around the inner binary with a very long period (Fig 1). The incidence of such systems in our sample, with respect to non X-ray selected samples, raises the question of their dynamical stability on a long time scale.

4. CONCLUSIONS

Stellar X-ray sources are thought to be young stars shining brightly in X-ray because of intense activity due to high rotation rate. However the contamination of this young population by coeval or older binaries with late-type component (typically BY Dra and RS CVn systems where the strong X-ray emission is due to synchronization of rotational and orbital motion) is presently unknown. This contamination can strongly alter X-ray based galactic evolution parameters ill defined at other wavelength (star formation rate). While X-ray population model predictions (Guillout et al., 1996) are in good agreement with observations in the soft energy band

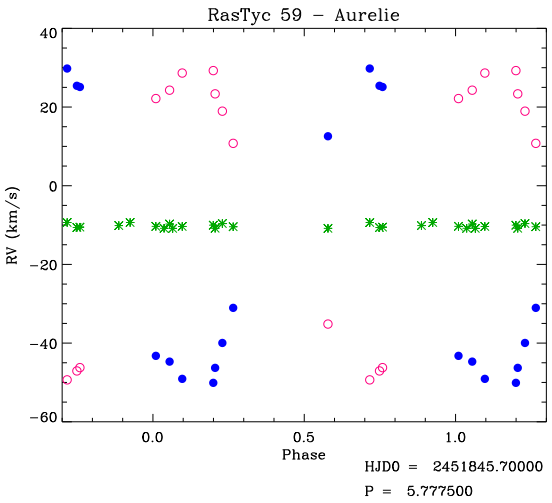

Figure 1. Preliminary orbital solution for the triple system RasTyc 59. Circles : close binary - asterix : tertiary component.

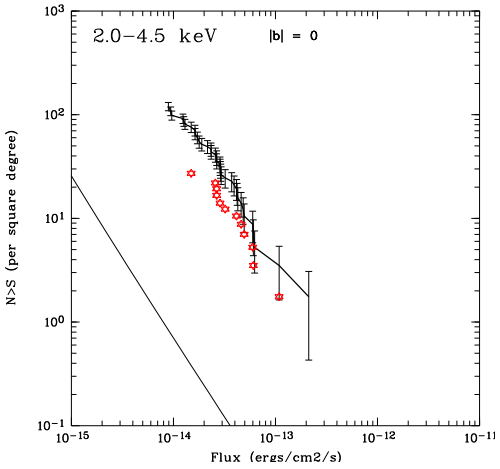

Figure 2. Low galactic latitude stellar logN(>S)-log(S) prediction (solid line) and observations (asterix) in the XMM-Newton hard energy band.

(Motch et al. , 2005), the number of stellar X-ray sources detected at higher energy is larger than expected by a factor ten (Fig. 2). Active late type stars in flare state or RS CVn binaries with high coronal temperature may explain the discrepancy.

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