

Optical/infrared counterparts to X-ray binary sources

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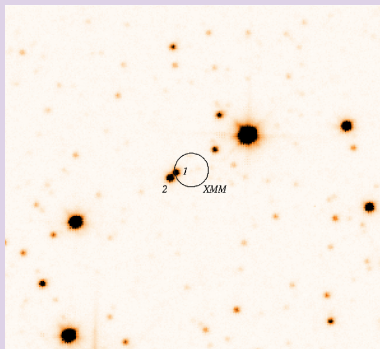
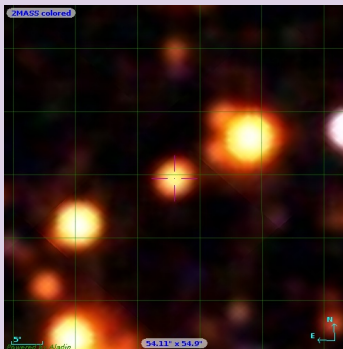
Introduction

The case of 2XMM J191043.4+091629

- X-ray source discovered with **ASCA, AX J1910.7+0917 (Sugizaki et al. 2001)**, associated to the **Einstein** source 2E 1908.3+0911.
- Also detected by **INTEGRAL (Winkler et al. 2003)** during an observation of the SGR 1900+14 field (Götz et al. 2006) and by **XMM-Newton (Watson et al. 2009)** in the vicinity of the Galactic supernova remnant W49B.
- IR counterpart **2MASS J19104360+0916291**.
- BUT, **UKIDSS-GPS DR5 catalogue** showed two objects that were astrometrically coincident with 2.13'' **XMM-Newton error circle** (Rodes-Roca et al. 2013).
- Obtaining **NICS spectra K-band and H-band (Telescopio Nazionale Galileo)**, we concluded that the **IR counterpart is an early B-type supergiant star**.

IR identification of 2XMM J191043.4+091629

2MASS-UKIDSS images



Left panel: $3.6' \times 2.6'$ 2MASS coloured map. The images are displayed with north up and east to the left. We note that the two NIR UKIDSS sources appear unresolved in the 2MASS image. *Right panel:* $15'' \times 15''$ K finding chart for 2XMM object. The black circle is centred on the *XMM-Newton* position of the source, with the radius indicating the $2.13''$ positional error.

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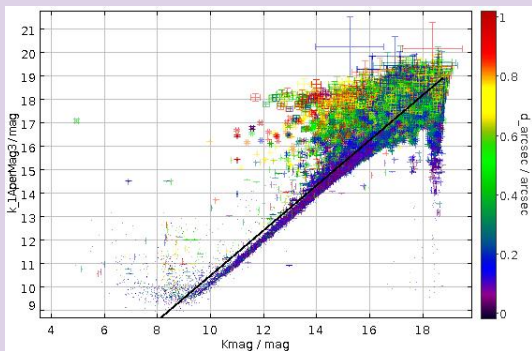
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X-Match

Searching for unresolved sources

In the framework of an ongoing programme, we have developed strategies to discover and characterise **optical/infrared unknown counterparts to X-ray binary systems**).

K_{2MASS} (x axis) and K_{UKIDSS} (y axis)



Near-IR spectroscopy using TNG/NICS

Unveiling X-ray sources

Our group is actively involved in a **long term analysis** to characterise **newly discovered HMXBs** from the current satellites, such as *INTEGRAL*, *XMM-Newton*, *Swift* or *Chandra*. In order to do it:

- We use the atlases of **IR spectral lines for OB stars** (Hanson et al. 2006).
- We combine with **photometry, multiwavelength and multimission data** and **VO tools (Aladin or TopCat)**.
- We model the observed spectra with synthetic spectra with the **Postdam model atmosphere code (PoWR)** and extract the physical properties.

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Preliminary results

Cross-matching

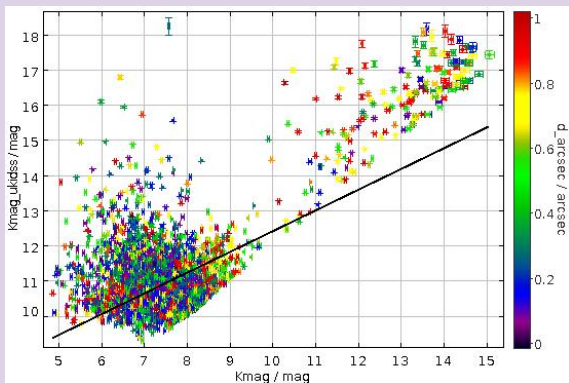
- The list of **X-Match** objects **2MASS-UKIDSS**, which position differs ≤ 1 arcsec, contained more than 8 million rows.
- Using **flags quality** reduced it (**TopCat**).
- We converted K_{ukidss} magnitudes to a K_{2mass} magnitudes (Carpenter 2003).
- $|K_{2mass} - K_{ukidss}| > 2$.

The 1SPXS catalogue

- **Swift/XRT X-ray point sources** (Evans et al. 2014)
- **Position error** around $5.5''$.
- The list of **1SPXS** objects contained around 0.5 million rows.
- Finally, **TopCat** objects **2MASS-UKIDSS-1SXPS**, which position differs ≤ 1 arcsec, contained 197 rows.

Preliminary results

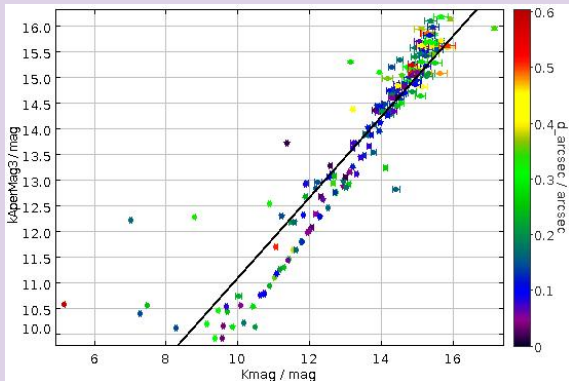
Plotting the candidates



Linear correlation of K magnitudes from 2MASS (x axis) and UKIDSS (y axis). Coloured points show the position differences (less than 1 arcsec).

Preliminary results

Plotting the candidates



Linear correlation of K magnitudes from 2MASS (x axis) and UKIDSS (y axis) with a coincident X-ray source from 1SXPS. Coloured points show the position differences (less than 1 arcsec).

Preliminary results

Completing data analysis

- **Spectral Energy Distribution** by **VOSA**.
- **Writing proposals** for taking IR spectra.
- **MAXI on-demand data**: light curves and spectra.
- **Characterising X-ray sources**: **HMXBs unresolved systems?**

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Preliminary analysis

Unveiling the objects

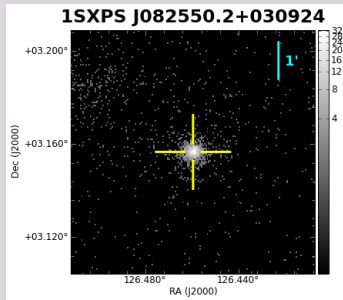
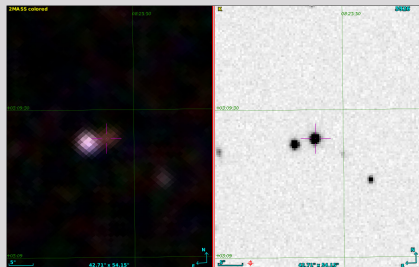
- For some detections, **when $K_{2mass} < 8$ mag UKIDSS images** seem to be saturated.
- Quite a few candidates have **no XMM-Newton** detection/observation.
- Apparently, objects are **normal stars**.
- Sometimes, **the objects are not found in Simbad** ($r \leq 2'$) ??????

Therefore

- We need to improve **the cross-match process**.
- By now, **2MASS-UKIDSS-1SPXS** contain 197 objects.
- Selecting the best 2MASS quality **Qfl = AAA** the number of objects are reduced to 104.
- For UKIDSS **ppErrBits < 256** (but not in our cross-table objects).

The case of 1SXPS J082550.2+030924

Which one is emitting in X-ray? Both of them?



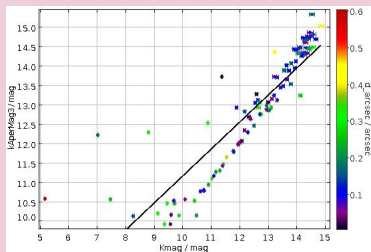
Left panel: 2MASS-UKIDSS image. The red cross is centered on the 1SXPS position. The fields are match in scales and orientation *Right panel: 1SXPS total image.*

Catalogue matches

Catalogued source details

D (")	Catalogue	Source ID	RA (J2000.0)	Dec (J2000.0)
0.8	2MASS	0931.069445	08 ^h 25 ^m 50.34 ^s	+03° 09' 24.4''
0.8	NED	PKS 0823+033	08 ^h 25 ^m 50.34 ^s	+03° 09' 24.5''
0.8	SIMBAD	QSO J0825+0309	08 ^h 25 ^m 50.34 ^s	+03° 09' 24.5''
1.9	NED	RX J0825.8+0309	08 ^h 25 ^m 50.40 ^s	+03° 09' 25.0''

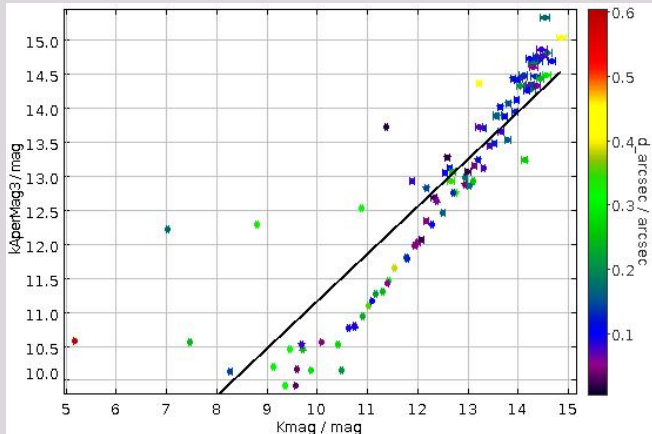
2MASS-UKIDSS cross-match



Linear correlation of K magnitudes from 2MASS ($Qf1 = AAA$, x axis) and UKIDSS (y axis) with a coincident X-ray source from 1SXPS. Coloured points show the position differences ($< 1''$).

Work in progress

Selecting potential candidates



High variable stars or binary/unresolved systems?

Since we are interested in point sources, we have discarded:

- BL Lac type objects.
- Galaxies.
- Novae.
- AGNs.

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Conclusions

The NIR and Swift/XRT data

- We have performed a **X-Match** using the catalogues **2MASS, UKIDSS and 1SPXS**.
- We have reduced the **common sources up to 104**, applying an **angular distance less than 1 arcsec** and selecting the $Q_{fl} = AAA$ in the 2MASS catalogue.
- This work will allow us **to identify and characterise** unresolved X-ray binaries.

Preliminary results

- Performing an identifier query in Simbad, quite a few coordinates showed **no astronomical objects in a radius of 2'**.
- We only took into account **astronomical objects** when the distance was less 5''.
- For bright sources, $K_{2MASS} < 8 \text{ mag}$, **UKIDSS showed saturated values**.

Conclusions

Future

- Work in a **more efficient way** to do X-match catalogues.
- Extend our work to other **X-ray catalogues** and **multiwavelength** data.
- **ARCHES: an opportunity to apply this study.**
- **Unveiling binary sources** based on the photometric variability and combining it with **Virtual Observatory tools** analysis.
- Perform **long-term photometric analysis** of the unidentified X-ray binary sources using the **Busot Observatory**.

Acknowledgements

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