The Be Phenomenon in Early-Type Stars, IAU Colloquium 175
ASP Conference Series, Vol. 214, 2000
M. A. Smith, H. F. Henrichs, and J. Fabregat, eds.

Searching for New Be/X-ray Binaries in the Galactic Plane: the Case of GS 0834−43, 1WGA J1958.2+3232 and AX J1820.5−1434

G.L. Israel[1], S. Covino[2], V.F. Polcaro[3], S. Campana[2], S. Mereghetti[4], A. Pizzella[5], P. Roche[6], L. Stella[1], F. Verrecchia[7]

[1]*Osservatorio Astronomico di Roma, Monteporzio Catone, Italy*

[2]*Osservatorio Astronomico di Brera, Merate, Italy*

[3]*Istituto di Astrofisica Spaziale, CNR, Roma, Italy*

[4]*Istituto di Fisica Cosmica e Tecnologie Spaziali, CNR, Milano, Italy*

[5]*European Southern Observatory, ESO, Santiago, Chile*

[6]*Astronomy Centre, CPES, University of Sussex, Brighton, UK*

[7]*Università degli Studi "La Sapienza" di Roma, Italy*

Abstract. Over the last year we obtained X-ray (ROSAT, BeppoSAX and ASCA) and optical (at ESO and at the Astronomical Observatory of Loiano) to infra-red (AAO) observations of a sample of newly discovered X-ray pulsars. Among this sample we discovered the likely optical counterpart of three of them located in the Galactic plane: GS 0834−43, 1WGA J1958.2+3232 and AX J1820.5−1434.

1. Introduction

We performed a search for the optical counterpart of a sample of recently discovered X-ray pulsars. In all cases we found a Be-type star within the relatively narrow X-ray position uncertainty regions, the optical properties of which are in good agreement with the X-ray findings.

The discovery of the optical counterparts has been performed combining different techniques. When possible HRI images were analysed using both a sliding cell and a wavelet-transform based algorithm (Lazzati et al. 1999; Campana et al. 1999). Multicolour photometry (V, R, I, and Hα bands) have also been obtained and photometry for each stellar object in the images have been derived by means of DAOPHOT II (Stetson 1987). Low-resolution spectroscopy has also been performed for some objects in the X-ray error circles. If the photometric conditions were adequate, the data have always been flux calibrated.

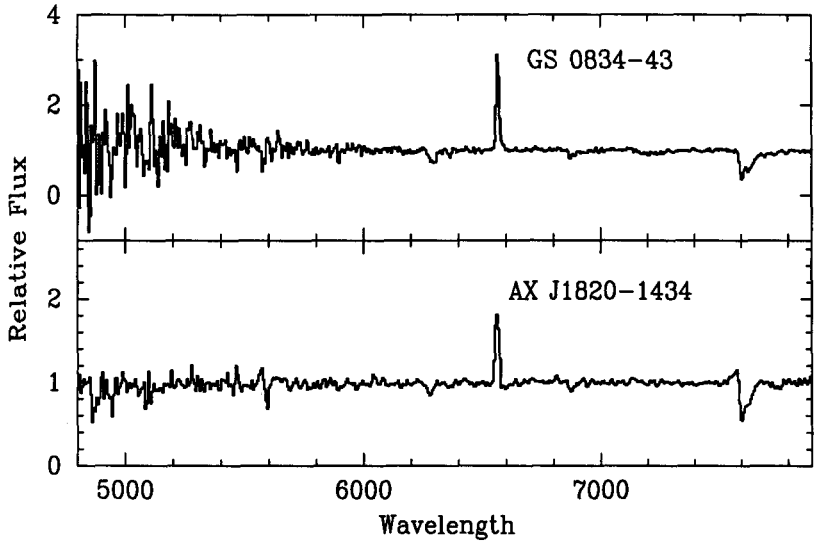

Figure 1. Low-resolution spectra of GS 0834−43 (upper panel; 1999 March 13 with NTT+EMMI) and AX J1820.5−1434 (lower panel; 1999 June 9 with 3.6m+EFOSC2).

2. GS 0834−43

The hard X-ray transient GS 0834−43 ($l_{II} \sim 262.0, b_{II} \sim -1.51$) was first discovered by the WATCH experiment on board GRANAT in 1990 at a flux level of about 1 Crab in the 5-15 keV energy band (Sunyaev 1990). In 1991 it was observed by GINGA, ROSAT and ART-P during which pulsations at 12.3 s were discovered (Makino 1990). We re-analyzed archival ROSAT PSPC observations of GS 0834−43, obtaining two new refined positions, $\sim 14''$ and $\sim 18''$ away from the previously published one, and a new spin period measurement (Israel et al. 1999a).

Based on these results we carried out an optical follow-up. Within the new error circles we found a relatively faint (V=20.1) reddened early-type star ($V - R$=2.24). The IR observations of the field confirm the presence of an IR excess for the Hα-emitting star (K'=11.4, $J - K'$=1.94) which is likely surrounded by a conspicuous circumstellar envelope. Spectroscopic and photometric data indicate a B0-2 V-IIIe spectral-type star located at a distance of 3-5 kpc. All these findings together, obtained in three different energy bands, allowed us to finally assess the Be-star/X-ray binary nature of GS 0834−43.

3. 1WGA J1958.2+3232

The X-ray source 1WGA J1958.2+3232 was serendipitously detected on May 1993 within the field of view of the Position Sensitive Proportional Counter (PSPC; 0.1-2.4 keV) in the focal plane of the ROSAT X-ray telescope (see Fig. 1). Highly significant pulsations at a period of 721±14 s were discovered in the

https://doi.org/10.1017/S0252921100056876 Published online by Cambridge University Press

ROSAT data (Israel et al. 1998). An ASCA observation performed on May 1998 detected 1WGA J1958.2+3232 at the flux level expected from the ROSAT pointing and confirmed the presence of a strong periodic signal at 734±1 s (Israel et al. 1999b). A luminosity of $\sim 10^{33}(d/1\mathrm{kpc})^2$ erg s^{-1} in the 2-10 keV energy band was obtained (assuming an absorbed power-law model). Due to the large uncertainty in the period determined by ROSAT, it was not possible to determine whether the system contains an accreting magnetic white dwarf or a neutron star, based on the period derivative. Even the spectral characteristics were consistent with both scenarios.

We carried out optical observations between May and September 1998 of the stars within the position error circle of 1WGA J1958.2+3232. Based on photometry and slitless spectroscopy, we selected a likely optical counterpart, which was subsequently determined to be a m_V=15.7 star at a distance of less than 3 kpc in good agreement with the X-ray results (Israel et al. 1999c). The proposed optical counterpart shows several H, He and Fe emission lines. However only a higher resolution spectrum or a measurement of the spin period derivative will firmly asses the nature of the system.

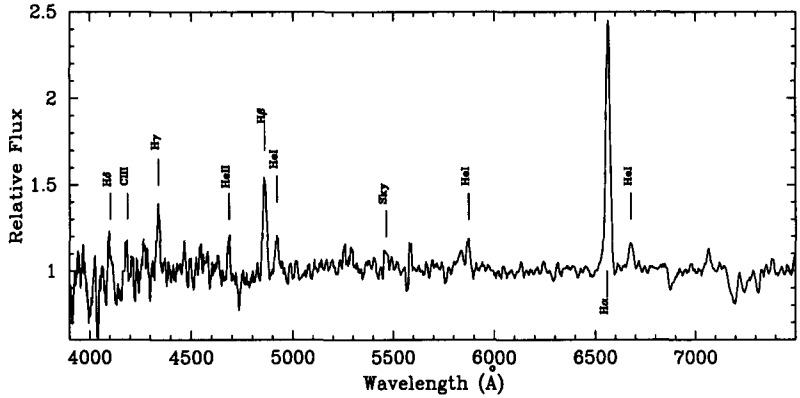

Figure 2. Low-resolution spectrum of 1WGA J1958.2+3232 obtained on July 1998. The strongest emission lines detected in the spectrum are marked.

4. AX J1820.5−1434

The X-ray source AX J1820.5−1434 was discovered on 1997 April 9 by the ASCA satellite (Kinugasa et al. 1998). Pulsations at a period of ∼152 s were detected in the 2-10 keV flux of the source with a pulsed fraction of ∼ 50% and energy independent. Based on the ASCA data alone it was not possible to asses the persistent or transient nature of the source. The ASCA energy spectrum gave a good fit either with a blackbody (kT=2.6 keV) and a power-law (Γ=0.9) model. The absorption corrected fluxes in the 2-10 keV band is $\sim 3.3\times10^{-11}$ erg cm^{-2} s^{-1}, which corresponds to an unabsorbed luminosity of $\sim 4\times10^{35}(d/10\mathrm{kpc})^2$ erg s^{-1}. Both timing and spectral properties of AX J1820.5−1434 are typical of an accretion-driven X-ray pulsar.

https://doi.org/10.1017/S0252921100056876 Published online by Cambridge University Press

We carried out an optical follow-up of the stars within the X-ray position uncertainty circle of AX J1820.5−1434 on July and September 1998 with the ESO telescopes. All the analysed stars are late O or early B-type main-sequence stars at different distances. In one case we revealed a strong Hα emission line from a R=17.33 mag O9.5-B0Ve type star, which we proposed as the optical counterpart of the pulsar (Israel et al. 1999d). Its optical parameters are in agreement with the X-ray findings.

References

Campana, S. et al. 1999, ApJ in press
Israel, G.L. et al. 1998, MNRAS 298, 502
Israel, G.L. et al. 1999a, MNRAS, submitted
Israel, G.L. et al. 1999b, MNRAS, submitted
Israel, G.L. et al. 1999c, A&A 345, L1
Israel, G.L. et al. 1999d, in preparation
Kinugasa, K. et al. 1998, ApJ 495, 435
Lazzati, D. et al. 1999, ApJ, in press
Makino, F. 1990, IAU Circ. 5148
Sunyaev, R. 1990, IAU Circ. 5122
Stetson, P.B. 1987, PASP 99, 191