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Study of the young open cluster IC2391: discovery of X-ray rotational modulation in a supersaturated star

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Abstract.
We present the analysis of the Guarantee Time *XMM-Newton*/EPIC observation pointed on the young open cluster IC 2391. We find evidence, for the first time, of X-ray rotational modulation on a supersaturated star, member of the cluster, implying the presence of structural inhomogeneities. We also present preliminary results of the spectral analysis of the X-ray brightest cluster stars.

Key words. Open clusters and associations – Stars coronae – Individual: (IC 2391)

1. Introduction

We present the analysis of the EPIC observation of the young open cluster IC 2391 observed during the guarantee EPIC time. IC 2391 is a relatively nearby cluster, with a distance of 162 pc, rich of low-mass stars. It was choosen as target for GTO time for EPIC, since its members are on the Zero Age Main Sequence and therefore include a significant number of fast rotators, in particular stars in the saturation and supersaturation regime (Prosser et al. 1996).

EPIC has observed the core of the cluster with an exposure time of 43 ksec for MOS cameras and 31 ksec for the pn one. The analysis has been performed on the summed image of all the cameras in the 0.3-7.8 keV bandpass, after the usual filtering and the removal of the high background times.

We have applied the Wavelet detection algorithm, developed at Osservatorio Astronomico di Palermo, to our summed image. The acceptance threshold has been determined from a set of simulations in order to accept only one spurious source. In total we have detected 99 sources, 25 identified with 33 cluster members. The *XMM* spatial resolution leaves a fraction of double identifications. In these cases we have adopted different criteria depending on the nature of the possible counterparts to assign an X-ray luminosity value to each star. We have also measured upper limits for the remaining 21 members falling in the field of view. Detections are distributed along

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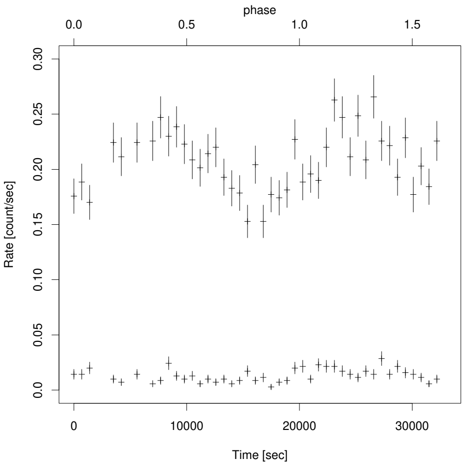

Fig. 1. X-ray light curve of the star VXR 45. Phase refers to the optical period (19 ksec). Bottom points represent the background.

all spectral types. The low number of detected early type stars is likely due to the fact that they are not intrinsic emitters, and the observed emission comes from unseen companions, an explanation often invoked to explain the emission of late B-A stars.

2. Spectral and variability analysis

For the eleven X-ray brightest cluster members we have been able to perform spectral fits, resulting three main groups:
1) spectra that can be fitted with 1-T thermal spectrum with T $\sim$ 1keV,
2) spectra that can be fitted with 2-T thermal spectra with low temperature between 0.3 and 0.6 keV and high temperature $\sim$1 keV, with comparable emission measures,
3) spectra that can be fitted with 1-T thermal spectrum with T $\sim$0.6 keV.
Indeed groups 1) and 2) are likely the same, with the spectra with lower statistics fitted with one-T fit and those with higher statistics requiring two temperature components. The third type of spectrum looks different: it is softer than the other spectra and appears to be common among coronae of dF stars, independently from statistics. The result, that dF stars have coronae softer than the other spectral types was already found in other clusters, as in the Pleiades (Briggs & Pye 2003), in NGC 2516 (Harnden et al. 2001) and in Blanco 1 (Pillitteri et al., in preparation).

Variability is a common properties of IC 2391 stars, with various involved phenomena: evident flares, small scale variations, slow decrease, and indications of periodic modulation in a few cases. However the best (and first) evidence of rotational modulation has been observed in the dG9 star VXR45, a star with a mass slightly smaller than that of the Sun, for which the optical period is known. Our X-ray light curve, reported in Fig. 1, suggests a period of 20 ksec, compared with the optical period of 19 ksec, that makes this star one of the fastest late-type rotators in the supersaturation regime. The folding of the X-ray light curve with the optical period confirms that we are really observing X-ray rotational modulation (Marino et al. 2003). The presence of modulation in such star indicates, for the first time, that in these very active stars, the corona is not completely covered by emitting regions, but that inhomogeneities have to be present.

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