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Classification of X-ray sources in the direction of M31

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Abstract:
The XMM-Newton Large Project for M31 has produced a catalogue of about 1900 X-ray sources in the direction of M 31[1]. The nature of many of them remain elusive, giving us little signs of their origin. Our goal is to classify the above sources using criteria based on properties of already identified ones. In particular we construct candidate lists of high mass X-ray binaries (HMXBs), low mass X-ray binaries (LMXBs) correlated with old globular clusters (GlCs) and Active Galactic Nuclei (AGN) based on their X-ray emission and the properties of their optical counterparts, if any. The analysis resulted in 20 BeXRB candidates, 49 AGN candidates and 42 X-ray sources found in the vicinity of old GlCs. Final identification of the above sources, except for the LMXBs, requires spectroscopic observations. Our catalogue will hopefully provide a good selection of targets for such observations.

1 Introduction

M31 is our nearest spiral galaxy, at a distance of 780 Kpc. XMM-Newton EPIC observations of the M 31 spiral galaxy, were taken between June 2006 and February 2008 and yielded a total of 1897 X-ray sources (0.2-12.0 KeV) covering for the first time the entire D25 ellipse of M31, down to a limiting luminosity of $\simeq= 10^{35} erg/s$ in the 0.2-4.5 KeV band [1]. This sample contains (i) sources within the M31 galaxy such as, X-ray binaries (XRBs), supersoft sources (SSS), supernova remnants (SNR), (ii) foreground stars and (iii) background objects i.e. active galactic nuclei (AGNs), galaxies and clusters of galaxies. A catalog was created by Stiele et al. [1] who attempted to identify and classify the X-ray sources. However, about 65% of the sources can still only be classified as 'hard' sources based on their hardness ratios (HR_i with $i = 1$ *to* 4) [2]. These could be XRBs, Crab-like supernovae or AGN. Our goal is to refine the classification criteria using results from optical spectroscopy in order to construct lists of candidate HMXBs, LMXBs and AGN.

2 Classification of X-ray sources

HMXBs: The HMXB population in M 31 remains largely elusive, with only a small number of supergiant HMXBs identified with optical spectroscopy [3] and no Be-XRB discovered to date. The occurrence of HMXBs, of the Be type in particular, is a sensitive star-formation indicator. For example, a large population of Be-XRBs has been found in the Small Magellanic Cloud. Using the well observed SMC sample of BeXRBs, we adopted a combination of optical colors and X-ray hardness ratios (HR), with limits derived from the SMC HMXBs, is used to identify candidate Be-XRBs in M 31. The X-ray criteria used are: $HR3 > -0.1$, $HR4 > -0.7$, while in the optical: $V = [20, 22]$,$(B - V) = [-0.25, 0.2]$. Our analysis resulted in 20 candidates (see fig.1) with some showing enhanced H-alpha emission, on the LGSS H-alpha images [5][7].
AGN: The optical and X-ray are criteria derived from a sample of spectroscopically confirmed AGN in our field of view (9 Seyfert 1 galaxies with redshifts $z \sim 0.7 - 1.6$, and $V < 21$), from observations at the 3.5m APO telescope [4]. Our analysis resulted in 49 candidates (see fig.1).

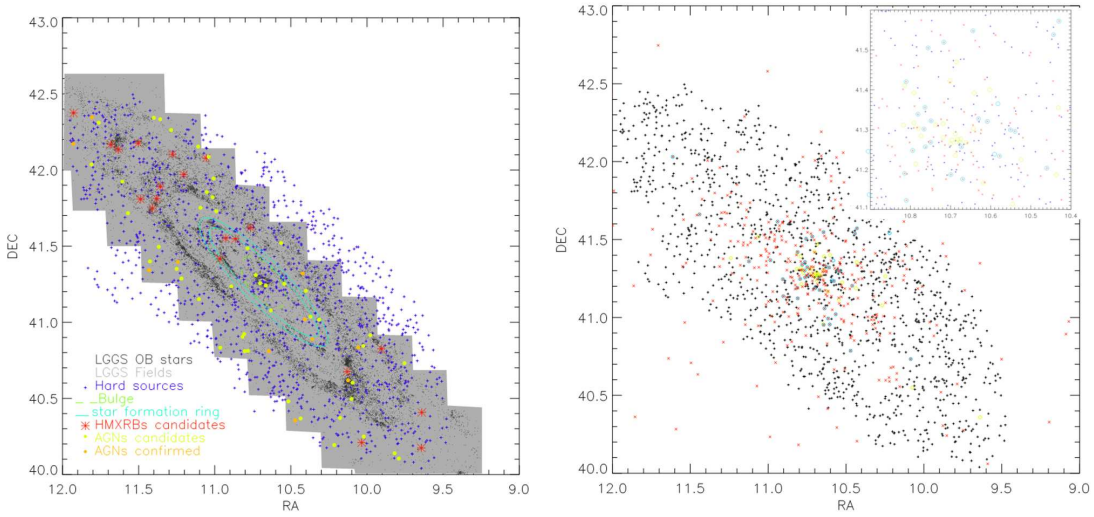

Figure 1: (Left: Distribution of BeXRB and AGN candidates overlaid on map of OB stars from LGGS [6]. Right: Distribution of XRBs based on variability [1] and LMXBs candidates overlaid on map of hard sources and old globular clusters)

LMXBs: We confirmed the association of X-ray sources with globular clusters (GlCs) using the revised Bologna Catalog (V.4 December 2009) (10). We found 42 confirmed old globular clusters correlated with X-ray sources i.e.about 11.5% of the old clusters, and 6.4% of all the confirmed clusters in M 31. Their distribution is shown in fig.1 Most of these are likely LMXBs as they are not associated with young stars. Inspection of the dynamical characteristics [8] of the clusters confirmed [9] that LMXBs are preferentially formed within more massive clusters or in clusters with higher collision rates. Kolmogorov-Smirnov tests confirm this hypothesis with a probability over 99.9%. An additional population of XRBs has been detected based on variability [1]. Their distribution is also shown in fig.1. Most of these are likely LMXBs as they are not associated with young stars.

References

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