Oh, no! Yet another galaxy identification for an Ultraluminous X-ray Source

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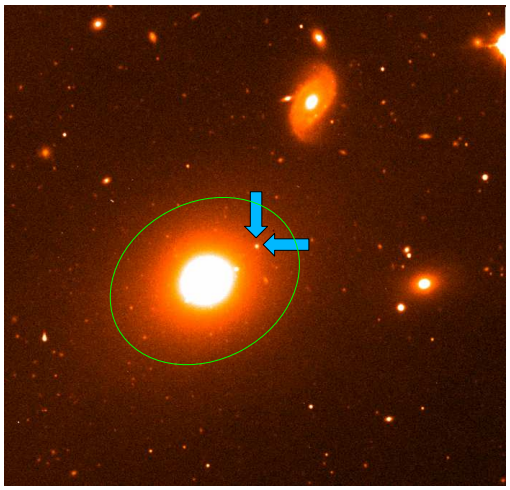
ABSTRACT: We report on the identification of the optical and infrared counterparts of the ultraluminous X-ray (ULX) source XMMU J121214.5+131248 (NGC4168-ULX1). The optical spectrum yields a redshift of z=0.217, which implies that the ULX is not associated with the nearby galaxy NGC4168, but rather it is a background object. Optical spectral line ratios and the spectral energy distribution constructed from the available data indicate that the source is likely a bulge-dominated galaxy with a starburst component.

INTRODUCTION: Ultraluminous X-ray sources (ULXs), i.e. off-nuclear sources with luminosities well above the Eddington limit for a typical neutron star, are now known to populate about 30% of the nearby galaxies (cf. van der Marel 2003). Despite much effort, little is presently known about the nature of these sources, particularly since the counterparts at other wavelengths are difficult to find. Indeed, often these sources are superposed against regions of high surface brightness in their host galaxy.

To date, only two ULXs appear to have a clear optical identification (Roberts et al. 2001; Wu et al. 2002), while for others it has been possible to study the nearby environment only (Pakull & Mirioni 2002; Wang 2002; Roberts et al. 2003). One ULX (NGC4698-ULX1) has been identified with a background BL Lac (Foschini et al. 2002a).

Here we report the identification of the nature of another ULX, NGC4168-ULX1. The derived optical redshift of $z = 0.217$ indicates a background galaxy in this case also.



BASIC INFORMATION ON NGC4168:

Coordinates (RA, Dec, J2000):	$12^h\ 12^m\ 17^s.3$, +13° 12' 17".9
Hubble Type*:	E2
Spectral class*:	Seyfert 1.9
Distance*:	16.8 Mpc
D_{25}*:	2'.75
M_B*:	-19.07
L_{Bol}*:	1.2×10^{43} erg s^{-1}
L_{FIR}*:	3.7×10^{41} erg s^{-1}
Galactic N_H:	2.56×10^{20} cm^{-2}
Galactic E(B-V):	0.036

*: From Ho et al. (1997)

BASIC INFORMATION ON NGC4168-ULX1:

Coordinates (RA, Dec, J2000):	$12^h\ 12^m\ 14^s.5$, +13° 12' 48"
XMM error box radius:	4"
XMM count rate:	4.0 ± 0.7 counts s^{-1}
0.5-10 keV flux:	$(1.8 \pm 0.3)\times10^{-14}$ erg cm^{-2} s^{-1}
$L_{(0.5\text{-}10\ keV)}$ if in NGC4168:	6×10^{38} erg s^{-1}

All data from Foschini et al. (2002b)

OPTICAL-NEAR INFRARED PHOTOMETRY. The image above shows the R-band frame (total exposure time: 10 minutes) of the NGC4168-ULX1 field acquired in Loiano starting at 23:52 UT of 4 March 2003. North is at top and East to the left. The field size is 6'×6'. The arrows indicate the position of the source. The green ellipse marks the D_{25} contour of NGC4168.

UBVRI magnitudes of the source in images acquired in Loiano on 4-5 March 2003 were measured through aperture photometry as the source profile was significantly larger than the image PSF (2".6 against 1".5). The magnitudes determined using an aperture radius of 4.5 pixels (corresponding to 2".6) are reported in the table below.

Near-Infrared (NIR) magnitudes of the source were extracted from the Two Micron All Sky Survey (2MASS, http://www.ipac.caltech.edu/2mass) observations were performed on 5 April 2000; the object has been detected in all the three bands (*JHK*). These magnitudes are also reported in the table below.

SPECTRAL ANALYSIS. The 3-hour spectrum taken at Loiano on 4 March 2003 (figure on the right) shows an evident emission line at 7980 Å which we identified as Hα. In the same spectral region we identified emissions at 7967, 8011, 8172 and 8191 Å as [N II] λ6548, [N II] λ6583, [S II] λ6716 and [S II] λ6731. Other clear emissions at 6090, 5910 and 4530 Å were identified with [O III] λ5007, Hβ and [O II] λ3727 respectively. The identified emission lines yield a redshift $z = 0.217$. This result is, in hindsight, not surprising, as the images acquired in Loiano show that the field is eminently populated by galaxies of various sizes and brightnesses, with very few foreground stars.

The 1-hour Asiago spectrum obtained on 26 February 2003, albeit having lower S/N due to shorter exposure and smaller spectral coverage (4200-7800 Å), shows the presence of Hβ and [O II] λ3727 at the same redshift, thus confirming the result of the Loiano observations. Table 2 reports the emission line fluxes as determined from the Loiano spectrum, dereddened for the Galactic absorption.

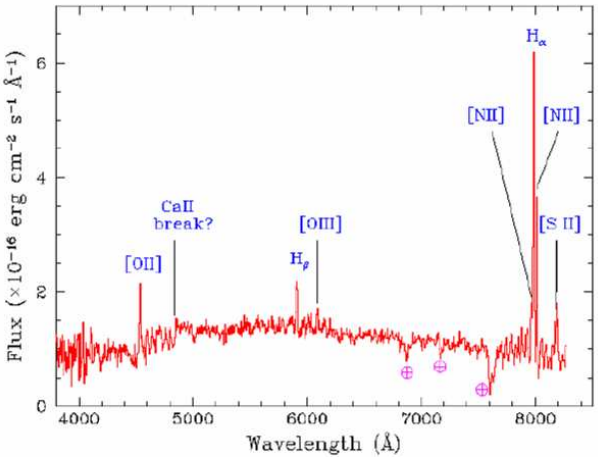
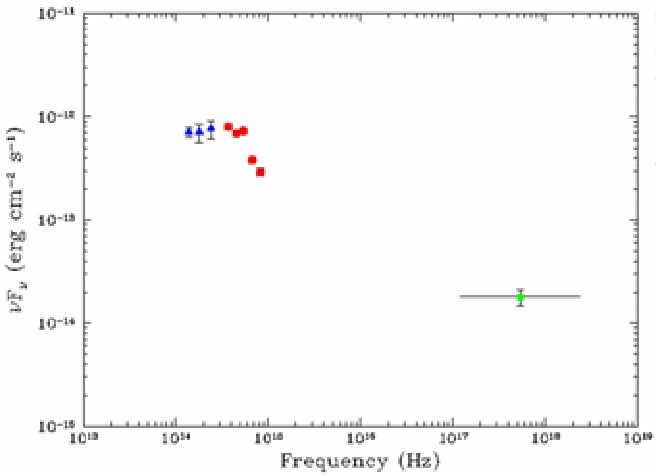


Table: Summary of the emission line fluxes detected in the Loiano spectrum (left) and of the Loiano+2MASS optical-NIR photometry (right). Fluxes (in units of 10^{-15} erg cm^{-2} s^{-1}) and magnitudes are corrected for Galactic absorption.

Hα	6.4 ± 0.3		*U*	19.32 ± 0.08
Hβ	1.1 ± 0.2		*B*	19.63 ± 0.04
[O II] λ3727	1.51 ± 0.15		*V*	18.58 ± 0.03
[O III] λ5007	0.35 ± 0.09		*R*	18.25 ± 0.03
[N II] λ6548	0.9 ± 0.18		*I*	17.61 ± 0.05
[N II] λ6583	2.9 ± 0.15		*J*	16.8 ± 0.2
[S II] λ6716	0.63 ± 0.13		*H*	16.1 ± 0.2
[S II] λ6731	0.86 ± 0.17		*K*	15.3 ± 0.1



DISCUSSION. So, yet another putative ULX is found to be a background source. Assuming a cosmology with $H_0 = 65$ km s^{-1} Mpc^{-1}, $\Omega_\Lambda = 0.7$ and $\Omega_m = 0.3$, we find that the luminosity distance to this source is 1.16 Gpc, and that its X-ray luminosity is 2.9×10^{42} erg s^{-1} in the 0.6-12 keV restframe range. The angular size of the source translates into a linear diameter of about 30 kpc at $z = 0.217$.

The [N II]/Hα and [S II]/Hα ratios measured from the optical spectrum of this source seem to suggest that the object is a starburst galaxy (Véron-Cetty & Véron 2000) although, according to the diagrams of Ho et al. (1993), a Narrow Emission Line Galaxy cannot be ruled out. The inspection of the SED of this source (see figure on the left) shows that a peak in the optical-NIR domain is apparent, followed by a drop across the *UB* bands. Most of the optical and NIR light may come from the integrated stellar emission of the galaxy: in this hypothesis, colors are typical of an old stellar population. The X-ray emission can instead be due to the integrated flux from multiple off-nuclear sources. Indeed, a total X-ray luminosity of ~10^{42} erg s^{-1} is high, but not unusual, for a starburst (David et al. 1992). All these characteristics point to the fact that this object is likely a bulge-dominated galaxy with a starburst component.

References:

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