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ESO OPTICAL/IR OBSERVATIONS OF IGR J17544−2619

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RESUMEN

IGR J17544−2619 es una fuente transitoria de rayos X duros, recientemente descubierta por *INTEGRAL*, con un comportamiento típico de las binarias X que contienen una estrella de neutrones o un agujero negro. Se ha propuesto una posible contraparte óptica e infrarroja, con magnitudes consistentes con una supergigante azul. En este trabajo presentamos nuevas observaciones fotométricas y espectroscópicas de la candidata a contraparte de IGR J17544−2619 y discutimos la naturaleza de la fuente.

ABSTRACT

IGR J17544−2619 is a hard, transient X-ray source recently discovered by *INTEGRAL*, with flaring behaviour typical of X-ray binaries containing a neutron star or black hole. A possible optical and infrared counterpart has been proposed, with magnitudes consistent with a blue supergiant star. In this work we present new ESO optical/NIR photometric and spectroscopic observations of the counterpart candidate of IGR J17544−2619, and discuss the nature of the source.

Key Words: **X-RAYS: BINARIES — X-RAYS: INDIVIDUAL: IGR J17544-2619**

1. INTRODUCTION

IGR J17544−2619 is a fast, recurrent, transient X-ray source discovered by the *INTEGRAL* observatory (Sunyaev et al. 2003). Its coordinates ($l = 3.24°$, $b = -0.34°$) locate it very near the direction to the galactic center. This source has undergone several bursts lasting for hours, separated by longer quiescence periods (Sunyaev et al. 2003; Grebenev et al. 2004; González-Riestra et al. 2004). *XMM-Newton* observations have shown that its X-ray spectrum is very hard (González-Riestra et al. 2004), implying a high absorption by a large hydrogen column density ($N_{\rm H} \sim 1.9$–4.3×10^{22} cm^{-2}). Its total unabsorbed luminosity in the 0.5–10 keV range, for an assumed distance of 8 kpc, is estimated in 10^{32} erg s^{-1} in quiescence, with peaks reaching 10^{35}–10^{36} erg s^{-1} during bursts. These values are consistent with those expected for high-mass X-ray binaries (HMXBs) in which the accretor is a black hole or a neutron star.

A possible optical/NIR counterpart of this source was proposed by Rodriguez (2003). This object (USNO-B1.0 0636-0620933) is probably an early type star, suggesting that IGR J17544−2619 might be a HMXB. Indeed, there are other X-ray sources, both steady and transient, recently discovered by high energy observatories (e.g., IGR J16318−4848, IGR J16465−4507, and XTE J1739−302) which also show high absorption and for which massive companions were identified (Filliatre & Chaty 2004; Smith 2004; Negueruela et al. 2005).

Hence, a new class of X-ray binaries is apparently being unveiled by high energy observatories. Establishing their nature is clearly an important problem in high energy astrophysics, and multiwavelength observations have been demonstrated to be a successful tool for this task. Accordingly, we performed optical and NIR observations of IGR J17544−2619 in order to complement high energy data. In this talk we present our observations of the source, and discuss their implication on the nature of the system.

2. OBSERVATIONS

Our data were taken with the New Technology Telescope (NTT) at ESO, as part of a Target of Opportunity program (P. I. Chaty) to perform multiwavelength observations of new X-ray sources. We imaged the field of the source in the optical BVR bands and NIR $JHK_{\rm s}$ bands. We also took optical spectra of the counterpart candidate proposed by Rodriguez (2003).

Subarcsecond astrometry of our fields (Figure 1) allowed us to determine the position of the 4″ radius *XMM-Newton* error circle for the source in our frames. Inside it we found a bright object (B in Figure 1), which is the candidate proposed by Rodriguez (2003), three faint, pointlike ones (F1–F3), and an extended source (E). These faint objects are visible only at the longer wavelengths; the pointlike ones are probably foreground stars, while the extended

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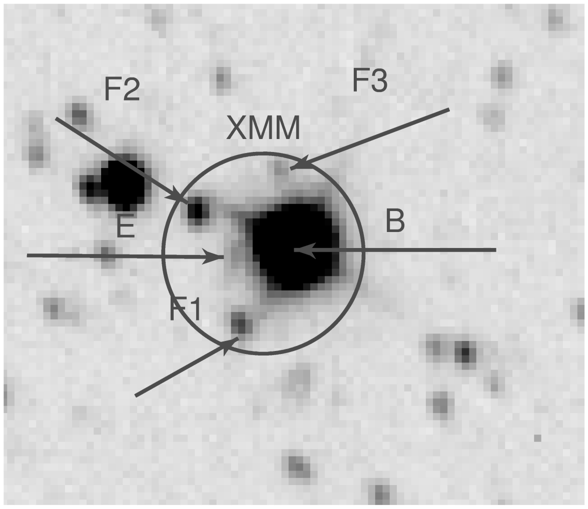

Fig. 1. K_s band image of the field of IGR J17544−2619. North is up and East is to the left. The circle is the *XMM-Newton* error box for the source (4″ radius). The five counterpart candidates (B,F1–F3 and E) found inside it are shown with arrows. The brightest one (B) is that proposed by Rodriguez (Rodriguez 2003).

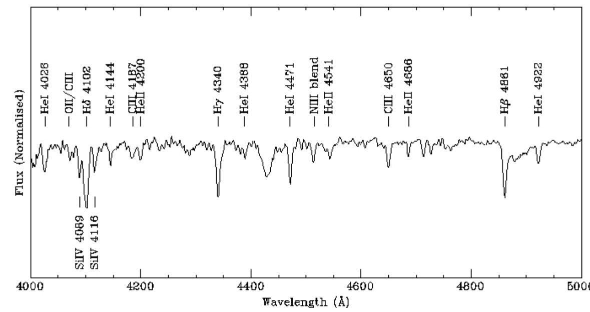

Fig. 2. Blue spectrum of candidate B, showing the identified lines. Strong He II lines suggest an O-type star. A detailed analysis gives O9Ib as the spectral type and luminosity class of this star.

one might be a background galaxy. Their faintness prevented any further measurement, hence we were forced to exclude them from our investigation. Nevertheless, we point out that they cannot be ruled out as possible counterparts until more accurate X-ray positions are obtained, or unless the properties of the brigthest candidate make a strong case for its association with the X-ray source.

The brightest candidate (B) presents the spectrum of an early-type star, given the intense He II lines observed (Figure 2). The ratio He II 4541 Å / He I 4471 Å allows us to classify this object as an O9 star, following the criteria of Walborn & Fitzpatrick (1990). Moreover, the He II 4686 Å, which is weak but clearly visible in absorption, indicates that this is an O9Ib star. Hence, the counterpart candidate proposed by Rodriguez (2003) is indeed an early type star, with a mass of $\sim$25 $M_\odot$ and a surface temperature of $\sim 3\times10^4$ K. If this is the correct counterpart of the high energy source, the system is a HMXB with a blue supergiant secondary. The red spectrum of candidate B shows a P-Cygni profile for the Hα line, indicating that the star is losing mass through a strong stellar wind. These winds are normally present in O-type stars.

Optical photometry of candidate B gives $B = 14.44 \pm 0.05$, $V = 12.65 \pm 0.05$ and $R < 11.9$. Given the O9Ib spectral type, these values imply a color excess $E(B-V) = 2.07 \pm 0.11$ which corresponds, using the relationship given by Dickey & Lockman (1990), to a hydrogen column density $N_{\rm H} = 1.2\times10^{22}$ cm^{-2}. This value is consistent with the lowest values obtained from the X-ray data (González-Riestra et al. 2004), since $E(B-V)$ gives $N_{\rm H}$ within a factor of two. These data allows us to compute the distance to the source, which turns out to be $d = 2-4$ kpc. In the case that this star is indeed associated to the high energy source, this value locates IGR J17544−2619 in the Scutum–Crux arm of the galaxy. The NIR magnitudes, $J = 8.71 \pm 0.02$, $H = 8.03 \pm 0.02$ and $K_s = 7.99 \pm 0.02$ are consistent with the intrinsic colours of an O9 star with the amount of reddening derived from the optical photometry.

Finally, we constructed V and K_s light curves of candidate B (Figures 3 and 4). The optical light curve shows a constant behaviour up to our accuracy limit of 0.08 mag. The NIR light curve presents instead erratic variations at the level of 0.05–0.10 mag. This fact suggests that the emission in each band originates in different parts of the system. The optical light curve is coming mainly from the star, hence the variations of the NIR light curve point to the existence of another component, probably a circumstellar medium or an accretion disk.

3. DISCUSSION

We presented new optical/NIR observations of IGR J17544−2619, and identified five possible counterparts for the X-ray source. The brightest one, USNO-B1.0 0636-0620933 is a reddened O9Ib star located in the Scutum–Crux arm of the Milky Way, 2–4 kpc away from the Sun in the direction of the galactic center. Other three faint, pointlike candidates are probably foreground stars, while the last one might be a background galaxy. No measurement could be made for these candidates. The extinction

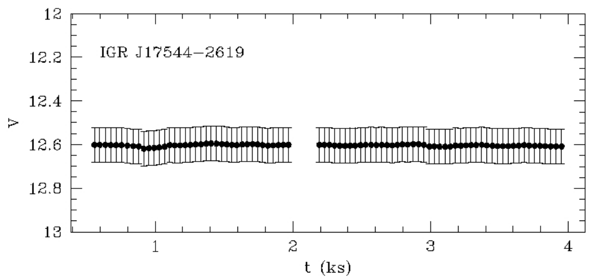

Fig. 3. V-band light curve for candidate B. Note the extremely constant behaviour of the source. The optical emission comes mainly from the O star.

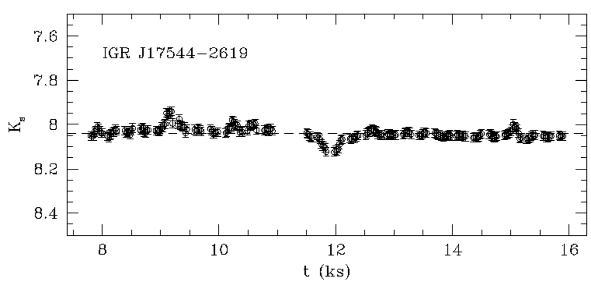

Fig. 4. $K_{\rm s}$-band light curve for candidate B. This curve shows erratic variations of up to ∼0.1 mag. The differences with the V-band light curve suggest that NIR emission originates in different a regions, probably a circumstellar medium or an accretion disk.

measured for USNO-B1.0 0636-0620933 is consistent with that obtained through X-ray data. This fact, together with the erratic variations observed in its NIR light curve, which suggest that the star is surrounded by a circumstellar medium or an accretion disc, points to its association with the high energy source.

Hence, IGR J17544−2619 is most probably a HMXB. The accretor properties cannot be investigated with our data, but the lack of radio emission (Walter 2004) suggests that it is a neutron star. The mass donor is a blue supergiant with a mass of ∼25 $M_\odot$. This implies that the system has evolved from a binary composed by two very massive stars and, given the short life of such a system, is consistent with the fact that we find it in a spiral arm of the Milky Way. The large and variable hydrogen column densities found in this system point to the existence of a circumstellar medium. This is also suggested by the comparison of our optical and NIR light curves.

If IGR J17544−2619 is indeed a HMXB, it would resemble XTE J1739−302 and IGR J16465−4507, both of which show fast X-ray transient behaviour, very low quiescence luminosity and blue supergiant companions. The physical mechanism driving the outbursts in the system is thought to be wind accretion from the supergiant donor.

Finally, we point out that a more detailed monitoring of this system through simultaneous multi-wavelength campaigns would be needed to precisely establish the nature of the source, unveil the accretion mechanism and shed light onto the origin and evolution of binaries comprising two very massive stars.

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