X-RAY EMISSION FROM STARS IN FIVE YOUNG AND BE-STARS RICH OPEN CLUSTERS

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ABSTRACT

We describe the X-ray source content of five young and Be rich open galactic clusters for which we have obtained deep multi-colour wide-field imaging and spectroscopy. Particular attention is paid to the massive stars in order to constrain evolutionary processes leading to the Be phenomenon and to search for low X-ray luminosity massive accreting binaries. The XMM-Newton EPIC spectral and timing properties of the brightest X-ray sources are discussed in the light of our current optical identification work. Most cluster sources are young solar type stars. In spite of the large number of Be stars located in these clusters we do not find any plausible new Be/X-ray candidate. We confront the apparent scarcity of Be + white dwarf binaries with the predictions of current theories of massive binary evolution. We briefly discuss the origin of the diffuse X-ray component which seems present in the core of several clusters.

Key words: Galaxy: open clusters - stars: OB, Be.

1. INTRODUCTION

We started a multiwavelength campaign aiming at studying the X-ray and optical properties of early type stars in open clusters and at searching for low X-ray luminosity high mass X-ray binaries. We report here preliminary results on 5 young open clusters selected for their high number of Be stars (see Tab. 1). X-ray observations were performed with the EPIC cameras on board XMM-*Newton*. Each cluster was observed for about 40 ks at the beginning of 2004. Deep UBVRI wide-field imaging was obtained with the INT (Canary Islands) in October 2004. Optical spectroscopy of a number of cluster members and X-ray source counterparts was acquired during several runs with the ESO-NTT, with the NOT (Canary Islands) and with the 1.93m at OHP.

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2. X-RAY SOURCE CONTENT

Many X-ray sources are identified with cluster members. Most of them are associated with young solar type stars. Their X-ray spectra are generally well described by a single kT$\sim$0.5–1 keV thin thermal component, albeit in some cases (usually the brightest ones) a second colder thermal component seems present. A small number of sources display hard X-ray spectra which are better described by a hot thermal plasma (kT$\sim$2–5 keV) or by a power law with a possible additional soft thermal component (kT$\sim$0.5 keV). Flare-like events are sometimes observed. Some optically unidentified sources exhibit very hard spectra with relatively large photoelectric absorption. Their properties are consistent with those of background AGNs.

3. MASSIVE STARS

We only discuss here *catalogued OB stars with spectral type determinations available in the literature* (mainly from the WEBDA data base and from Simbad). Our set of OB star identifications is thus very incomplete, even at the bright optical end. Our extensive spectroscopic survey will soon provide a comprehensive sample of early and late OB stars in all target clusters. So far, 14 catalogued OB stars have been detected in X-rays. All are earlier than B2.5 (except for a B8 star in NGC 663). Non detected OB stars range from B0 to B9. Fig. 1 shows the X-ray luminosity (based on a thermal component with kT = 0.5 keV) versus bolometric luminosity. At our sensitivity limit, mainly designed to highlight accreting binaries, we only detect the brightest OB stars. At early spectral types, the observed L_X-L_{bol} relations are consistent with those derived from field stars. At later spectral

Table 1. Properties of the target open clusters.

NGC	Age (Myr)	# Be stars	$L_{x,lim}$ erg s^{-1} (0.5 – 4.5 keV)	Detected X-ray sources	Catalogued OB stars	
					Detected in X-rays # (SpT)	Undetected # (SpT)
7419	14	37	$\sim 9.4\times10^{30}$	63	0	5 (B0-B4)
884	11	25	$\sim 4.6\times10^{30}$	124	4 (O6-B2)	21 (B0-B8)
869	12	28	$\sim 3.8\times10^{30}$	166	5 (B0.2-B1)	71 (B0.5-B9)
663	16	34	$\sim 4.6\times10^{30}$	90	5 (09.5-B2.5) + 1 (B8)	28 (B2-B9)
3766	24	11	$\sim 1.2\times10^{30}$	202	0	12 (B2-B9)

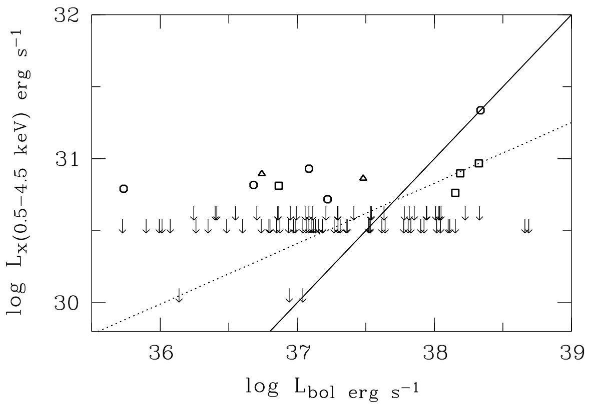

Figure 1. L_X-L_{bol} diagram for OB stars with known spectral classification. Open squares: NGC 869; circles: NGC 663; triangles: NGC 884. Arrows show upper limits. Dotted line shows the relation obtained by Berghöfer et al. (1997) for OB stars with $L_{bol} < 10^{38}$ erg s^{-1}. The solid line corresponds to the "canonical" $L_X = 10^{-7} \times L_{bol}$ relation.

types, part of the excess X-ray emission could be due to unseen young solar type companion stars.

Evolutionary models predict that ~ 5-20% of the Be stars could be formed through close binary evolution (Van Bever & Vanbeveren, 1997). This could be the case of the Be + neutron star system VES 625/RX J0146.9+6121 in NGC 663. However, about 70% of the Be stars formed in binaries could have a white dwarf (WD) remnant companion (Raguzova, 2001; Waters et al., 1989; Pols et al., 1991). In spite of this high expected frequency, up to now no Be + WD system has been clearly established. The only tenable candidates are the γ-Cas analogs (Lopes de Oliveira et al., 2005), whose X-ray properties share many similarities with those of cataclysmic variables. The five target clusters contain at least 135 Be stars, implying that between 4 to 19 of them could have a WD companion. At the moment, we cannot find clear evidence of such binaries apart from the interesting case of a B2Ve star in NGC 884 which shows an unusually hard X-ray spectrum with kT ~ 5.6 keV, and $L_x \sim 10^{31}$ erg s^{-1}. The (apparent) scarcity of Be + WD binaries could be explained by the young ages of the target clusters. Although binary evolution scenarios leading to Be + WD systems exist at those ages, they may not be as common as those operating at later times. Our observation could also have interesting consequences on the likelihood of the binary channel for Be stars. However, it is also possible that the likely low eccentricity WD orbits could induce very efficient tidal torque truncation of the Be star circumstellar disc resulting in a depressed mass accretion rate on the WD (Negueruela & Okazaki, 2001).

4. DIFFUSE X-RAY EMISSION ?

Diffuse X-ray emission seems present in the core of NGC 3766, and is also suspected in NGC 869 and 884. This emission could be either due to unresolved low X-ray luminosity cluster sources or to hot winds from massive stars.

REFERENCES

Berghöfer, T.W., Schmitt, J.H.M.M., Danner, R., & Cassinelli, J.P. 1997, A&A, 322, 167

Lopes de Oliveira, R., Motch, C., Haberl, F., Negueruela, I., & Janot-Pacheco, E. 2005, in the proceedings of the COSPAR Colloquium on Spectra and Timing of Accreting X-ray Binaries, Bombay, Feb 2005

Negueruela, I., & Okazaki, A.T. 2001, A&A, 369, 108

Pols, O.R., Coté, J., Waters, L.B.F.M., & Heise, J. 1991, A&A, 241, 419

Raguzova, N.V. 2001, A&A, 367, 848

Van Bever, J., & Vanbeveren, D. 1997, A&A, 322, 116

Waters, L.B.F.M., Pols, O.R., Hogeveen, S.J., Coté, J., & van den Heuvel, E.P.J. 1989, A&A, 220, L1