

Search for Serendipitous ULX Candidates in *XMM-Newton* Observations

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Abstract. We report the serendipitous discovery of several ULX candidates in *XMM-Newton* observations. Such discoveries suggest that ULXs are not a negligible component of the extra-galactic X-ray source population.

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1. Introduction

Ultraluminous X-ray sources (ULXs) are extra-nuclear point-like X-ray sources in galaxies with luminosities only surpassed by active galactic nuclei (AGN). ULXs are observationally defined to have $L_x > 10^{39}$ erg s⁻¹, equal to the Eddington limit for accretion onto a $\sim 7M_\odot$ compact object. The high apparent luminosities of many ULXs raise the question whether some ULXs may be powered by accretion onto “intermediate-mass” black holes (see Miller & Colbert *et al.* 2004 for a review). Alternatively ULXs may involve accretion onto stellar-mass black holes with the high luminosities originating either in truly super-Eddington radiation from inhomogeneous accretion discs, or through anisotropic radiation patterns and/or relativistic beaming. Most of the ULX candidates reported to date have been discovered in pointed observations of the specific galaxies. The sensitivity of typical *XMM-Newton* observations is such that ULX candidates can be detected to a distance of ~ 100 Mpc. This allows a search for serendipitous ULX candidates in *XMM-Newton* observations and thus provides the means to accumulate a valuable new and unbiased sample of ULX candidates in external galaxies. Here we present the preliminary results from just two relatively nearby galaxies.

2. The ULX candidate in UGC 03422

UGC 03422 is a nearby SAB(rs) galaxy ($z = 0.01355$, Falco *et al.* (1999), corresponding to a distance of 57 Mpc) lying at a distance of $\simeq 6.4'$ to the northwest of the Seyfert 2 galaxy Markarian 3. This field (including UGC 03422) has been observed 12 times by *XMM-Newton* with exposure times ranging in 3.5 ks to 58.5 ks. One of the serendipitous X-ray sources in the Markarian 3 field lies in the outer spiral arm of UGC 3422, $\simeq 43.4''$ southeast of the optical centre of the galaxy. Deep optical imaging of the Markarian 3 field obtained with Isaac Newton Telescope with the prime focus Wide Field Camera shows that the ULX candidate lies close to several prominent HII regions in the outer spiral arm of the galaxy, a comparable location to other confirmed ULXs in other galaxies.

The X-ray spectrum of the ULX candidate extracted from the longest *XMM-Newton* observation (ObsID: 0111220201) is relatively hard, broadly consistent with other ULXs. Assuming the source lies in the galaxy, its derived X-ray luminosity in the 0.2–10 keV band is $\approx 10^{40}$ erg s⁻¹. Its location in the galaxy, X-ray luminosity and X-ray spectrum make it a good ULX candidate. Further work is underway to investigate the long-term variability of this object and look for possible X-ray spectral changes.

3. ULX candidates in KUG 0214-057

Another example of the serendipitous detection of ULX candidates in an external galaxy is the discovery of at least three, and possibly four, ULX candidates in the barred spiral galaxy KUG 0214-057 as already reported by Watson *et al.* (2005).

KUG 0214-057 is a 15 mag. barred spiral galaxy at $z = 0.018$ (corresponding to a distance of 75 Mpc) covered by a relatively deep (50 ksec) *XMM-Newton* observation made as part of the Subaru *XMM-Newton* Deep Survey. The four ULX candidates lie in the prominent spiral arms of the galaxy. At least three, and possibly four, of them may be physically associated to the galaxy with X-ray luminosities from $\sim 5 \times 10^{39}$ erg s⁻¹ to $\sim 10^{40}$ erg s⁻¹ and X-ray colours consistent with what is expected for ULX source spectra. An interesting aspect of the discovery of these ULXs in KUG 0214-057 is that, using the ULX population as a metric, the implied star formation rate is very high for this relatively low-mass galaxy.

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