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XMM-Newton survey of the Local Group galaxy M 33 – catalogue results and global properties

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Abstract. Using 24 overlapping XMM-Newton observations of the Local Group spiral galaxy M 33, we have detected 447 sources in each individual pointing and in deep combined images. A total of 61 sources exhibit significant flux variations by a factor of up to 144, on time scales of hours to months or years. The detected variability, together with the hardness ratio (HR) method and optical identification (when available), is used to classify the sources as X-ray binaries (XRBs), supernova remnants (SNRs) and super-soft sources (SSS) in M 33, as well as background AGN and foreground stars in the field of view. The majority of sources can only be classified as 'hard', according to their HRs. We find that the luminosity distribution of the detected SNRs and SNR candidates in M 33 is similar to M 31, and slightly steeper than that of the LMC.

Keywords. X-rays: galaxies, X-rays: binaries, (ISM:) supernova remnants.

1. Catalogue results

Using deep combined XMM-Newton images of M 33, Pietsch *et al.* (2004) detected 408 X-ray sources. We have analysed all observations individually to study long-term X-ray flux variability, and compiled an additional catalogue with 350 objects. These two catalogues contain source positions, X-ray fluxes in 5 energy bands, HRs and cross-correlations with optical, infrared and radio data. The detected X-ray properties (HRs and variability) and cross-correlations have been used to classify sources as: XRBs, SNRs and SSS as intrinsic M 33 sources, and also foreground stars and background AGN. The majority of sources could only be classified as 'hard' according to the HRs. The summary of all sources and source classes is presented in the left panel of Fig. 1, while on the right we show their spatial distribution.

2. SNR population of M 33

Fig. 2 (left) shows the luminosity distributions of the SNR populations in M 33, M 31 and the LMC. Although M 31 has fewer detected and classified SNRs and SNR candidates per surveyed area, the distribution of this class of sources seems to be almost the same

Class	Cat(1)	Cat(2)	Total*/Common
XRB	2	10	10/2
SNR	44	25	39/25
SSS	5	11	12/4
fgStar	35	29	37/21
AGN & Gal	14	13	15/12
'hard'	267	206	271/187
Unclassified	41	56	69/28
Total	408	350	447/311

Cat(1): combined catalogue, Pietsch et al. 2004
Cat(2): individual catalogue, Misanovic et al. 2005
*Some sources have been re-classified in Cat(2)

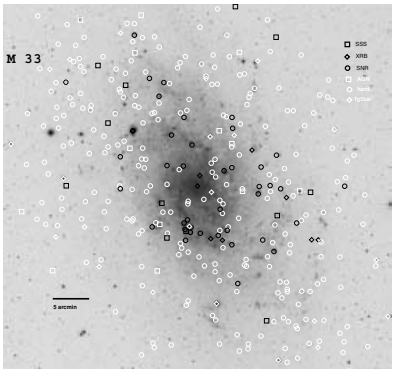
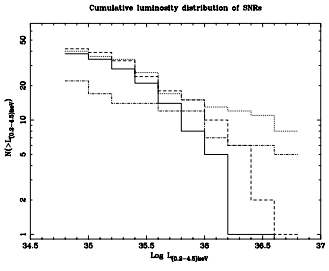


Figure 1. Left panel: The detected and classified sources in the combined and individual observation catalogues. **Right panel:** Spatial distribution of all X-ray sources classified in these two catalogues.



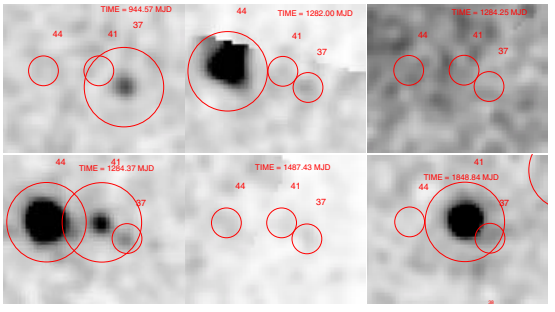


Figure 2. Left panel: Luminosity distribution of SNRs in M 33 (solid line), M 31 (dashed line) and the LMC (detected by ROSAT; dotted-dashed and dotted lines). For detailes see Misanovic *et al.* (2005). **Right panel:** Broad band XMM-Newton images of the region around two sources demonstrating extreme flux variability between observations on a time scale of several hours. The sources are classified as XRB candidates.

in both spiral galaxies. The SNRs in the LMC have a slightly flatter distribution, which was attributed to relatively higher metallicity of the LMC by Haberl & Pietsch (2001), and also recently confirmed by Ghavamian *et al.* (2005).

3. Variability

There are 61 significantly variable sources in our catalogue, with flux variability amplitudes in the range from 0.3 to more than 144. The detected variability was used as an efficient tool to classify sources. In particular, the extreme variability on relatively short time-scale was used to select several new XRB candidates in M 33 (e.g. the two sources shown at the right panel in Fig. 2).

References

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