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Searching for unknown counterparts in X-ray binary systems using Virtual Observatory tools

J. J. Rodes[1,2], J. M. Torrejón[1,2], G. Bernabéu[1,2], Á. Giménez-García[1,2,3], D. I. Méndez[1,2], R. García-Lozano[1,2] and S. Martínez-Núñez[1]

[1] Department of Physics, Systems Engineering, and Signal Theory, University of Alicante, 03080 Alicante, Spain
[2] University Institute of Physics Applied to Sciences and Technologies, University of Alicante, 03080 Alicante, Spain
[3] School of Physics, Faculty of Science, Monash University, Clayton, Victoria 3800, Australia

Abstract

In the framework of an ongoing programme, we have developed strategies to discover and characterize optical/infrared unknown counterparts to X-ray binary systems using the standard tools of the Virtual Observatory. First, we have selected some potential candidates from different X-ray catalogues. Then we have used the Virtual Observatory tools to search for optical and infrared point data sources that were coincident with the position of the X-ray source. In this work we present some examples of our ongoing programme showing the potential of the Virtual Observatory as a discovery tool.

1 Introduction

The International Gamma-Ray Laboratory (*INTEGRAL*) has discovered new kind of high-energy emitters, such as supergiant fast X-ray transients (SFXTs) and highly absorbed supergiant X-ray binaries (SGXBs). Until these discoveries, the population of these systems was relatively small, in agreement with evolutionary scenarios. However, binary star population synthesis model fails to reproduce the current distribution of high-mass X-ray binaries (HMXBs). Besides, it is necessary a multiwavelength study and an identification of the optical/infrared counterpart to characterize these sources.

The Virtual Observatory (VO) has power tools such as Aladin [1] or Topcat [6] we have used to search for unidentified sources. As we demonstrated in our previous paper [5], the UKIDSS-GPS DR8 catalogue (United Kingdom Infrared Deep Sky Survey-Galactic

Plane Survey: Data Release 8) has a spatial resolution higher than the 2MASS catalogue (Two Micron All Sky Survey). Besides, to advance our current understanding on the nature of the X-ray objects, we have used (or we will do) near-Infrared (NIR) spectroscopy.

2 Identifying potential candidate counterparts

Since we are interested in optical/NIR identification of X-ray sources with arcsec-scale error boxes, we have performed both image and table cross-correlation between UKIDSS and 2MASS catalogues to confirm potential candidate counterparts of X-ray unknown sources. Figure 1 show a region centred at the position $\alpha = 19^h\ 10^m\ 43^s$ and $\delta = +09^\circ\ 16'\ 30.0''$, with a radius of $\approx$1 arcmin. As it can be seen, there are 68 common infrared sources in both catalogues. Although most of them are individual point detections, we identified a few 2MASS sources that are coincident with two or more UKIDSS sources.

From Fig. 1 we can develop two kind of research projects. The first one is to resolve 2MASS sources and the second one is to study the variability of the infrared magnitudes. Although we know there are K-band, $J-H$, $J-K$, and $H-K$ colour transformation equations from UKIDSS to the photometric system in 2MASS (see [2], [3], and [4]), we have plotted the K magnitudes for both photometric systems to explore high variable sources.

Figure 2 shows the linear correlation between the K magnitudes obtained from both catalogues. On the basis ot these data, we considered the sources which

$$\Delta K = |K_{\rm UKIDSS} - K_{\rm 2MASS}| \geq 0.5 \text{ mag}$$

as a potential objects to analyse its nature, i.e. whether its are variable stars or binary/unresolved systems.

Furthermore, using VO tools we have confirmed potential candidate counterparts of some INTEGRAL sources (usually known as IGRs[1]). A proposal to observe these objects in the NIR has been approved and done.

3 Summary and conclusions

Virtual Observatory tools have an important role to play in providing information on the nature of X-ray binary sources and resolving multiple systems. We have shown that VO tools can be used to:

- Perform complete research projects ([7], see also VO Science papers),
- Support your research project as a complement ([5]),
- Help in your observational proposal ([5]).

Finally, we are developing new studies with VO tools such as:

[1] http://irfu.cea.fr/Sap/IGR-Sources/

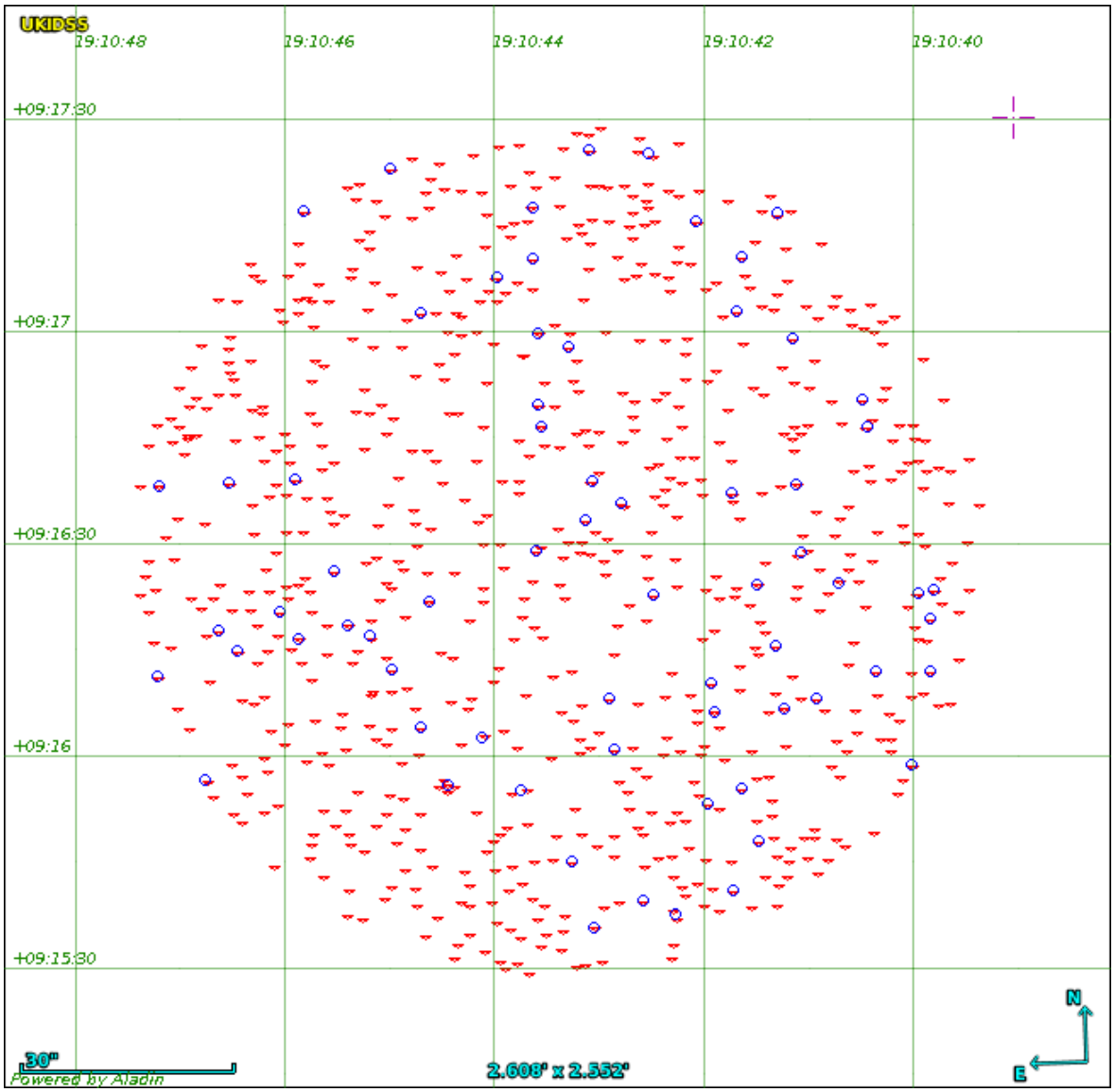

Figure 1: 2.6′×2.6′ finding chart for unresolved source candidates comparing 2MASS-PSC (blue circles) and UKIDSS (red triangles) catalogues.

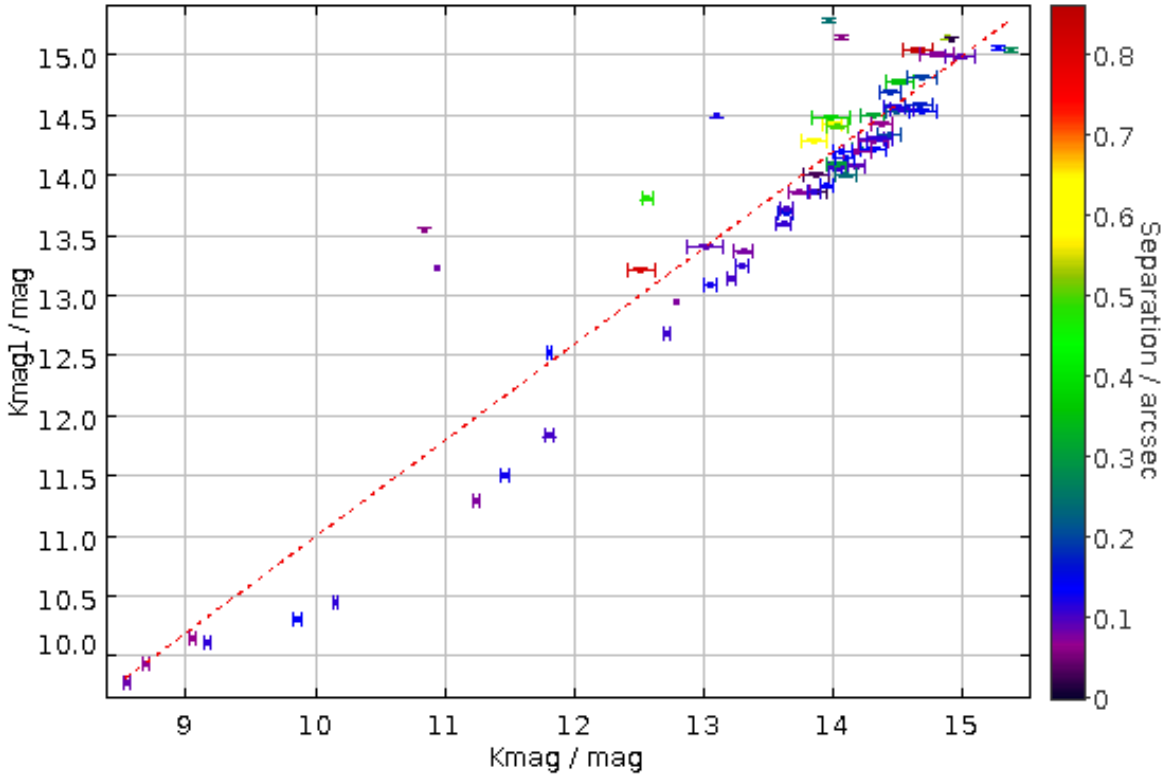

Figure 2: Linear correlation of K magnitudes from 2MASS (x axis) and UKIDSS (y axis). Position differences are less than 1 arcsec and colour-coded.

- Correlation between the new catalogue of Wolf-Rayet galaxies and X-ray, radio-emission, and IR catalogues (both images and spectroscopy, D. I. Méndez),
- Characterization of W UMa binary systems (PhD student R. García-Lozano has discovered some of them and calculate its orbital period),
- Discover unresolved 2MASS identifications and/or binary systems following our previous work [5].

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