COMPLETE HISTORY OF THE NEWLY DISCOVERED ACCRETING PULSAR 2RXP J130159.6-635806.

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ABSTRACT

We report on analysis of the poorly studied source 2RXP J130159.6-635806 at different epochs with *ASCA*, *Beppo*SAX, *XMM-Newton* and *INTEGRAL*. The source shows coherent X-ray pulsations at a period $\sim$ 700 s with an average spin up rate of about $\dot{\nu} \sim 2 \times 10^{-13}$ Hz s^{-1}. A broad band (1-60 keV) spectral analysis of 2RXP J130159.6-635806 based on almost simultaneous *XMM-Newton* and *INTEGRAL* data demonstrates that the source has a spectrum typical of an accretion powered X-ray pulsar, i.e. an absorbed power law ($\Gamma \sim 0.5 - 1.0$) with a high energy (at ~ 25 keV) cut-off. The long term behaviour of the source, its spectral and timing properties, tend to indicate a high mass X-ray binary with Be companion. We also report on the identification of the likely infrared counterpart to 2RXP J130159.6-635806.

Key words: X-rays, pulsars: individual: 2RXP J130159.6-635806.

1. INTRODUCTION

On February 7, 2004, during a routine Galactic plane scan, the *INTEGRAL* observatory detected a source which was not in the *INTEGRAL* reference catalog. Search in the archive led to the identification of several *ROSAT* sources in the *INTEGRAL* error box. Among them 2RXP J130159.6-635806 is the closest one to the best estimate of the source position obtained with *INTEGRAL* (Chernyakova et al., 2004). The only mention of this source in the literature before the observations reported here and in Chernyakova et al. (2005) can be found in Kaspi et al. (1995).

Here we present the analysis of all available X-ray data from *ASCA*, *Beppo*SAX, *INTEGRAL*, and *XMM-Newton* in order to understand the nature of this variable source and investigate its properties.

2. RESULTS OF THE ANALYSIS

During the *XMM-Newton* monitoring programme of PSR B1259–63, two sources were clearly detected. The best coordinates we derive for 2RXP J130159.6-635806 are RA$_{J2000}$=$13^h01^m58^s.8$, DEC$_{J2000}$=-63°58′10″ (the conservative error estimation is 3″). This position is about 6″ from the best *ROSAT* position of 2RXP J130159.6-635806. The uncertainty of the localisation of 2RXP J130159.6-635806 with *ROSAT* is 5″, therefore we conclude that most likely *XMM-Newton* source and the *ROSAT* one are the same.

The 1993–2004 time history of the $2 - 10$ keV flux from 2RXP J130159.6-635806 as observed by *ASCA* and *XMM-Newton* is shown in the upper panel of Figure 1. While during the *ASCA* (1994 – 1995) and the first half of the *XMM-Newton* observations (2001 – 2003) the flux of the source was practically constant, an outburst occured between the end of January and the beginning of February 2004. During this period the source flux increased by a factor of more than 5. This outburst was also detected by *INTEGRAL* in the $20 - 60$ keV energy range.

The *XMM-Newton* and *ASCA* data show that the spectrum of the source in $2 - 10$ keV energy range is well described by a simple power law modified by absorption. For all observations, the value of the photo-absorption is practically constant with an average value of $N_{\rm H} = (2.48 \pm 0.07) \times 10^{22}$cm^{-2}, which is higher than it follows from the measurements of the interstellar hydrogen in the Galaxy at this place. This indicates that part of the absorption might be intrinsic to the source. *INTEGRAL* data show a presence of a high-energy cut-off at about ~ 25 keV, typical for accreting X-ray pulsars

Analyzing the light curve of 2RXP J130159.6-635806 we found that it demonstrates near coherent strong variations with a characteristic time about 700 s. The values of the pulse period obtained between 1994 and 2004 are shown in Figure 2. An average spin up rate changes from $\dot{P} \simeq$

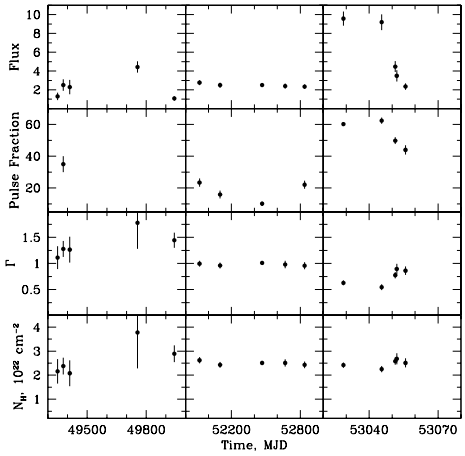

Figure 1. Time evolution of the spectral parameters of 2RXP J130159.6-635806 and $2-10$ *keV pulse fraction (in %). Flux is given in units of* 10^{-11} *erg/s/cm*^{2}*. labelfig:allspec*

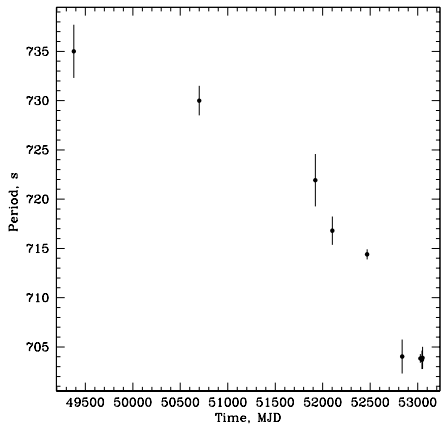

Figure 2. Time evolution of 2RXP J130159.6-635806 pulse period.

-6×10^{-8}s s^{-1} in 1994 – 2001, to approximately $\dot{P} \simeq -2 \times 10^{-7}$s s^{-1} in 2001 – 2004.

3. OPTICAL COUNTERPART

The accretion powered X-ray pulsars are usually found within high-mass X-ray binaries (HMXB). The HMXB may be divided mainly into those with main-sequence Be star companions, and those with evolved OB supergiants companions.

Most of Be/X-rays binaries are transients, displaying X-ray outburst and long period of quiescence, when no X-ray flux is detected. A smaller group of Be/X-rays binaries are persistent sources with rather low X-ray luminosity ($< 10^{35}$erg/s), relatively long (> 200s) pulse periods and very weak iron line at 6.4 keV. (e.g Negueruela 2004 and references therein).

The supergiant binaries may be further subdivided into two classes, depending on whether the mass transfer is due to the Roche lobe overflow, or a capture from the stellar wind. As the typical spin period for the pulsars with the companions filling its Roche lobe is less than 20 seconds (e.g. Corbet 1986) such a companion seems to be unlikely for 2RXP J130159.6-635806. The wind-fed supergiant binaries has long (of several hundreds seconds) spin period, and are pesistent sources with short, irregular outbursts(e.g. Corbet 1986). All the known systems display approximately the same X-ray luminosity $\sim 10^{36}$ erg/s. Variable X-ray activity of 2RXP J130159.6-635806 indicates that this binary system unlikely contains an OB supergiant.

In any of the cases mentioned above we should expect that the optical companion of the X-ray source should be bright in the optical and infrared spectral bands. In order to check this we used the results of 2MASS surveys and found a source with coordinates (equinox 2000) RA=$13^h01^m58^s.7$, DEC=-63°58′09″ (at $\sim 1.1''$ from the best *XMM-Newton* position) and magnitudes $J = 12.96 \pm 1.33$, $H = 12.05 \pm 0.03$, $K_s = 11.35 \pm 0.09$. The good agreement between both positions would tend to suggest that this source is the likely counterpart to 2RXP J130159.6-635806. Using the value of Galactic absorption $N_{\rm H} = 1.7 \times 10^{22}$ cm^{-2} we estimate the dereddened magnitudes $J_{der} = 10.73 \pm 1.33$, $H_{der} = 10.72 \pm 0.03$, $K_{sder} = 10.51 \pm 0.09$ (only statistical uncertainties are quoted). If the companion star is a Be main sequence star with surface temperature around 10000 K and the radius around 6-10 $R_\odot$ we can expect to see its infrared brightness $J, H, K \sim 10 - 11$ if the binary system is at the distance $\sim 4 - 7$ kpc. An additional tentative argument in favour of such source distance is the source location in the direction to the Crux spiral arm tangent, as HMXBs are concentrated towards galactic spiral arms. At such a distance unabsorbed intrinsic luminosity of 2RXP J130159.6-635806 is about $\sim 5 \times 10^{34}$ – 10^{35} erg/s, *i.e.* compatible with the typical luminosities of the persistent Be/X-rays binaries.

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