Obscured BeXRBs through IR spectroscopy

J. J. Rodes, G. Bernabéu, J. M. Torrejón, A. Magazzù

Universitat d'Alacant
Universidad de Alicante

IU FACyT — I.U. de Física Aplicada a las Ciencias y las Tecnologías

www.dfests.ua.es
Dept. de Física, Enginyeria de Sistemes i Teoria del Senyal
Dpto. de Física, Ingeniería de Sistemas y Teoría de la Señal

E-04

Abstract

The identification and spectral characterization of the optical/infrared counterparts in X-ray binaries is an essential step to understand the physics of these systems. We report on the **first infrared spectroscopy** of three INTEGRAL X-ray binary sources which present high absorption. Our spectra show that almost **all the significant features are in emission**, consistent with a Be companion star. **We correct the infrared excess** taking into account the circumstellar envelope emission in order to obtain a **refined estimation of the distance** to the X-ray sources and their X-ray luminosities. Based on these results we discuss how their X-ray characteristics fit into the BeX-ray scenario.

Introduction

In the framework of an ongoing programme to discover and characterize optical/infrared counterparts to high-mass X-ray binaries (HMXBs), we characterized the *XMM-Newton* unidentified source 2XMM J191043.4+091629 as a HMXB [9]. It turned out to be a distant SGXBs which helps to trace independently the galactic structure. In an attempt to detect and characterize new HMXBs, we have selected HMXB candidates from the list of *INTEGRAL* sources, IGRs (*http://irfu.cea.fr/Sap/IGR-Sources*) with small position errors (provided by X-ray telescopes like *XMM-Newton* or *Swift*).

To advance our current understanding on the nature of our IGRs selection, we used observations in the near-IR range acquired with the *Telescopio Nazionale Galileo* (TNG) 3.5-m telescope. The spectral classification of hot stars based on a K-band spectrum cannot be completed without ambiguities because of the lack of enough spectral features in that range [3]. However, the combination with the H-band spectrum represents a powerful tool to characterize the donor star [5] and, together with the X-ray behaviour, establish the nature of the system unambiguously.

References

[1] Bozzo, E., Ferrigno, C. et al. 2011, *A&A, 531, A65*
[2] Esposito, P., Israel, G. L. et al. 2013, *MNRAS, 433, 2028*
[3] Hanson, M. M., Conti, P. S. & Rieke, M. J. 1996, *ApJS, 107, 281*
[4] Hanson, M. M., Kudritzki, R.-P. et al. 2005, *ApJS, 161, 154*
[5] Hanson, M. M., Rieke, G. H. & Luhman, K. L. 1998, *AJ, 116, 1915*
[6] Kaur, R., Paul B. et al. 2008, *MNRAS, 386, 2253*
[7] Masetti, N., Bassani, L. et al. 2006, *A&A, 455, 11*
[8] Riquelme, M. S., Torrejón, J. M. & Negueruela, I. 2012, *A&A, 539, A114*
[9] Rodes-Roca, J. J., Torrejón, J. M. et al. 2013, *A&A, 555, A115*
[10] Rodes-Roca, J. J., Bernabéu, G. et al. 2017, *submitted*

Conclusions

From the analysis of the **NIR spectra**, **photometry** and its **X-ray properties**, we have derived:

- Its **BeX nature**.
- Its **distances, applying the circumstellar excess correction**.
- K-band common field of view around **IGR J19294+1816** is consistent with a **single source** in *2MASS* and *UKIDSS* surveys.

Photometry

The **envelope emission contaminates the spectrum** and produces an overluminosity (for non Be-shell) with respect the underlying B star photospheric value, which leads to a **systematic under estimation of the distance** and, hence, the X-ray luminosity. We will use the recipes given in [8] to correct for these effects. The **distance** is computed from the usual equation

$$V - M_V - A_V^{\rm tot} = 5 \log d - 5 \tag{1}$$

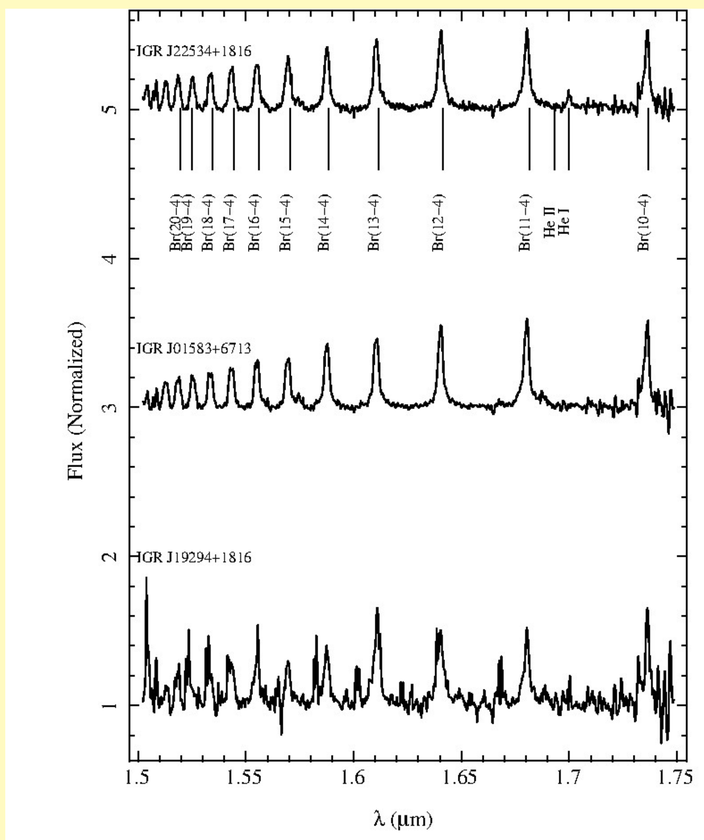
where V is the observed magnitude, M_V is the absolute magnitude for the corresponding spectral type and luminosity class and $A_V^{\rm tot}$ has two terms: the **interstellar absorption towards the source** $A^{\rm is} = 3.1\, E^{\rm is}(B-V)$ and the **circumstellar *emission***:

$$A_{\rm V}^{\rm tot} = \begin{cases} 3.1\, E^{\rm is}(B-V) - 0.6 \left(\frac{W^{\rm env}({\rm H}_\alpha)}{-30}\right) & \text{if } -W^{\rm env}({\rm H}_\alpha) < 15 \\ 3.1\, E^{\rm is}(B-V) - 0.3 & \text{if } -W^{\rm env}({\rm H}_\alpha) \geq 15 \end{cases} \tag{2}$$

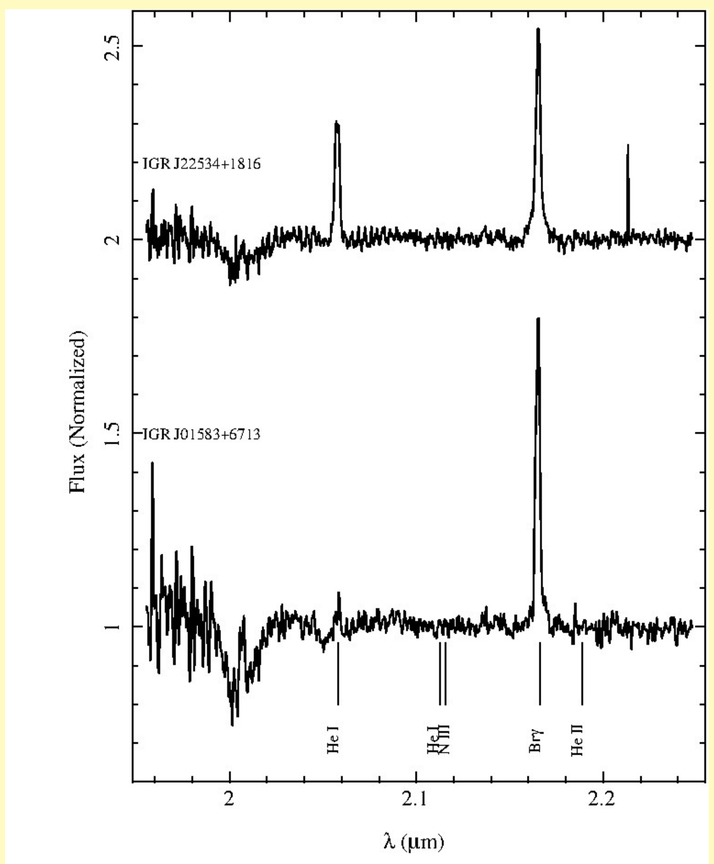
The fact that **all the significant lines** are in **emission** implies a **well developed envelope** which is the responsible for the **strong IR excess**. Therefore, we can assume a saturated regime in equation (2). In these conditions: $A_V^{\rm tot} = 3.1\, E^{\rm is}(B-V) - 0.3$.

Near-IR spectra

We present the first IR spectra ever of IGR J01583+6713, IGR J22534+6243 and IGR J19294+1816. Near-IR (NIR) spectra of the sources are shown in bottom figures, with identified spectral features marked. All of the significant lines are in emission. The NIR H-band of the three systems **exhibit the Brackett series** from Br(19-4) line at 1.5248 μm to the Br(10-4) transition at 1.7366 μm. The presence of a very clearly defined series of Brackett H I emission lines in the H-band points towards an **early Be type star**, since these lines disappear for O type stars. The NIR K-band spectrum shows the Brγ line at 2.1661 μm and the He I 2.0580 μm. In the atlas of [4], no luminosity class III star shows He I 2.0580 μm in emission.



a) H-band spectra



b) K-band spectra

As all of the sources are X-ray emitters, the systems are consistent with a **Be X-ray binary nature**, as also inferred by [7] and [6] in **IGR J01583+6713**, [2] in **IGR J22534+6243**, and [1] in **IGR J19294+1816**. According to [8], the spectral type is restricted to a narrow interval from B0 to B3.

Funding

This work was supported by the project **ESP2014-53672-C3-3-P**. AM acknowledges the support by the grant by the University of Alicante under visiting research programme INV15-10.