Astrophys Space Sci (2006) 304:295–297
DOI 10.1007/s10509-006-9135-7

ORIGINAL ARTICLE

X1908+075: A Late O-Type Supergiant with a Neutron Star Companion

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Received: 1 November 2005 / Accepted: 1 February 2006

Abstract X1908 + 075 is a highly-absorbed Galactic X-ray source likely made up of a pulsar accreting wind material from a massive companion. We have used near-IR photometric data complemented by follow-up spectroscopy to identify the likely counterpart to this X-ray source and to assign a spectral type O7.5–9.5 If to the primary. Further details can be found in Morel and Grosdidier (2005).

Keywords Stars: early-type · Infrared: stars · X-rays: binaries · X-rays: individual: X1908+075

1. X1908 + 075 seen in X-rays

Because of their short lifetimes (∼15,000 yr), OB supergiants harbouring a compact object (a neutron star or more rarely a black hole) constitute a rare, yet important and poorly understood evolutionary phase of massive binaries. The highly absorbed Galactic X-ray source X1908 + 075 has been recently found to belong to this class of objects and is made up of a neutron star accreting wind material (without RLOF) from the massive primary (Wen et al., 2000). X1908+075 displays energy-dependent, sinusoidal modulations of the X-ray power ($<L_X$ [5–100 keV]$>\sim 5 \times 10^{36}$ ergs s^{-1}) with a period of about 4.4 days. Pulsed emission with $\mathcal{P} = 605$ s has been detected. The following physical parameters for the primary star have been estimated based on *RXTE* data: $M = 9 - 31 M_{\odot}$, $R < 22$ R$_{\odot}$ and a wind mass-loss rate greater than $1.3 \times 10^{-6} M_{\odot}$ yr^{-1} (Levine et al., 2004). This led to the suggestion that the mass donor could be a Wolf-Rayet star.

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2. Identification of the potential counterparts

JHK_s-band images of the field were acquired on service observing mode in 2001 with the IR camera CAIN-II mounted on the TCS (Teide observatory, Canary Islands). Several sources are detected in the science frames going down to $J = 17.8$, $H = 16.5$ and $K_s = 16.5$ mag (Fig. 1). Note that these observations are of higher quality than the 2MASS data.

The colour-colour and colour-magnitude diagrams for the stars detected in the X-ray error boxes are shown in Fig. 2. The potential counterparts were pre-selected by considering the expected positions of two representative early-type stars (O5 V and O9 I) lying at $d = 7 \pm 3$ kpc and suffering $A_V = 15 \pm 5$ mag of extinction, as estimated from the X-ray data (Wen et al., 2000). Three candidates (A, B and C; see also Fig. 1 for their position) have near-IR properties consistent with the assumed distance and amount of visual extinction. However, candidate C lies slightly outside the intersection of the two X-ray error boxes.

3. Spectroscopic follow-up

Medium-resolution ($R\sim 800$) HK-band spectroscopy of the two prime candidates A and B was obtained on service observing mode with CGS4 at UKIRT in 2002. The observations were serendipitously carried out at superior conjunction of the neutron star ($\phi\sim 0.07$) according to the ephemeris for a circular orbit (Levine et al., 2004).

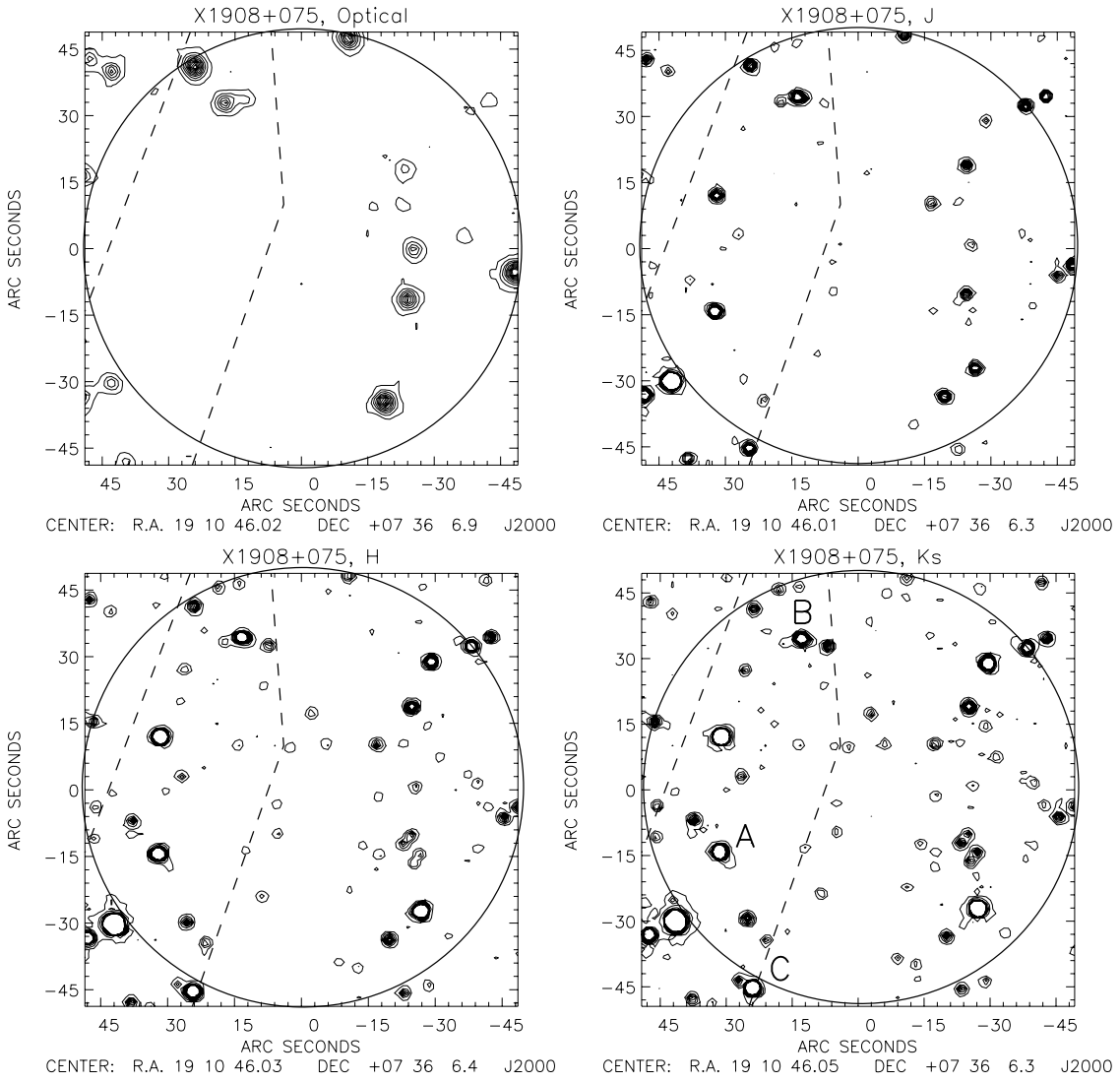

Fig. 1 Contour maps of the field in the optical (POSS-II red plate), J, H and K_s bands. The 50″ error circle of the *Einstein* satellite (*solid line*) and the diamond-like error box of the *HEAO 1* satellite (*dashed line*) are overlayed. The position of the potential candidates (A, B and C) is indicated in the lower, right-hand panel

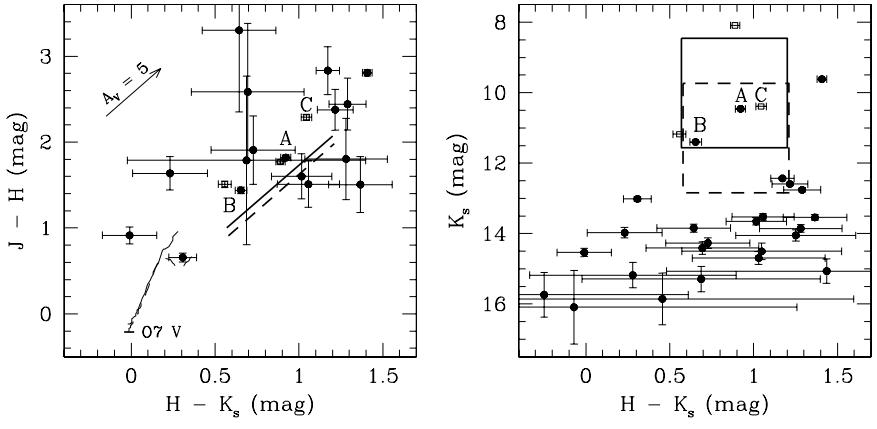

Fig. 2 Colour-colour and colour-magnitude diagrams for the stars in common between the *Einstein* and *HEAO 1* error boxes (*filled circles*). The 3 brightest sources to the South-East of the field lying within the *HEAO 1* error box, but just outside the *Einstein* error circle are also plotted (*open circles*). The position of candidates A, B and C is indicated. The diagonal lines in the left-hand panel and the boxes in the right-hand panel show the expected loci of the counterpart to X1908 + 075, assuming an O5 V (*dashed line*) or an O9 I (*solid line*) star

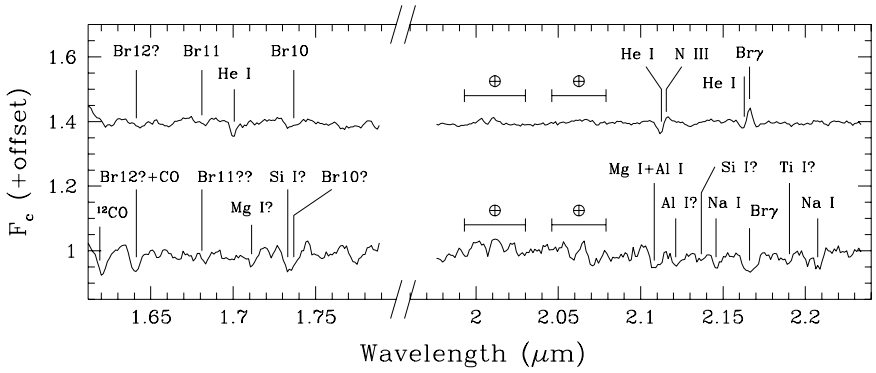

Fig. 3 HK-band spectra of candidates A (*top*) and B (*bottom*). The most prominent spectral features are labelled. The ⊕ symbols mark the position of the strong telluric lines. Some spurious features arising from an imperfect telluric subtraction can be seen at these locations

The spectrum of candidate B points to a cool star, most likely of luminosity class I–III (see Fig. 3). However, the measured strength of the diagnostic H, He and N lines all converge to a classification of candidate A as a late O-type star, while Brγ in emission strongly suggests a supergiant (see, e.g. Hanson et al., 1998). This leads us to propose a O7.5–O9.5 If classification.

4. Summary

- We have identified the likely counterpart to X1908 + 075 as a late O-type supergiant. This classification is compatible with the stellar parameters independently derived from X-ray data. Less than 10 binary systems of this type have been optically identified in the Galaxy.
- We obtain the following parameters for the counterpart: $\alpha = 19\text{h}\ 10\text{m}\ 48.204\text{s}$ and $\delta = +07^\circ 35' 52.32''$ (J2000). $J = 13.199 \pm 0.018$, $H = 11.380 \pm 0.012$ and $K_s = 10.457 \pm 0.018$ mag. $d \sim 7$ kpc and $A_V \sim 16.5$ mag (the latter value is roughly consistent with the hydrogen column density derived from modelling of the X-ray spectrum).
- Our data do not support the primary being a Wolf-Rayet star and firmly rule out a Be/X-ray binary.
- The lack of evidence for an embedded young cluster in the line of sight to X1908 + 075 (Bica et al., 2003, and references therein) strengthens the case for candidate A being the counterpart. However, further X-ray observations with higher spatial resolution, as well as near-IR spectroscopic data for other possible candidates in the field, are needed for an unambiguous identification. We are currently attempting to detect in photometric data the orbitally modulated changes which would confirm our results.

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