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Identification of Optical Counterparts of ULX sources

Carlos M. Gutiérrez and Martín López-Corredoira

Instituto de Astrofísica de Canarias, 38200 la Laguna, Tenerife, SPAIN
email: cgc@ll.iac.es, martinlc@ll.iac.es

Abstract. We present the results of an on-going program for the identification and characterization of optical counterparts of Ultra-Luminous X-ray (ULX) sources. The targets have been selected from the catalogues by Colbert & Ptak (2002) and Swartz *et al.* (2004). A clear identification based on unambiguous optical spectral features was possible for 26 objects. A large number of objects result to be QSOs at higher redshift than the putative parent galaxy, and other ULXs seem to be associated to HII regions. In a few cases the optical counterpart results a foreground star in our galaxy. The observational program will continue to obtain a representative sample for statistical studies.

Keywords. X-rays: Ultra-luminous sources.

One of the most intriguing astrophysical objects are the ultra-luminous X-ray sources (ULXs) which have been discovered around nearby galaxies by the X-ray satellites Einstein, ROSAT, Chandra and XMM. Assuming that they are at the distance of their parent galaxies, their luminosities in the 0.1–2.4 Kev X-ray band are in the range $10^{39} - 10^{40}\,\mathrm{erg\,s^{-1}}$. Several explanations about the nature of these objects in terms of intermediate mass black holes associated with globular clusters, HII regions, supernova remnants, etc (Pakull & Mirioni 2002; Angelini *et al.* 2001; Gao *et al.* 2003; Roberts *et al.* 2003; Wang 2002), local QSOs (Burbidge *et al.* 2003), hypothetical supermassive stars or beamed emission (King *et al.* 2001; Kording *et al.* 2002) have been proposed. To disentangle the nature of these objects it is important but still scarce the identification of optical counterparts (e. g. Roberts *et al.* 2001; Wu *et al.* 2002; Maseti *et al.* 2003; Liu *et al.* 2004). This motivated us to start this study searching for such optical counterparts in the Digital Sky Survey (DSS) images, in the digitalized USNO catalogues, and in the released Sloan Digital Sky Survey (SDSS) images. For instance, we have identified possible optical counterparts, in an error circle compatible with the X-ray position, for ∼50 % of ULXs listed in Colbert & Ptak (2002). The typical magnitudes of such objects are 18–20 in the *b* band and are therefore bright enough targets for spectroscopic observations with 2 to 4 m telescopes.

Previously we have presented the identification of 9 of such optical counterparts (Arp *et al.* 2004; Gutiérrez & López-Corredoira 2005) showing that 8 of these sources correspond to QSOs at higher redshift than their putative parent galaxy. Another object was associated with an HII region at the redshift of the parent galaxy (NGC 1073). Here, we present 17 new identifications of such optical counterparts based on long-slit spectroscopic observations obtained in several runs at the William Herschel Telescope (WHT) in the Observatory Roque de los Muchachos, La Palma, and at the 1.93 m telescope in the Haute Provence Observatory (OHP). The typical slit width was 2 arcsec, and the resolution $\sim 3 - 6$ Å. Exposure times were between 900 and 1800 sec for WHT observations, and between 1800 and 5400 sec for observations at OHP. The spectra were

ID	Obs.	Galaxy	z_{gal}	D_{gal} (Mpc)	$\log(L_X)$ (erg s^{-1})	Sep ($'$)	z_{ULX}	Type
IXO 22	OHP Mar 2005	IC 342	0.0001	3.90	39.2	5.1	0.00	HII region
IXO 31	WHT Feb 2004	Holmberg II	0.0005	4.50	40.2	2.1	0.0009	HII region (or M star)
IXO 32	WHT Feb 2004	NGC 2775	0.0045	18.05	39.2	3.7	2.770	QSO
IXO 34	WHT Feb 2004	NGC 3031	-0.0001	3.55	40.0	12.5	0.001	HII region
IXO 35	WHT Feb 2004	NGC 3226	0.0038	17.63	39.2	2.4		M star
IXO 37	WHT Feb 2004	IC 2597	0.0076	40.09	40.9	1.9	0.567	ELG
IXO 40	WHT Feb 2004	NGC 3923	0.0058	22.24	39.9	4.4	0.787	QSO
IXO 43	OHP Mar 2005	NGC 4151	0.0033	20.30	39.3	5.0	0.24	ELG
IXO 54	OHP Mar 2005	NGC 4438	0.0002	16.80	39.9	3.5	0.66	QSO
IXO 57	OHP Mar 2005	NGC 4472	0.0033	16.80	39.8	8.1	0.85	QSO
IXO 65	OHP Mar 2005	NGC 4559	0.0027	9.70	39.9	2.0	0.0027	HII region
IXO 70	OHP Mar 2005	NGC 4649	0.0037	14.85	39.3	7.0	0.62	QSO
SW 38	OHP Mar 2005	NGC 3079	0.0037	15.51	39.5	1.9	0.004	HII region
SW 44	OHP Mar 2005	NGC 3556	0.0023	9.67	39.6	0.7		star
SW 45	OHP Mar 2005	NGC 3556	0.0023	9.67	39.2	0.1	0.0023	HII region
SW 90	OHP Mar 2005	NGC 4490	0.0019	7.80	39.4	1.2	0.0015	HII region
SW 134	OHP Mar 2005	NGC 5457	0.0008	7.24	38.9	6.2		M star

analyzed following a standard procedure using IRAF†. The Table presents a summary of our results (another four objects were observed but the optical spetra did not allow a clear characterization). The columns are: (1): name of the ULX (IXO or SW for objects from the Colbert & Ptak (2002) or Swartz *et al.* (2004) catalogues respectively). (2): telescope and epoch of observation. (3)–(5): name, redshift and distance of the parent galaxy. (6): X-ray luminosity assuming that the ULXs are at the distance of the parent galaxy. (7): projected distance between the ULXs and their parent galaxy. (8)–(9): redshift and nature of the optical counterpart of the ULXs.

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Francesco Polcaro tries to follow several Irish dialects. From left to right: Cóilín Ó Maoiléidigh, Brendan Jordan (hands + dessert only), Francesco Polcaro, Catherine Handley, Eamonn Cunningham, Carol Woods (who had avoided being photographed when the Conference Photo was taken), Hilary O'Donnell.

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