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IDENTIFYING THE FAINT X-RAY SOURCES IN THE GLOBULAR CLUSTER NGC 2808 WITH XMM-NEWTON

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Abstract. Globular clusters (GCs) are believed to contain a large number of interacting binaries which are thought to delay the ineluctable core collapse of these high-density clusters. However over-crowding in the optical domain makes their detection difficult, and the nature of this population remains largely unknown. Using X-rays, it is possible to detect most of the interacting binaries and their products such as low mass X-ray binaries (LMXBs) often in quiescence (qLMXBs), cataclysmic variables (CVs), millisecond pulsars (MSPs), as well as active binaries (ABs).

We present an analysis of the globular cluster NGC 2808 using a 42 ks XMM-Newton observation. We show that at least seven X-ray sources are associated with the cluster, and show evidence that these are indeed interacting binaries. The brightest source in the innermost region has X-ray emission characteristics of a cataclysmic variable for which we have possibly detected the spin period of the white dwarf, indicating an intermediate polar. Two X-ray sources, including the brightest one, have a ultra-violet counterpart. Finally, we have detected at least one qLMXB.

1 Introduction

Since the first X-ray observations of the sky, an excess of X-ray sources in globular clusters has been observed (Katz 1975). The 13 bright X-ray sources ($L_X > 10^{36}$ $erg\ s^{-1}$) found in the 151 known Galactic GCs are neutron star LMXBs. Numerous faint X-ray sources ($L_X < 10^{34.5}$ $erg\ s^{-1}$) are shown to be a variety of interacting binary systems (e.g. Webb et al. 2004). This excess of interacting binaries in GCs is thought to be the consequence of dynamical processes occuring in the core of GCs (close encounters and even direct collisions due to the high density of stars).

The globular cluster NGC 2808 is one of the most massive of our Galaxy. Previous studies in optical showed interesting features in the color-magnitude diagram. The existence of a second main-sequence and irregularities in the horizontal branch imply an enrichment of helium of the environment, and are interpreted as the presence of several generations of stars (D'Antona et al. 2005).

2 XMM-Newton observation

NGC 2808 was observed in 2005 February for 42 ks with the three EPIC cameras (MOS1, MOS2 and PN) on board the XMM-Newton observatory. We processed the data using the XMM Science Analysis System (SAS v6.5). We used *emproc* and *epproc* to reduce the data for MOS and PN observation data files respectively. Then we filtered the resulting event lists for bad pixels and valid event patterns. Based on the light curve of events exceeding 10 keV we could identify periods of high background, due to soft protons flares, and select good time intervals for the observation leading to 41.4 ks and 34.4 ks of clean observation for MOS and PN respectively.

Source detection. We performed the source detection using the script *edetect_chain* which calls a sliding box algorithm and ran the task *emldetect* to compute the maximum likelihood (ML) of each source candidate. We selected sources with a ML greater than 10 (4σ detection). The list of events has been divided into three energy bands (0.5–1.5 keV, 1.5–3 keV, and 3–10 keV). We first processed the whole field of view with a large binning of 75 and a sliding box of 5 pixels. Because the PSF is narrower and better defined in the central region

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of the detectors, it has been processed separately with a binning of 40 and a sliding box of 3 pixels. For this central region, we used the task *emldetect* with different parameters to allow a simultaneous fit of three sources, and to detect possible merged sources.

We detect 104 sources in the field of view, of which 7 sources are located in the half mass radius of the GC.

Minimum detectable flux. We determined the minimum detectable flux in several annuli (to account for vignetting) and used a log(N)-log(S) relation (Hasinger et al. 2001) in order to estimate the number of background sources we expect to detect in our observation (assuming no cosmic variance). We first evaluated the background for each annulus in several regions without sources. To determine the background, we assumed a 0.2 keV black body spectrum with an absorption of 1.2 10^{21} cm^{-2}, calculated from optical observations (Bedin et al. 2000). The minimum detectable flux was then estimated to be the 3σ limit over the background flux.

We find a good agreement of estimated and detected sources for the outer annuli. An excess of detected sources in the central region implies that the 7 most central sources are very likely to belong to the GC.

3 Preliminary analysis

Based on X-ray colours, spectra and lightcurves for the brightest sources, and UV counterparts (Dieball et al. 2005), we discuss the identification of some sources related to the cluster (see Servillat et al., in prep.).

Source C1. The X-ray spectrum of C1 is best fitted with a bremsstrahlung model with kT = $9.5^{+8.1}_{-2.9}$ keV (3σ errors) and the absorption of the cluster. We used the C statistic (Cash, W., 1979) which can be used regardless of the number of counts in each bin: C = 49.9 for 56 degrees of freedom for this fit. This spectrum is hard and well fitted by this thermal model, as expected for a CV. In addition, C1 has a UV counterpart proposed to be a CV, strengthening the latter hypothesis. We have detected a possible periodicity at 430 seconds in the lightcurve, possibly the spin period of the white dwarf which would indicate an intermediate polar. Its luminosity is quite high ($L_{0.5-10\ keV}$ = 1.17 10^{33} erg s^{-1} if it belongs to the cluster), possibly due to the contribution from nearby and unresolved sources.

Source C2. The number of qLMXBs in globular clusters appears to scale with the cluster collision rate (Gendre et al. 2003; Pooley et al. 2003). Statistically, one would expect two to three quiescent neutron star LMXBs in NGC 2808. We note that the luminosity $L_{0.5-10\ keV}$ = 5.7 10^{32} erg s^{-1} and X-ray spectrum of C2 are consistent with the qLMXB hypothesis, the latter being soft and well fitted (C = 43.4 for 36 degrees of freedom) with a hydrogen atmosphere model with plausible parameters for a neutron star: mass and radius are frozen at 1.4 $M_\odot$ and 12 km, $\log(T_{eff}) = 6.01 \pm 0.014$ and $N_H = 2.1 \pm 0.4$ 10^{21} cm^{-2}.

Source C7. The X-ray colours indicate a hard spectrum consistent with the CV hypothesis, as is the luminosity $L_{0.5-10\ keV}$ = 7 10^{31} erg s^{-1}. The position is compatible with a UV object proposed to be a CV.

Further work needs to be done to identify the other sources in the field of view.

4 Conclusion

The XMM-Newton observations indicate that the majority of the central sources are indeed close binaries. Source C1 appears to be an intermediate polar, supporting the hypothesis that GC CVs have intermediate magnetic fields that may account for the lack of CV outbursts in GCs (Dobrotka et al. 2006).

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