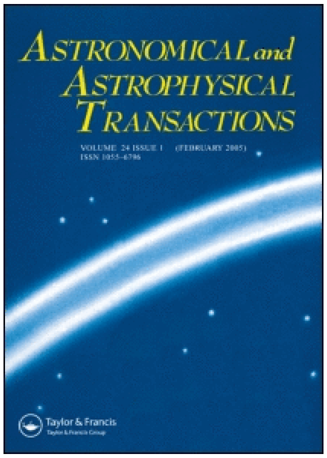

Astronomical & Astrophysical Transactions
The Journal of the Eurasian Astronomical Society
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713453505

Be-X-ray binaries and candidates

N. V. Raguzova [a]; S. B. Popov [a]
[a] Sternberg Astronomical Institute, Moscow, Russia

Online Publication Date: 01 June 2005
To cite this Article: Raguzova, N. V. and Popov, S. B. (2005) 'Be-X-ray binaries and candidates', Astronomical & Astrophysical Transactions, 24:3, 151 - 185
To link to this article: DOI: 10.1080/10556790500497311
URL: http://dx.doi.org/10.1080/10556790500497311

Astronomical and Astrophysical Transactions
Vol. 24, No. 3, June 2005, 151–185

Be–X-ray binaries and candidates

N. V. RAGUZOVA* and S. B. POPOV

Sternberg Astronomical Institute, Universitetski pr. 13, 119992 Moscow, Russia

(Received 13 July 2005)

We present a compilative catalogue of Be–X-ray binaries and candidates in the Galaxy and in the Large and Small Magellanic Clouds. This catalogue contains 130 sources and provides information on names and spectral types of optical components, distances, on spin characteristics of neutron stars and on orbital and X-ray properties of binary systems. We give brief comments on each object and provide necessary references to original data.

Keywords: Catalogues; Be–X-ray binaries; Neutron stars

1. Introduction

Be–X-ray binaries form the largest subclass of high-mass X-ray binaries. These objects have attracted the interest of specialists in several branches of astrophysics: stellar astrophysics, accretion theory, close binary evolution, etc. In recent years, because of new X-ray satellites, data available on these sources has greatly increased (see a recent review and references in [1]). In this paper (which is an extended and updated version of [2]), we present a compilative catalogue of these sources and provide brief comments on each source in the sample.

2. The catalogue

In the tables below we present a compilative catalogue of Be–X-ray stars. We separate galactic sources into systems in the Large Magellanic Cloud (LMC) and systems in the Small Magellanic Cloud (SMC). In each table the sources are ordered according to right ascension. In the first column we give the names of the sources. When possible, the first name corresponds to the notation in [3]. In the second and third columns, we present the spectral types of the massive companion and their magnitudes, respectively. In the fourth column, we give the spin periods P_{spin}, and in the fifth column, the orbital periods P_{orb}. Then, in the fifth and sixth columns, we give the orbital eccentricities e and the distances d to the source, respectively.

*Corresponding author. Email: raguzova@sai.msu.ru

Astronomical and Astrophysical Transactions
ISSN 1055-6796 print/ISSN 1476-3540 online
http://www.tandf.co.uk/journals
DOI: 10.1080/10556790500497311

In the eighth column, we give the maximal observed luminosities $L_{\max}$. In the last column, the pulse fractions are given. For sources in the LMC and the SMC, we do not show the distances; also as the orbital eccentricities are not known for systems in the SMC we omit the values for them in this column, too. Some comments and more detailed descriptions of each object can be found in the relevant sections on comments on the tables below (sections 2.1, 2.2 and 2.3 refer to galactic, LMC or SMC sources, respectively). References in the tables are given in square brackets, as usual, after each quantity (in a few cases we do not follow the data up to the first determination of a parameter but give a reference to some catalogue).

2.1 *Galactic sources: comments to table 1*

0053+604 (γ Cas, 3A 0053+604, BD+59 144, HD 5394, LS I +60° 133, 2S 0053+604, 1H 0053+604, 4U 0054+60). γ Cas is one of the best known Be stars; it was the first emission-line star discovered by Angelo Secchi in 1866, and it has a spectral classification of B0.5IVe [4]. Its visual magnitude varies between about 3.0 and 1.6, although usually it stays around 2.5. This object is one of the ROSAT bright sources and also was detected by IRAS. γ Cas has long been known to be very variable in optics and it is also a moderately strong X-ray source with a luminosity of the order of 10^{33}–10^{34} erg s^{-1} [8, 49, 50]. Such a luminosity would not be surprising for X-ray emission from an early-type star of spectral type O or B; some active early-type stars have similar luminosities [51, 52]. However, the hardness of the X-ray emission of γ Cas is extraordinarily high in comparison with the usual X-ray emission from early-type stars. If we fit the spectrum with a thermal model, the resultant temperature is roughly 10 keV or more [53, 54]. This is not common for early-type stars and resembles more the spectra of X-ray pulsars and accreting white dwarf binaries. There are currently two competing interpretations of the nature of the observed X-ray emission: one is the accretion of the wind from γ Cas on to a white dwarf companion and the other is that X-rays originate because of some physical processes in the outer atmosphere of γ Cas itself. Arguments for and against these two hypotheses have been best summarized in studies by Kubo *et al.* [55] and Robinson and Smith [56].

0115+634 (V635 Cas, 1H 0115+635, 4U 0115+63, 3U 0115+63, 2E 0115.1+6328, H 0115+634, 4U 0115+634). This source is one of the best-studied Be–X-ray systems. This transient was first reported in the Uhuru satellite survey [57, 58], although a search in the Vela 5B database revealed that the source had already been observed by this satellite since 1969 [59]. X-ray outbursts have been observed from 4U 0115 + 63 by Uhuru [60], HEAO-1 [61, 62], Ginga [63], CGRO Burst and Transient Source Experiment (BATSE) [64] and the Rossi X-ray Timing Explorer (RXTE) [65–67] and reoccurred with intervals from 1 year to several years. Precise positional determinations by the SAS-3, Ariel V and HEAO-1 satellites [68, 69] were used to identify this system with a heavily reddened Be star with a visual magnitude $V = 15.5$ [70, 71]. Rappaport *et al.* [72] used SAS-3 timing observations to derive the orbital parameters of this binary system. Because of the fast rotation of the neutron star, centrifugal inhibition of accretion prevents the onset of X-ray emission unless the ram pressure of accreted material reaches a relatively high value. The magnetic field of the neutron star is 1.3×10^{12} G [73]. The pulse fraction was obtained in a model-dependent way in the range 20–50 keV (see [10] for details and references).

J0146.9+6121 (V831 Cas, 2S 0142+61, RX J0146.9+6121, LS I +61° 235). RX J0146.9+6121 is an accreting neutron star with a 25 min spin period, the longest known period

Table 1. Be–X-ray binaries and candidates in the Galaxy.

Name	Spectral type	m_V	P_{spin} (s)	P_{orb} (days)	e	d (kpc)	L_{max} (erg s^{-1})	Pulse fraction (%)
0053+604 (γ Cas)	B0.5IVe [4]	1.6–3.0 [5]		203.59 [6]	0.26 [6]	0.188 [7]	3.9×10^{34} [8]	
0115+634	B0.2Ve [9]	15.5 [9]	3.6 [8]	24.3 [9]	0.34 [9]	7–8 [9]	3.0×10^{37} [8]	40–60 [10]
J0146.9+6121 (V831 Cas)	B1III–Ve [11]	11.2 [11]	1412 [8]			2.5 [8]	3.5×10^{35} [8]	
0236+610 (V615 Cas)	B0Ve [12]	10.7 [3]		26.45 [3]		3.1 [8]	2×10^{34} [8]	
0331+530 (BQ Cam)	O8–9Ve [13]	15.7 [13]	4.4 [8]	34.3 [13]	0.3 [13]	7 [4]	$>10^{38}$ [13]	
0352+309 (X Per)	O9.5IIIe–B0Ve [14]	6.1–6.8 [14]	837 [14]	250 [14]	0.11 [14]	1.3 [14]	3×10^{35} [14]	
J0440.9+4431	B0III–Ve [15]	10.78 [15]	203 [8]			3.2 [8]	3×10^{34} [8]	
0535+262 (V725 Tau)	B0IIIe [16]	8.9–9.6 [3]	105 [8]	111 [3]	0.47 [4]	2.4 [8]	2×10^{37} [8]	20–100 [17, 18]
0556+286	B5ne [3]	9.2 [3]						
J0635+0533	B1–2III–Ve [3]	12.83 [3]	0.0338 [3]			2.5–5 [19]	$(9-35) \times 10^{33}$ [19]	≈20 [20]
0726-260	O8–9Ve [3]	11.6 [3]	103.2 [3]	34.5 [3]		≈6 [21]	2.8×10^{35} [21]	≈30 [21]
0739-529	B7IV–Ve [3]	7.62 [3]						
0749-600	B8IIIe [3]	6.73 [3]						
J0812.4-3114	B0.2IVe [22]	12.42 [3]	31.89 [3]	80 [22]		9 [23]	1.1×10^{36} [23]	
0834-430	B0–2III–Ve [3]	20.4 [3]	12.3 [3]	105.8 [4]	0.12 [4]	5 [8]	1.1×10^{37} [8]	<15 [24]
J1008-57	O9e–B1e [4]	15.27 [3]	93.5 [3]	247.5 [4]	0.66 [4]	2 [8]	2.9×10^{35} [8]	60 [25]
1036-565	B4IIIe [3]	6.64 [3]						
J1037.5-5647	B0III–Ve [3]	11.3 [3]	862 [3]			5 [8]	4.5×10^{35} [8]	52 [26]
1118-615	O9.5III–Ve [3]	12.1 [3]	405 [3]			5 [8]	5×10^{36} [8]	
1145-619	B1Vne [3]	9.3 [3]	292.4 [3]	187.5 [3]	>0.5 [4]	0.5 [8]	7.4×10^{34} [8]	28–70 [4]
1249-637	B0IIIe [3]	5.31 [3]						
1253-761	B7Vne [3]	6.49 [3]						
1255-567	B5Ve [3]	5.17 [3]						
1258-613 (GX 304-1)	B0.7Ve [4]	13.5 [3]	272 [3]	132.5 [4]	>0.5 [4]	2.4 [8]	1×10^{36} [8]	
1417-624	B1Ve [4]	17.2 [3]	17.6 [3]	42.12 [3]	0.446 [4]	10 [8]	8×10^{36} [8]	
J1452.8-5949			437.4 [3]			9 [8]	8.7×10^{33} [8]	50–100 [27]
J1543-568			27.1 [4]	75.6 [28]	<0.03 [28]	>10 [28]	$>10^{37}$ [28]	60–70 [28]
1553-542	Be?		9.26 [4]	30.6 [3]	<0.09 [4]	10 [8]	7×10^{36} [8]	30 [29]
1555-552	B2nne [3]	8.6 [3]						
J170006-4157			714.5 [3]			10 [8]	7.2×10^{34} [8]	≈30 [30]
J1739-302						8.5 [31]	4.2×10^{37} [31]	
J1739.4-2942	Be?							
J1744.7-2713	B2III–Ve [3]	8.4 [3]				0.9 [32]	1.8×10^{32} [32]	25 [10]
J1749.2-2725	Be?		220.38 [3]			8.5 [8], [33]	2.6×10^{35} [8], [33]	
J1750-27			4.45 [3]	29.8 [3]				

(*continued*)

Table 1. Continued.

Name	Spectral type	m_V	P_{spin} (s)	P_{orb} (days)	e	d (kpc)	L_{max} (erg s^{-1})	Pulse fraction (%)
J1820.5-1434	O9.5–B0Ve [34]		152.26 [36]			4.7 [8]	9×10^{34} [8]	33 [36]
1843+00	B0–2IV–Ve [37]	20.9 [37]	29.5 [3]			>10 [37]	3×10^{37} [38]	7 [24]
1845-024			94.8 [3]	242.18 [4]	0.88 [3]	10 [8]	6×10^{36} [8]	
J1858+034			221 [3]					25 [39]
1936+541	Be [3]	9.8 [3]						
J1946+274	B0–1IV–Ve [40]	18.6 [40]	15.8 [3]	169.2 [40]	0.33 [40]	5 [8]	5.4×10^{36} [8]	30 [41]
J1948+32	B0Ve [42]	14.2 [43]	18.76 [4]	40.4 [42]	0.03 [42]	9.5 [42]	2.1×10^{37} [42]	55–70 [42]
2030+375	B0e [4]	19.7 [3]	41.8 [4]	46.03 [3]	0.41 [4]	5 [8]	1×10^{38} [8]	36 [10]
J2030.5+4751	B0.5V–IIIe [3]	9.27 [3]				2.7 [32]	1.7×10^{33} [32]	
J2058+42	Be [44]		198 [3]	110 [3]		7 [8]	2×10^{36} [8]	36 [10]
2103.5+4545	B0Ve [45]	14.2 [45]	358.6 [45]	12.7 [45]	≈0.4 [45]	6.5 [45]	3×10^{36} [45]	45–80 [46]
2138+568 (Cep X-4)	B1–B2Ve [47]	14.2 [47]	66.3 [4]			3.8 [8]	9.1×10^{35} [8]	5–85 [47]
2206+543	B1e [3]	9.9 [3]	392 [3]	9.57 [4]		2.5 [8]	2.5×10^{35} [8]	
2214+589	Be [3]	11 [3]						
J2239.3+6116	B0–2III–Ve [3]	15.1 [3]	1247 [48]	262.6 [4]		4.4 [3]	$\approx 2.3 \times 10^{36}$ [48]	40 [48]

of any X-ray pulsar in a Be-star system. This fact was realized [74] only after the rediscovery of this source in the ROSAT all-sky survey and its identification with the eleventh-magnitude Be star LS I +61° 235 [75]. Indeed, the 25 min periodicity had already been discovered with EXOSAT [76], but it was attributed to a nearby source 4U 0142+614. The optical star is probably a member of the open cluster NGC 663 at a distance of about 2.5 kpc [77]. For this distance, the 1–20 keV luminosity during the EXOSAT detection in 1984 was about 10^{36} erg s^{-1} [74]. All the observations of RX J0146.9 + 6121 carried out after its rediscovery yielded lower luminosities, of the order of a few 10^{34} erg s^{-1}, until an observation with the RXTE satellite showed that in July 1997 the flux started to rise again [78], although not up to the level of the first EXOSAT observation.

0236+610 (V615 Cas, 2E 0236.6+6101, LS I +61° 303, 1E 0236.6+6100, RX J0240.4+6112). LS I +61° 303 is a radio-emitting X-ray binary which exhibits radio outbursts every 26.5 days. The radio outburst peak and the outburst phase are known to vary over a time scale of about 4 years [79, 80]. The 26.5 day period is believed to be the orbital period. Hutchings and Crampton [12] confirmed the radio period by analysis of a 3 year observation of radial velocity. They concluded that the optical spectrum corresponds to a rapidly rotating B0V star. The 4 year modulation has been discovered on the basis of continued radio monitoring.

0331+530 (BQ Cam, EXO 0331+530, V 0332+53). EXOSAT observed three outbursts from V 0332+53 between November 1983 and January 1984. Two properties of the system were discovered: the 4.4 s spin period and a sudden decrease in luminosity at the end of recurrent outbursts about 1 month long. The latter was interpreted as an onset of the centrifugal barrier [81, 82]. An upper limit of about 5×10^{33} erg s^{-1} to the source quiescent emission (1–15 keV) was derived on that occasion with the EXOSAT medium-energy detector. Doppler shifts in pulse arrivals indicated that the pulsar is in orbit around a Be star with a period of 34.3 days and eccentricity 0.3 [81]. Observations during a subsequent outburst with Ginga led to the discovery of a cyclotron line feature corresponding to 3×10^{12} G magnetic field [83]. BeppoSAX and Chandra observations allowed this transient to be studied at the faintest flux levels thus far [84]. Campana *et al.* [84] concluded that the quiescent emission of this X-ray transient probably originates from accretion on to the magnetospheric boundary of the neutron star in the propeller regime and/or from deep crustal heating resulting from pycnonuclear reactions during the outbursts. Recently, the source was observed by Integral [85]. The existence of cyclotron lines was confirmed: the fundamental line at 24.9 ± 0.1 keV, the first harmonic at 50.5 ± 0.1 keV as well as the second harmonic at 71.7 ± 0.8 keV.

0352+309 (X Per, HD 24534, 3A 0352+309, 2E 0352.2+3054, H 0352+309, 4U 0352+30, 4U 0352+309, 1H 0352+308, 2A 0352+309, H 0353+30, HD 24534, 3U 0352+30). The X-ray source 4U 0352+309 is a persistent low-luminosity pulsar in a binary system with the Be star X Per. Its 837 s pulsation period was discovered with the Uhuru satellite [86, 87], and is still one of the longest periods of any known accreting pulsar (see [64] and references therein). X Per is a bright and highly variable star with a visual magnitude that ranges from about 6.1 to about 6.8 [88, 89]. The spectral class has been estimated to be O9.5III to B0V [90–92]. Based on spectroscopic parallax, distance estimates range from 700 ± 300 pc to 1.3 ± 0.4 kpc [89, 91–93]. The X-ray luminosity varies on long timescales (years) from about 3×10^{35} to about 5×10^{34} erg s^{-1} (for the assumed distance 1.3 kpc [94]). Delgado-Marti *et al.* [14] have determined a complete orbital ephemeris of the system using data from RXTE.

Coburn *et al.* [95] have discovered a cyclotron resonant scattering feature at 29 keV in the X-ray spectrum of 4U 0352+309 using observation taken with RXTE. The cyclotron resonance scattering feature energy implies a magnetic field strength at the polar cap of 3.3×10^{12} G.

J0440.9+4431 (RX J0440.9+4431, VES 826). RX J0440.9+4431/BSD 24–491 was confirmed as an accreting Be–X-ray system following the discovery of X-ray pulsations, with a barycentric pulse period of 202.5 ± 0.5 s from RXTE observations [26].

0535+262 (V725 Tau, HD 245770, 1A 0535+26, 1H 0536+263, 3A 0535+262, BD+26 883, 4U 0538+26, 1A 0535+262, H 0535+262). The transient A 0535 + 26 is one of the best-studied Be–X-ray binaries. This source was discovered in 1975 by Ariel V [96] and showed a 104 s periodicity, indicating the presence of a highly magnetized neutron star. The optical counterpart was later identified with the Be star HDE 245770 [97], allowing the classification of the source as a Be–X-ray binary. The pulsed fraction is 20% at 30–40 keV and increases significantly with increasing energy, reaching 100% at 100 keV [18]. The magnetic field of the neutron star is 4.3×10^{12} G [73].

0556+286 (4U 0548+29, 1H 0556+286). The X-ray source was detected by HEAO-1. Probably earlier it was observed by Uhuru 4U 0548 + 29 [98]. No detection was made after that. A Be star is known in this direction.

J0635+0533 (SAX J0635+0533). This was discovered by BeppoSAX [19]. Ziolkowski [4] gave the spectral classification of the optical counterpart as B0.5IIIe. The X-ray luminosity is $(9-35) \times 10^{33}$ erg s^{-1} (2–10 keV) for $d = 2.5$–5 kpc [19]. The bolometric luminosity (0.1–40 keV) was estimated to be 1.2×10^{35} erg s^{-1} for $d = 5$ kpc [20]. The pulse fraction was obtained by BeppoSAX (2–10 keV). The source can be identified with the γ-ray source 2EG J0635+0521. Low luminosity together with very fast rotation indicate that the neutron star has a low magnetic field (see discussion in [20]).

0726-260 (4U 0728-25, 3A 0726-260, V441 Pup, 1H 0726-259, LS 437). This has been detected by many experiments (Uhuru, HEAO-1, Ariel V, ROSAT and RXTE). The pulse fraction was estimated as $(I_{\max} - I_{\min})/(I_{\max} + I_{\min})$ from the graph in [21] (RXTE data, 2–20 keV). The spectral and photometrical analysis of this source led Negueruela *et al.* [99] to conclude that the primary is an O8–9Ve star.

0739-529 (1H 0739-529). This was detected by HEAO-1 [98].

0749-600 (1H 0749-600). This was detected by HEAO-1 [98]. It is situated in the open cluster NGC 2516 [3].

J0812.4-3114 (RX J0812.4-3114, V572 Pup, LS 992). RX J0812.4-3114 was discovered by Motch *et al.* [32] during a search for high-mass X-ray binaries by cross-correlating the SIMBAD OB star catalogues with low Galactic latitude sources from the ROSAT all-sky survey. Thus, this X-ray source has an identified optical counterpart, the Be star LS 992, and so it was suspected that this source belongs to the Be–X-ray binaries. Reig *et al.* [22] recently classified it as B0.2IVe, while in [3] it is classified as B0.5III–Ve. The X-ray light curve of LS 992/RX J0812.4-3114 is characterized by 31.88 s pulsations, while the X-ray spectrum is best represented by an absorbed power-law component with a exponential cut-off [23]. In December 1997 the source made a transition from a quiescent state to a flaring state [100], in which regular flares separated by 80 day intervals were detected with the all-sky monitor onboard the RXTE. Corbet and Peele [100] attributed the origin of these flares to the periastron passage of the neutron star, hence this periodicity was naturally associated with the orbital period. Corbet and Peele [100] have found strong evidence for the presence of a period of about 80 days in the all-sky monitor light curve of RX J0812.4-3114. By comparison with other Be-star X-ray binaries, the time of maximum flux is likely to coincide with the periastron passage of a neutron star. The orbital period of about 80 days combined with the pulse period of about 32 s is consistent with the correlation between the orbital period and the pulse period that is found for the majority of Be/neutron star binaries [101].

0834-430 (GS 0834-430). The hard X-ray transient GS 0834-430 was 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 [24]. The source was later observed by Ginga [102, 103] and ROSAT as a part of the all-sky survey [104]. The pulsations at a period of 12.3 s were observed during the Ginga, ROSAT and ART-P observations [104–107]. GS 0834-43 was also monitored by BATSE between April 1991 and July 1998. In particular, seven outbursts were observed from April 1991 to June 1993 with a peak and intra-outburst flux of about 300 mCrab and less than 10 mCrab respectively [108]. The recurrence time of 105–115 days was interpreted as the orbital period of the system. However, no further outbursts have been observed since July 1993 either by CGRO BATSE or by the all-sky monitor on board RXTE. All these findings suggest that GS 0834-43 is a new Be-star–X-ray binary system with an eccentric orbit [108]. Based on both photometric and spectroscopic findings, Israel *et al.* [109] concluded that the optical counterpart of this X-ray pulsar is most likely a B0–2III–Ve star at a distance of 3–5 kpc. The pulse fraction was obtained by BATSE (20–50 keV).

J1008-57 (GRO J1008-57). This was discovered by BATSE in 1993. A pulse fraction of about 60% was obtained by ROSAT (0.1–2.4 keV) [10]. High-energy data (BATSE data, 20–70 keV) give nearly the same value of about 67% [10]. The orbital period is uncertain. An estimate of 247.5 days was obtained from the best fit of BATSE data [110]. Other (earlier) estimates were about 135 days [3]. The counterpart is shown to be an OB star with a strong infrared excess and Balmer emission lines, suggesting a Be-type primary [111].

1036-565 (3A 1036-565, 1A 1034-56). This is probably the same object as J1037.5-5647.

J1037.5-5647 (LS 1698, RX J1037.5-5647). This was discovered by ROSAT in 1997 and is probably the same source as 4U 1036-56/3A 1036-565. The source was observed in quiescence [26]. $L_{\rm min} = 1.1 \times 10^{34}$ erg s^{-1}. The pulse fraction was obtained by RXTE (3–20 keV).

1118-615 (1A 1118-615, 1A 1118-616, WRAY 15-793, 2E 1118.7-6138). The hard X-ray transient A 1118-615 was discovered serendipitously in 1974 by the Ariel 5 satellite [112] during an observation of Cen X-3 (4U 1119-603). The same series of observations revealed pulsations with a period of 405.3 ± 0.6 s [113]. However, in the initial announcement of the discovery of the pulsations, they were wrongly attributed to an orbital period, suggesting that A 1118-615 consisted of two compact objects [113]. This hard X-ray transient underwent a major outburst only twice: in 1974, when it was discovered by the Ariel V satellite, and from December 1991 to February 1992 [64]. The source was observed by Motch *et al.* [114] using the Einstein Observatory and EXOSAT observatory in 1979 and 1985, respectively. On both occasions a weak signal was detected, confirming that low-level accretion was occurring. The correct optical counterpart was identified as the Be star He 3-640/Wray 793 by Chevalier and Ilovaisky [115]. The primary has been classified as O9.5III–Ve [116], with strong Balmer emission lines indicating the presence of an extended envelope. According to Villada *et al.* [117], the exact classification is complicated by many faint absorption and emission lines (mostly of Fe II), but the overall spectrum is found to be similar to that of the optical counterparts to other known Be–X-ray sources. The source was observed by Coe and Payne [118] at ultraviolet wavelengths using the IUE satellite. They confirmed the identification of the counterpart and reported prominent ultraviolet lines characteristic of a Be star. Despite the large observational efforts made during the last few years and mainly after the 1991–1992 outburst, the Hen3-640/1A 118-615 system is still poorly understood. The orbital period of the system is unknown. Corbet's [101] pulse period/orbital period diagram gives an orbital period estimate of about 350 days.

1145-619 (V801 Cen, 2S 1145-61, 2S 1145-619, 2S 1145-62, LS 2502, 3U 1145-61, 4U 1145-62, 4U 1145-619, 4U 1145-61, 3A 1145-619, 2E 1145.5-6155, H 1147-62, H 1145-619). This is initially observed by Uhuru (together with 1145.1-9141). Two sources were distinguished by the Einstein Observatory (HEAO-2). In the paper by Liu *et al.* [3] the optical counterpart was classified as B1Vne. The pulse fraction was obtained by BATSE (20–50 keV).

1249-637 (1H 1249-637, 2E 1239.8-6246, BZ Cru). This was detected by HEAO-1 [98] and is probably a white dwarf accretor.

1253-761 (1H 1253-761). This was detected by HEAO-1 [98] and is probably a white dwarf accretor.

1255-567 (1H 1255-567, μ^2 Cru). This was detected by HEAO-1 [98].

1258-613 (GX 304-1, 4U 1258-61, V850 Cen, H 1258-613, 2S 1258-613, 3A 1258-613). This was discovered by Uhuru. In [4] it was classified as B0.7Ve. In [3] it was classified as B2Vne.

1417-624 (2S 1417-624, 2S 1417-62, 4U 1416-62, 2E 1417.4-6228, 3A 1417-624, H 1417-624). The X-ray source 2S 1417-62 was detected by SAS-3 in 1978 [119]. Analysis of the SAS-3 observations showed an evidence of pulsations of about 57 mHz [120]. Einstein Observatory and optical observations identified a Be-star companion at a distance of 1.4–11.1 kpc [121]. From the timing analysis of BATSE observations, orbital parameters were determined and a correlation was found between the spin-up rate and the pulsed flux [122].

The orbital period and eccentricity of the source were found to be 42.12 days and 0.446 respectively.

J1452.8-5949 (1SAX J1452.8-5949). 1SAX J1452.8-5949 was discovered during a BeppoSAX galactic plane survey in 1999 [27]. Coherent pulsations were detected with a barycentric period of a 437.4 ± 1.4 s. The X-ray properties and lack of an obvious optical counterpart are consistent with a Be-star companion at a distance of between approximately 6 and 12 kpc. The pulse fraction is high. It was determined in the BeppoSAX band 1.8–10 keV. Be–X-ray systems display a correlation between their spin and orbital periods [101] which in this case implies an orbital period of more than 200 days for 1SAX J1452.8-5949.

J1543-568 (XTE J1543-568). The transient X-ray source XTE J1543-568 was discovered by RXTE in 2000 [28]. A subsequent pointed observation by the proportional counter array of RXTE revealed a pulsar with a period of 27.12 ± 0.02 s. Later the pulsar was found in earlier data from BATSE on board the Compton Gamma-Ray Observatory. The orbital period is 75.56 ± 0.25 days. The mass function and position in the pulse period versus orbital period diagram are consistent with the fact that XTE J1543-568 is a Be–X-ray binary. The eccentricity is less than 0.03; so it is among the lowest for 12 Be–X-ray binaries whose orbits have now been well measured. This confirms the suspicion that small kick velocities of neutron stars in high-mass X-ray binaries are more common for these systems than is generally expected for neutron stars [28, 123]. There is only a lower limit for its distance. The optical component is unknown, and so in't Zand *et al.* [28] were able only to put limits $V = 21$ for 10 kpc and $V = 23$ for 26 kpc. The spectral class determination given by Ziolkowski [4] is, probably, a misprint (see also [124]). The pulse fraction (RXTE data) slightly depends on energy (from 2 to 20 keV).

1553-542 (2S 1553-542, 2S 1553-54, H 1553-542). The X-ray source 2S 1553-542 was discovered during observations with SAS-3 in 1975 [29]. The pulse fraction was determined by SAS-3 (2–11 keV).

1555-552 (1H 1555-552, LS 3417, RX J155422.2-551945, 2E 1550.3-5510, 1E 1550.4-5510). This was detected by HEAO-1 [98].

J170006-4157 (AX J170006-4157, AX J1700-419, AX J1700.1-4157). This source was discovered and observed three times between 1994 and 1997 by ASCA [30]. Significant pulsations with $P = 714.5 \pm 0.3$ s were discovered from the third observation. The X-ray spectrum is described by a flat power-law function with a photon index of 0.7. Although the spectrum could also be fitted by thermal models, the obtained temperature was unphysically high. The hard spectrum suggests that the source is a neutron star binary pulsar similar to X Pers (4U $0352 + 309$), but the possibility that it is a white dwarf binary cannot be completely excluded. It was not indicated as a Be candidate in [3]. A pulse fraction in the range 0.7–10 keV was determined from the graph in [30].

J1739-302 (XTE J1739-302, AX J1739.1-3020). This source was discovered during observations of the black-hole candidate 1E 1740.7-2942 with the proportional counter array of RXTE [31]. The luminosity was estimated for a 2–100 keV range with the assumption that the source is at the Galactic centre. Smith *et al.* [31] tentatively identified XTE J1739-302 as a Be–neutron star binary because its spectral shape is similar to that of those systems: a gradual steepening over the 2–25 keV range.

J1739.4-2942 (RX J1739.4-2942). This was discovered by ROSAT [125] and is probably identical with GRS 1736-297.

J1744.7-2713 (RX J1744.7-2713, GRO J1744-28, HD 161103, V3892 Sgr, LS 4356). This was discovered by ROSAT [32]. The luminosity was estimated for the energy range 0.1–2.4 keV. The pulse fraction was taken from the paper by Harmon *et al.* [10]. It has been obtained by BATSE in the range 20–40 keV.

J1749.2-2725 (AX J1749.2-2725). This was discovered by ASCA [33]. It was not indicated as a Be candidate in [3].

J1750-27 (GRO J1750-27, AX J1749.1-2639). GRO J1750-27 is the third of the transient accretion-powered pulsars discovered using BATSE. A single outburst from GRO J1750-27 was observed with BATSE [126]. Pulsations with a 4.45 s period were discovered on 29 July 1995 from the Galactic centre region as part of the BATSE all-sky pulsar monitoring programme [64]. An orbit with a period of 29.8 days was found by Scott *et al.* [126]. A large spin-up rate, spin period and orbital period together suggest that accretion is occurring from a disc and that the outburst is a 'giant' type typical of a Be–X-ray transient system.

J1820.5-1434 (AX J1820.5-1434). This X-ray source was discovered in 1997 by ASCA [36]. Pulsations with a period of about 152 s were detected in the 2–10 keV flux of the source with a pulsed fraction of about 33%. The pulse fraction is not strongly energy dependent. Both the timing and the spectral properties of AX J1820.5-1434 are typical for an accretion-driven X-ray pulsar. Israel *et al.* [34] proposed the O9.5–B0Ve star as an optical counterpart of the pulsar.

1843+00 (GS 1843+00). The transient X-ray source GS 1843+00 was discovered during the Galactic plane scan near the Scutum region by X-ray detectors on board the Ginga satellite [127]. Coherent pulsations with a period of about 29.5 s were observed with a very small peak-to-peak amplitude of only 4% of the average flux. The pulse fraction was obtained by BATSE (20–50 keV). Luminosity estimates are as follows: 2×10^{36} erg s^{-1} (20–200 keV; 10 kpc) [128]; 3×10^{37} erg s^{-1} (0.3–100 keV; 10 kpc) [38].

1845-024 (2S 1845-024, GS 1843-02, 4U 1850-03, 1A 1845-02, 1H 1845-024, 3A 1845-024, GRO J1849-03). The pulsar GS 1843-02 was discovered by Ginga in 1988 [129] during a galactic plane scan conducted as part of a search for transient pulsars [130]. The same source is known as GRO J1849-03. X-ray outbursts occur regularly every 242 days. Finger *et al.* [130] presented a pulse timing analysis that shows that the 2S 1845-024 outbursts occur near the periastron passage. The orbit is highly eccentric ($e = 0.88 \pm 0.01$) with a period of 242.18 ± 0.01 days. The orbit and transient outburst pattern strongly suggest that the pulsar is in a binary system with a Be star. From the measured spin-up rates and inferred luminosities, Finger *et al.* [130] concluded that an accretion disc is present during outbursts.

J1858+034 (XTE J1858+034). The hard X-ray transient XTE J1858+034 was discovered with the RXTE all-sky monitor in 1998 [131]. The spectrum was found to be hard, similar to the spectra of X-ray pulsars. Observations were made immediately after this with the proportional counter array of RXTE and regular pulsations with a period of 221.0 ± 0.5 s were discovered [39]. The pulse profile is found to be nearly sinusoidal with a pulse fraction of about 25%. From the transient nature of this source and pulsations they suggested that this is a Be–X-ray binary. The position of the X-ray source was refined by scanning the sky around the source with the proportional counter array [132]. From the RXTE target-of-opportunity public archival data of the observations of XTE J1858 + 034, made in 1998, Paul and Rao [133] have discovered the presence of low-frequency quasiperiodic oscillations. The pulse fraction was obtained by RXTE (2–10 keV).

1936+541 (1H 1936+541). This was detected by HEAO-1 [98].

J1946+274 (XTE J1946+274, GRO J1944+26, 3A 1942+274, SAX J1945.6+2721). The pulse fraction was obtained by the Indian X-ray Astronomy Experiment (IXAE) (2–18 keV). Coburn *et al.* [134] presented data on the cyclotron feature in the spectrum of XTE J1946+274 which corresponds to a field of about 3.9×10^{12} G. Wilson *et al.* [40] proposed a distance of 9.5 ± 2.9 kpc based on a correlation between measured spin-up rate and flux.

J1948+32 (GRO J1948+32, GRO J2014+34, KS 1947+300). This transient X-ray source was discovered in 1989 during the observations of the Cyg X-1 region by the TTM telescope aboard the Kvant module of the Mir space station [135]. The flux recorded from it was 70 ± 10 mCrab in the energy range 2–27 keV. In 1994 the BATSE monitor discovered the X-ray pulsar GRO J1948+32 with a period of 18.7 s in the same region [136]. Galloway *et al.* [137] presented results which can indicate a glitch in that system. Based on the behaviour of the pulsation period during the outburst of 2000–2001, they determined the parameters of the binary: the orbital period $P_{\mathrm{orb}} = 40.415 \pm 0.010$ days and the eccentricity $e = 0.033 \pm 0.013$. The optical counterpart is a B0Ve star. Tsygankov and Lutovinov [42] estimated the magnetic field strength of the pulsar as about 2.5×10^{13} G, and the distance to the binary as $d = 9.5 \pm 1.1$ kpc. The pulse fraction depends on the source's intensity, the orbital phase and the energy range [42].

2030+375 (EXO 2030+375, V2246 Cyg). EXO 2030+375 was discovered in May 1985 with the EXOSAT satellite during a large outburst phase [138]. This outburst was first detected in a 1–20 keV energy band and its luminosity is close to the Eddington limit (assuming a 5 kpc distance to the source) for a neutron star [139]. The X-ray emission of the transient pulsar EXO 2030+375 is modulated by pulsations of about 42 s and periodic type I outbursts of about 46 days, which are produced at each periastron passage of the neutron star, *i.e.* when the pulsar interacts with the disc of the Be star. Wilson *et al.* [140] presented the results of observations of the transition to global spin-up in this source somewhen between June 2002 and September 2003. The source is not indicated as a Be candidate in [3]. The pulse fraction was obtained by BATSE in the range 30–70 keV [10]. See a detailed description in [141].

J2030.5+4751 (RX J2030.5+4751, SAO 49725). This was discovered by ROSAT [32]. This object is indicated as a likely Be–X-ray candidate in [3], but not in many other papers.

The pointing data show that the X-ray source is relatively hard. The L_x/L_{bol} ratio is close to 3×10^{-6}. This is rather strong evidence in favour of an accreting compact object around SAO 49725 [32].

J2058+42 (GRO J2058+42, CXOU J205847.5+414637?). GRO J2058+42 is a transient 198 s X-ray pulsar. It was discovered by BATSE during a 'giant' outburst in 1995 [142]. The pulse period decreased from 198 to 196 s during the 46 day outburst. BATSE observed five weak outbursts from GRO J2058+42 that were spaced by about 110 days. The RXTE all-sky monitor detected eight weak outbursts with approximately equal durations and intensities. GRO J2058+42 is most likely a Be–X-ray binary that appears to produce outbursts at the periastron and apastron. No optical counterpart has been identified to date (see, however, [143]), and no X-ray source was present in the error circle in archival ROSAT observations [142]. Wilson *et al.* [44] have suggested that GRO J2058+42 and CXOU J205847.5+414637 are the same source. The pulse fraction was obtained by BATSE in the range 20–70 keV (see [10] for details).

J2103.5+4545 (SAX J2103.5+4545). SAX J2103.5+4545 is a transient high-mass X-ray binary pulsar with a pulse period of about 358 s discovered with the wide-field camera onboard BeppoSAX during an outburst in 1997 [144]. Its orbital period of 12.68 days has been found with RXTE during the 1999 outburst [145]. The likely optical counterpart, a Be star with a magnitude $V = 14.2$, has been recently discovered [146]. During the outburst in 1999, Baykal *et al.* [147] for the first time observed with RXTE a transition from the spin-up phase to the spin-down regime, while the X-ray flux was declining. Inam *et al.* [148] observed a soft spectral component (black body with a temperature of 1.9 keV) and a transient 22.7 s quasiperiodic oscillation during a XMM-Newton observation performed in 2003. The pulsed fraction increases with increasing energy from about 45% at 5–40 keV to about 80% at 40–80 keV [46].

2138+568 (GS 2138-56, Cep X-4, V490 Cep, 1H 2138+579, 4U 2135+57, 3A 2129+571). The X-ray source Cep X-4 was discovered with a transient high-level X-ray flux in 1972 by OSO-7 [149]. The source was not detected again until 1998 when a new outburst was detected by Ginga. During these observations, coherent 66 s pulsations were discovered, revealing an X-ray pulsar with a complex X-ray spectrum including a possible 30 keV cyclotron absorption feature [150, 151]. Cep X-4 has been associated with a Be star that lies within the ROSAT error box. A cyclotron line was detected by Mihara *et al.* [151]; it corresponds to the magnetic field $B = 2.3 \times 10^{12}\ (1 + z)$ G. The pulse fraction strongly depends on energy and is highly variable with time from nearly 0% up to more than 80% [47]. The RXTE pulse fraction decreases with increasing intensity.

2206+543 (3U 2208+54, 4U 2206+54, 1H 2205+538, 1A 2204+54, 3A 2206+543). The hard X-ray source 4U 2206+54 was first detected by the Uhuru satellite [57]. The source is included in the Ariel V catalogue as 3A 2206+543 [152]. 4U 2206+54 has been detected by all satellites that have pointed at it and has never been observed to undergo an outburst. Steiner *et al.* [153] used the refined position from the HEAO-1 scanning modulation Collimator to identify the optical counterpart with the early-type star BD $+53^\circ$ 2790. From their photometry, they estimated that the counterpart was a B02e main sequence star and therefore concluded that the system was a Be–X-ray binary. Corbet *et al.* [154] have announced the detection of a periodicity of 9.570 ± 0.004 days in the X-ray light curve. If this is the binary period, then it would be the shortest known for a Be–X-ray binary, apart from the periodicity of about 1.4 days in the optical light curve of RX J0050.7-7316 [155]. Optical and ultraviolet spectroscopy of the optical component BD $+53°$ 2790 show it to be a very peculiar object, displaying emission in the H I, He I and He II lines and variability in the intensity of many lines of metals [156]. Strong wind troughs in the ultraviolet resonance lines suggest a large mass loss rate. These properties might indicate that the star displays at the same time Of and Oe phenomena or even hint at the possibility that it could be a spectroscopic binary consisting of two massive stars in addition to the compact object [156]. Certainly there is an O9.5V star in the system which is probably a mild Of star, and which probably feeds the compact object with its stellar wind [156]. See also the recent data and discussion by Corbet and Peele [157]. These workers confirmed the orbital period of about 9.6 days. This value is surprisingly short if one takes into account the long spin period of the neutron star (see figure 2 later, where this system is definitely displaced from the normal trend). The spin period was not detected in many observations. Corbet and Peele [157] discussed several possibilities other than the Be–X-ray interpretation including an accreting white dwarf. Nearly perfect alignment between magnetic and spin axis is also a possibility. The high-energy spectra show clear indications of the presence of an absorption feature at 32 keV. This feature gives strong support for the existence of a cyclotron resonance scattering feature, which implies a magnetic field of 3.6×10^{12} G [158]. A tentative detection of a cyclotron resonance feature in absorption was also presented earlier by Masetti *et al.* [159].

2214+589 (1H 2214+589) This was detected by HEAO-1 [98]. This object is mentioned in [3] as a Be candidate. However, it is not mentioned in many lists of Be–X-ray systems (for example in [4]). Not much is known about this source.

J2239.3+6116 (3A 2237+608, SAX J2239.3+6116, SAX J2239.2+6116, 3U 2233+59, 4U 2238+60). This was discovered by BeppoSAX [48]. SAX J2239.3+6116 is an X-ray transient which often recurs with a periodicity of 262 days [160]. Because of the Be-star nature of the likely optical counterpart the periodicity may be identified with the orbital period of the binary. The pulse fraction was determined from the graph in [48] as $(I_{\max} - I_{\min})/(I_{\max} + I_{\min})$. It corresponds to the approximate energy range 1–10 keV. $L_{\max}$ corresponds to the distance 4.4 kpc and the highest flux 10^{-9} erg cm^{-2}s^{-1} in the energy range 2–28 keV [48].

2.2 *Sources in the Large Magellanic Cloud: comments to table 2*

J0501.6-7034 (RX J0501.6-7034, 2E 0501.8-7038, 1E 0501.8-7036, HV 2289, CAL 9). This Einstein Observatory and ROSAT variable source was identified with a Be star by Schmidtke *et al.* [165]. Later Schmidtke *et al.* [166] identified this star with HV 2289, a known variable with a large amplitude of variability.

J0502.9-6626 (RX J0502.9-6626, CAL E). The X-ray source RX J0502.9-6626 was originally detected by the Einstein Observatory [167] at a flux of about 3×10^{36} erg s^{-1}. The source was detected three times with the position-sensitive proportional counter of ROSAT at luminosities of about 10^{35}–10^{36} erg s^{-1} and once with the high-resolution images during a bright outburst at 4×10^{37} erg s^{-1} [168]. During the outburst, pulsations at 4.0635 s were detected.

Table 2. Be–X-ray binaries and candidates in the LMC.

Name	Spectral type	m_V	$P_{\rm spin}$ (s)	$P_{\rm orb}$ (days)	e	$L_{\max}$ (erg s^{-1})	Pulse fraction (%)
J0501.6-7034	B0Ve [161]	14.36 [161]				7×10^{34} [161]	
J0502.9-6626	B0Ve [161]	14.42 [161]	4.1 [161]			4×10^{37} [161]	
J0516.0-6916	B1V [161] Be [162]	15.0 [3]				5×10^{35} [3]	
J0520.5-6932	O9Ve [161]	14.4 [3]		24.4 [163]		8×10^{38} [163]	
J0529.8-6556	B0.5Ve [161]	14.81	69.5 [161]			2×10^{36} [161]	
053109-6609.2	B0.7Ve [161]		13.7 [161]	24.5 [161]		1×10^{37} [161]	54–78 [164]
J0531.5-6518	B2Ve [161]	16.02 [161]				3×10^{35} [161]	
J0535.0-6700	B0Ve [161]	14.87 [161]				3×10^{35} [161]	
0535-668	B0.5IIIe [161]	12.3–14.9 [3]	0.069 [3]	16.7 [3]	>0.5 [4]	1×10^{39} [161]	
0544-665	B0Ve [161]	15.55 [161]				1×10^{37} [161]	
0544.1-710	B0Ve [161]	15.25 [161]	96.08 [161]			2×10^{36} [161]	

The identification of this source with the Be star [W63b] 564 = EQ 050246.6-663032.4 [169] was confirmed by Schmidtke *et al.* [165].

J0516.0-6916 (RX J0516.0-6916). The identification of this source with a Be star is unclear. In several observations the source did not display any characteristics of Be behaviour; however, Schmidtke *et al.* [162] classify it as a Be star.

J0520.5-693 (RX J0520.5-6932). This X-ray source has been observed at a low X-ray luminosity (5×10^{34} erg s^{-1}) in the early 1990s by ROSAT [165]. The light curve of the optical counterpart exhibits significant modulation with a period of 24.4 days, which is interpreted as the orbital period [170]. A spectral type O9V was proposed for the optical counterpart. In a recent paper, Edge *et al.* [163] presented new optical and infrared data and archive BATSE data on the outburst.

J0529.8-6556 (RX J0529.8-6556, RX J0529.7-6556). The transient X-ray source RX J0529.8-6556 was detected during one single outburst as a 69.5 s X-ray pulsar by Haberl *et al.* [171], who identified it with a relatively bright blue star showing weak $H\alpha$ emission.

053109-6609.2 (EXO 053109-6609.2, RX J0531.2-6609, RX J0531.2-6607, EXO 0531.1-6609). This source was discovered by EXOSAT during deep observations of the LMC X-4 region in 1983 [172]. It was detected again in 1985 by the SL2 XRT experiment. The lack of detection in EXOSAT observations made between these dates demonstrates the transient nature of the source. The companion is optically identified with a Be star [173]. Burderi *et al.* [164] reported a timing analysis of the Be transient X-ray binary EXO 053109-6609.2 in an outburst observed with BeppoSAX. The pulsed fraction is nearly constant in the whole energy range. The source shows pulsations from 0.1 to 60 keV. In the medium-energy concentrator spectrometer pulse profile in the 1.8–10.5 keV band the pulsed fraction is 0.54 ± 0.05. In the low-energy concentrator spectrometer pulse profile (the 0.1–1.8 keV band), the main pulse is still evident, while the interpulse is more broadened, and the pulsed fraction is 0.78 ± 0.28. The Phoswich detection system pulse profile (the 15–60 keV energy band) still shows a double-peaked structure (the pulsed fraction is 0.64 ± 0.16) in phase with the previous structures.

Although the statistics are poor, the pulsed fraction does not seem to decrease with increasing energy [164].

J0531.5-6518 (RX J0531.5-6518). This source was detected with the position-sensitive proportional counter of ROSAT in June 1990 [174]. The source is probably variable, since other pointings failed to detect it. The optical counterpart is probably a Be star coming back from an extended disc-less phase [161].

J0535.0-6700 (RX J0535.0-6700). This source was observed by the position-sensitive proportional counter of ROSAT at a luminosity of about 3×10^{35} erg s^{-1} [174]. Its positional coincidence with an optically variable star in the LMC (RGC28 in [175]) is very good. RGC28 is an early-type Be star and probably it is the optical counterpart to RX J0535.0-6700 [161]. The star displays periodic variability in its I-band light curve at 241 days, which Reid *et al.* [175] originally believed to be the period of a Mira variable. Haberl and Pietsch [174] suggested that this variability can be related to the orbital period.

0535-668 (RX J0535.6-6651, 1A 0538-66, 1A 0535-66). This source was discovered by the Ariel V satellite in June 1977, during an outburst in which the flux peaked at about 9×10^{38} erg s^{-1} [176]. When active, 1A 0535-66 displays very bright short X-ray outbursts separated by 16.7 days, which is believed to be the orbital period. The optical counterpart experiences drastic changes in the spectrum, with the appearance of strong P-Cyg-like emission lines, and brightening by a magnitude of more than 2 in the V band [177]. The Be star has a V magnitude of about 14.9 during the X-ray quiescent periods. The magnitude reaches a peak of 12.3 magnitude during the X-ray outbursts. Detection of a 69 ms pulsation in the X-ray signal has been reported only once [178]. Further X-ray observations of outbursts were made by Skinner *et al.* [179] using the HEAO-1 satellite. The X-ray outbursts were found to last up to at least 14 days or to be as short as a few hours. 1A 0535-66 in its largest outbursts [179] has a luminosity of around 10^{39} erg s^{-1}. ROSAT [180] and ASCA [181] observations have revealed low-level outbursts with luminosities of 4×10^{37} erg s^{-1} and 2×10^{37} erg s^{-1} in the two ROSAT observations and about 5.5×10^{36} erg s^{-1} in the ASCA observation. Because of the low count rate and sampling frequency it was not possible to determine whether the 69 ms pulsations were present in the data. The ratio of $L_{\rm max}$ to $L_{\rm min}$ in soft X-rays is greater than 1000. Alcock *et al.* [182] reported the discovery of a periodicity of 421 days.

0544-665 (H 0544-665, H 0544-66). This source was discovered with the HEAO-1 scanning modulation collimator by Johnston *et al.* [183]. The brightest object within the X-ray error circle was found to be a variable B0–1V star [184] but no emission lines have been observed in its spectrum to identify it as a Be star. In [161] the star is classified as B0Ve, van der Klis *et al.* [184] published photometry which showed a negative correlation between optical magnitudes and colour indices, typical of Be stars whose variability is due to variations in the circumstellar disc. Stevens *et al.* [185] suggested that the object may be a Be star in a state of low activity. They detected $H\alpha$ and $H\beta$ in emission in February 1998.

J0544.1-710 (RX J0544.1-7100, AX J0544.1-7100, AX J0548-704, 1WGA J0544.1-7100, 1SAX J0544.1-7100). This source is a transient X-ray pulsar ($P = 96$ s) with the hardest X-ray spectrum observed by BeppoSAX [186] and by ROSAT in the LMC [174]. The observations of the optical counterpart were presented by Coe *et al.* [170], who found it to display large variability in the I-band light curve and $H\alpha$ in emission. An approximate spectral type of B0Ve was proposed.

2.3 *Sources in the Small Magellanic Cloud: comments on table 3*

J0032.9-7348 (RX J0032.9-7348). This source was discovered by Kahabka and Pietch [232] in ROSAT pointed observations made in December 1992 and April 1993. Stevens *et al.* [185] identified two Be stars within the position-sensitive proportional counter error circle of RX J0032.9-7348.

J0045.6-7313 (RX J0045.6-7313). This source was detected once in the 0.9–2.0 keV band of the position-sensitive proportional counter of ROSAT. An emission-line object in the error circle suggests a Be–X-ray binary [8].

J0047.3-7312 (RX J0047.3-7312, 2E 0045.6-7328, XMMU J004723.7-731226, SXP 264, AX J0047.3-7312?). Haberl and Sasaki [8] proposed RX J0047.3-7312 as a Be–X-ray binary candidate because this source exhibits a flux variation by a factor of 9 and has an emission-line object 172 in the well-known catalogue by Meyssonnie and Azzopardi [233] as a counterpart. A probable binary period of 48.8 ± 0.6 days has been detected in observations of the optical counterpart to this X-ray source [190]. The relationship between this orbital period and the pulse period of 263.6 s is within the normal variance found in the Corbet [234] diagram.

J0048.2-7309 (AX J0048.2-7309). AX J0048.2-7309 was detected in two ASCA observations and shows a hard spectrum and a flux variability by a factor of about 5 [192]. The emission-line object 215 in [233], was found in the error circle of AX J0048.2-7309. Data suggest that this source is a Be–X-ray binary.

J0048.5-7302 (RX J0048.5-7302, XMMU J004834.5-730230). The emission-line object 238 in [233] is the brightest optical object in the error circle of RX J0048.5-7302 [8]. A Be–X-ray binary interpretation has been suggested by Haberl and Sasaki [8].

J0049-729 (AX J0049-729, AX J0049-728, RX J0049.0-7250, RX J0049.1-7250, XTE J0049-729). This source was discovered with ROSAT [232] in pointed observations. Yokogawa and Koyama [192] reported X-ray pulsations in ASCA data of this source. The X-ray flux in the band 0.7–10 keV was 1.2×10^{-11} erg cm^{-2} s^{-1}, with sinusoidal pulse modulation. Kahabka and Pietch [235] suggested the highly variable source RX J0049.1-7250 as a counterpart. Stevens *et al.* [185] identified two Be stars, one only 3″ from the X-ray position and one just outside the error circle given by Kahabka and Pietch [232]. Yokogawa *et al.* [194] reported the results of two ASCA observations of this X-ray source. The pulse fraction was about 70% independent of the X-ray energy. Using MACHO and OGLE-II data, Schmidtke and Cowley [193] found a strong periodicity at $P = 33.3$ days, which is probably the orbital period, in good agreement with the relation between orbital and pulse periods first recognized by Corbet [234].

J0049.2-7311 (RX J0049.2-7311, XMMU J004913.8-731136). The position of the $H\alpha$ bright object coincides with this X-ray source. Coe *et al.* [187] proposed this object as a more

Table 3. Be–X-ray binaries and candidates in the SMC.

Name	Spectral type	m_V	P_{spin} (s)	P_{orb} (days)	L_{max} (erg s^{-1})	Pulse fraction (%)
J0032.9-7348	Be				1.3×10^{37} [8]	
J0045.6-7313	Be?				1.2×10^{35} [8]	
J0047.3-7312	Be?	15.85 [187]	263.6 [188]	48.8 [189]	1.8×10^{36} [188]	47 [190]
J0048.2-7309	Be?				5.2×10^{35} [191]	
J0048.5-7302	Be?				3.0×10^{35} [188]	
J0049-729	Be	16.92 [8]	74.67 [192]	33.3 [193]	7.5×10^{36} [194]	70 [194]
J0049.2-7311	Be?				2.0×10^{35} [188]	
J0049-732	Be?	16.51 [187]	9.1320 [195]	91.5 [196]	4.1×10^{35} [195]	
J0049.5-7331	Be?				5.1×10^{35} [191]	
J0049.7-7323	Be	15.22 [187]	755.5 [197]	394 [187]	7.7×10^{35} [188]	
J0050.7-7316 (DZ Tuc)	B0–0.5Ve [198]	15.4 [198]	323.1 [199]		1.8×10^{36} [8]	41 [200]
J0050.7-7332	Be?				2.4×10^{34} [8]	
J0050.9-7310	Be?				4.5×10^{35} [188]	
J0051-722	Be	15.06 [187]	91.12 [8]	88.4 [187]	2.9×10^{37} [8]	
J0051.3-7250	Be?				3.6×10^{34} [188]	
J0051-727			293 [201]		1.7×10^{37} [201]	
J0050-732 #1			16.6 [202]	189 [204]	3.7×10^{36} [202]	
J0050-732 #2			25.5 [202]		3.0×10^{36} [202]	
J0051.8-7310	Be	14.45 [187]	172.4 [203]	147 [204]	5.6×10^{36} [204]	
J0051.8-7231	Be	14.87 [187]	8.9 [188]	185 [187]	1.4×10^{36} [8]	25 [205]
WW 26	Be?				6.0×10^{34} [8]	
0050-727 (SMC X-3)	O9V–IIIe [3]	14.91 [187]	7.78 [200]	44.6 [187]	6×10^{37} [206]	27 [200]
J0052.1-7319	O9.5IIIe [207]	14.6 [207]	15.3 [8]		1.3×10^{37} [8]	
J0052-725	Be?	15.02 [187]	82.46 [200]		3.4×10^{36} [196]	28–42 [200]
J0052-723	B0V–B1Ve [208]	15.8 [208]	4.78 [188]		7.2×10^{37} [208]	
0051.1-7304	Be	14.28 [8]			1.6×10^{35} [8]	
J0052.9-7158	Be	15.53 [187]	167.8 [209]		2.0×10^{37} [8]	44 [209]
J005323.8-722715	Be?	16.19 [187]	138.04 [200]	125 [200]	1.18×10^{35} [200]	59 [200]
XTE SMC 95			95 [210]		2×10^{37} [210]	
J0055-727	Be?		18.4 [211]	34.8 [212]	2.6×10^{37} [211]	
J0053.8-7226	Be	14.72 [187]	46.63 [188]	139 [213]	7.4×10^{36} [8]	25 [213]
0053-739 (SMC X-2)	B1.5Ve [214]	16.64 [187]	2.37 [188]		4.7×10^{38} [204]	
J0054.5-7228	Be?				1.5×10^{36} [8]	
J0054.8-7244	Be?	14.99 [187]	503.5 [200]	268 [215]	5.5×10^{35} [200]	63 [200]

(*continued*)

Table 3. Continued.

Name	Spectral type	m_V	P_{spin} (s)	P_{orb} (days)	L_{max} (erg s^{-1})	Pulse fraction (%)
J0054.9-7226	B0–1III–Ve [3]	15.28 [8]	59 [220]	65 [216]	4.3×10^{37} [204]	
J005517.9-723853	Be?	16.01 [187]	701.7 [217]		4×10^{35} [217]	
J0055.4-7210	Be?	16.78 [187]	34.08 [200]		1.1×10^{35} [200]	57 [200]
0054.4-7237	Be?	16.51 [187]	140.1 [188]		4.0×10^{34} [8]	
J0057.4-7325	Be?		101.45 [218]		1.2×10^{36} [219]	
J005736.2-721934	Be?	15.97 [187]	562 [213]	95.3 [187]	1.2×10^{36} [219]	73 [200]
J0057.8-7202	Be?	15.65 [187]	281.1 [220]		1.6×10^{36} [8]	
J0057.8-7207	Be?		152.3 [188]		4.3×10^{35} [8]	
J0057.9-7156	Be?				5.7×10^{34} [8]	
J0058.2-7231	B2–3Ve [221]	14.90 [221]		59.72 [222]	2.1×10^{35} [8]	
J0059.2-7138	B0III–Ve [204]	14.08 [8]	2.763 [8]		5.0×10^{37} [8]	37 [223]
J0059.3-7223	Be?	14.83 [187]	202 [187]		3.2×10^{35} [191]	
J010030.2-722035	Be?				2.6×10^{34} [220]	
J0101.0-7206	Be	15.72 [187]	304.49 [224]		1.3×10^{36} [8]	
J0101.3-7211	Be	15.49 [187]	455 [188]		7.3×10^{35} [15]	
J0101.6-7204	Be?				3.8×10^{35} [8]	
J0101.8-7223	Be?				2.2×10^{35} [8]	
J0103-728			6.85 [188]		3.8×10^{37} [225]	
J0103-722	O9–B1III–Ve [3]	14.80 [8]	345.2 [8]		1.5×10^{36} [8]	
J0103.6-7201	O5Ve [226]	14.6 [226]	1323 [226]		6.4×10^{36} [226]	
J0104.1-7244	Be?				3.8×10^{34} [8]	
J0104.5-7221	Be?				4.8×10^{34} [8]	
J0105-722	Be?	15.63 [187]	3.343 [8]		1.5×10^{35} [8]	
J0105.9-7203	Be?				6.5×10^{34} [8]	
J0106.2-7205	B2–5III–Ve [3]	16.7 [3]			5×10^{34} [227]	
J0107.1-7235	Be?				2.3×10^{34} [8]	
0107-750	Be	17 [3]			4.3×10^{35} [191]	
J0111.2-7317	B0.5–B1Ve [20]	15.52 [187]	31.03 [8]		2.0×10^{38} [8]	45 [207]
J0117.6-7330	B0.5IIIe [228]	14.18 [187]	22.07 [8]		1.2×10^{38} [8]	11.3–78 [229]
J0119.6-7330	Be?				1.5×10^{34} [8]	
J0119-731	Be?		2.165 [188]		6.3×10^{36} [230]	
SXP46.4			46.4 [188]			
SXP89.0			89 [188]			
XTE SMC144s			144.1 [188]	61.2 [231]		
SXP165			164.7 [188]			

likely counterpart to the ASCA SXP9.13 pulsar. However, other researchers have proposed RX J0049.4-7310 as the correct identification for SXP9.13 pulsar [196, 236].

J0049-732 (AX J0049-732, RX J0049.4-7310). This source was discovered as an X-ray pulsar by Imanishi *et al.* [237] with ASCA. The X-ray flux at 2–10 keV was about 8×10^{-13} erg cm^{-2} s^{-1}. A more likely scenario for AX J0049-732 is either a Be–X-ray binary or an anomalous X-ray pulsar. Direct information to distinguish between these two possibilities can be obtained by measuring the pulse period derivative and its orbital modulation. Two sources 427 and 430 in the ROSAT position-sensitive proportional counter catalogue of [238] are possible counterparts of AX J0049-732. Filipović *et al.* [239] searched for optical counterparts of these ROSAT sources and found an emission-line object, possibly a Be star, at the position of source 427 but found no counterpart for source 430. Hence, they suggest that source 427 is more likely to be a counterpart of AX J0049-732. However, the angular separation of these sources of $1.43'$ is significantly larger than the ASCA error radius, and Ueno *et al.* [195] proposed that source 430 is a more likely counterpart. Schmidtke *et al.* [196] found an orbital period of 91.5 days for RX J0049.4-7310 in the MACHO data.

J0049.5-7331 (RX J0049.5-7331, AX J0049.5-7330). This source can most probably identified as the emission-line object 302 in [233], according to Haberl and Sasaki [8].

J0049.7-7323 (AX J0049.4-7323, AX J0049.5-7323, RX J0049.7-7323). This X-ray source has been detected five times to date, three times by the ASCA observatory [240] and twice by the RXTE spacecraft [204]. Ueno *et al.* [197] reported an ASCA observation which revealed coherent pulsations of period 755.5 ± 0.6 s from a new source in the SMC. The spectrum was characterized by a flat power-law function with a photon index of 0.7 and an X-ray flux of 1.1×10^{-12} erg cm^{-2} s^{-1} (0.7–10 keV). They noted that the possible Be–X-ray binary RX J0049.7-7323 [8] was located within the ASCA error region. Edge and Coe [221] reported the spectroscopic and photometric analysis of possible optical counterparts to AX J0049.4-7323. They detected strong $H\alpha$ emission from the optical source identified with RX J0049.7-7323 within error circle for AX J0049.4-7323 and concluded that these are one and the same object. They noted that the profile of the curve exhibits a distinct double peak. This is consistent with Doppler effects which would be expected from a circumstellar disc viewed in the plane of rotation. There is also definite V/R asymmetry between the peaks. It is a compelling evidence for the presence of a Be star. Cowley and Schmidtke [241] analysed the long-term light curve of the optical counterpart obtained from the MACHO database. They showed that the optical object exhibited outbursts every 394 days, which they proposed to be the orbital period of the system. They also showed the presence of a quasiperiodic modulation with a period of about 11 days, which they associated with the rotation of the Be star disc. The phase of two RXTE detections is exactly synchronized with the ephemeris derived from the optical outbursts. Therefore, as Coe and Edge [242] concluded, the period of 394 days can represent the binary period of a system with X-ray outbursts synchronized with the periastron passage of the neutron star.

J0050.7-7316 (DZ Tuc, AX J0051-732, RX J0050.6-7315, RX J0050.7-7316, AX J0051-733, RX J0050.8-7316). This X-ray source was detected in archival data from the imaging proportional counter of the Einstein Observatory and from the position-sensitive proportional counter and high-resolution images of ROSAT; the 18 year history shows flux variations by a factor of at least 10 [199]. The source was reported as a 323 s pulsar by Yokogawa and Koyama [243] and Imanishi *et al.* [199]. Subsequently Cook [244] identified a 0.7 day optically variable object within the ASCA X-ray error circle. Long-term optical data from over 7 years revealed both a modulation of 1.4 days and an unusually rapid change in this possible binary period [198]. The system was discussed in the context of being a normal high-mass X-ray binary by Coe and Orosz [155] who presented some early OGLE data on the object identified by Cook [244] and modelled the system parameters. Coe and Orosz [155] identified several problems with understanding this system, primarily that, if it was a binary, then its true period would be 1.4 days and it would be an extremely compact system. In addition, the combination of the pulse period and such a binary period violates the Corbet [101] relationship for such systems. Raguzova and Lipunov [245] calculated the critical orbital period for the existence of a Be–X-ray pulsar binary, which is about 10–20 days. They proposed an explanation for the lack of Be stars with an accreting neutron star as companion with orbital periods less than 10 days as caused by the synchronization of the Be star during its evolution. Coe *et al.* [198] reported extensive new data sets from both OGLE and MACHO, as well as a detailed photometric study of the field. Their results reveal many complex observational features that are difficult to explain in the traditional Be–X-ray binary model.

J0050.7-7332 (RX J0050.7-7332). This source was only detected once by the position-sensitive proportional counter of ROSAT. The emission-line object in the error circle suggests a Be–X-ray binary identification [8].

J0050.9-7310 (RX J0050.9-7310, RX J0050.8-7310, XMMU J005057.6-731007). This source can most probably be identified as the emission-line object 414 in [233], suggesting a Be–X-ray binary [8].

J0051-722 (AX J0051-722, RX J0051.3-7216). This source was first detected as a 91.12 s pulsar in RXTE observations [246], although it was initially confused with the nearby 46 s pulsar 1WGA J0053.8-7226 [247]. Stevens *et al.* [185] estimated the magnitude of the optical component (Be star) as $V \sim 15$ from digitized sky survey images. The spacing of flares observed from AX J0051-722 suggests an orbital period of about 120 days [248]. Schmidtke *et al.* [196] found an optical period of 88.25 days using MACHO data.

J0051.3-7250 (RX J0051.3-7250). Two close emission-line objects are found near this source, suggesting that RX J0051.3-7250 is a Be–X-ray binary.

J0051-727 (XTE J0051-727). Corbet *et al.* [201] have detected this new transient X-ray pulsar in the direction of the SMC with the RXTE proportional counter array. The object showed a 1.6–01.7 mCrab flux in the 2–10 keV band.

J0050-732#1 (XTE J0050-732#1). This source was discovered by Lamb *et al.* [202] from archival data of RXTE.

J0050-732#2 (XTE J0050-732#2). This source was discovered by Lamb *et al.* [202] from archival data of RXTE.

J0051.8-7310 (2E 0050.2-7326, RX J0051.8-7310, AX J0051.6-7311, RX J0051.9-7311, XMMU J005152.2-731033). This X-ray source was detected by Cowley *et al.* [249] during ROSAT high-resolution imager observations of Einstein Observatory imaging proportional counter source 25 and identified as a Be star by Schmidtke *et al.* [162].

J0051.8-7231 (2E 0050.1-7247, RX J0051.8-7231, 1E 0050.1-7247, 1WGA J0051.8-7231). 2E 0050.1-7247 was discovered in Einstein Observatory observations. The X-ray luminosity, time variability and hard spectrum led Kahabka and Pietch [232] to suggest a Be–X-ray binary nature for the source. Israel *et al.* [205] discovered 8.9 s X-ray pulsations in 2E 0050.1-7247 during a systematic search for periodic signals in a sample of ROSAT position-sensitive proportional counter light curves. The signal had a nearly sinusoidal shape with a 25% pulsed fraction. The source was detected several times between 1979 and 1993 at luminosity levels ranging from 5×10^{34} to 1.4×10^{36} erg s^{-1} with both the imaging proportional counter of the Einstein Observatory and the position-sensitive proportional counter of ROSAT. The X-ray energy spectrum is consistent with a power-law spectrum that steepens as the source luminosity decreases. Israel *et al.* [250] revealed a pronounced $H\alpha$ activity from at least two B stars in the X-ray error circles. These results strongly suggest that the X-ray pulsar 2E 0050.1-7247 is in a Be-type massive binary. Coe *et al.* [187] have proposed an orbital period of 185 ± 4 days from the red-light data.

WW 26 (WW 26). Haberl and Sasaki [8] suggested a Be–X-ray binary nature for this object. They found two emission-line objects 521 and 487 from [233] near this source.

0050-727 (SMC X-3, H 0050-727, 2S 0050-727, 3A 0049-726, 1H 0054-729, H 0048-731, 1XRS 00503-727). SMC X-3 was detected by Li *et al.* [206] with SAS-3. This long-known X-ray source was not detected by the position-sensitive proportional counter of ROSAT, but it is included in the high-resolution imager catalogue. SMC X-3 has been identified with a previously detected 7.78 s RXTE pulsar by using the Chandra data archive [200]. The Be star counterpart corresponds to object 531 in [233].

J0052.1-7319 (1E 0050.3-7335, 2E 0050.4-7335, RX J0052.1-7319). The X-ray transient RX J0052.1-7319 was discovered by Lamb *et al.* [251] from the analysis of ROSAT high-resolution images and BATSE data. The object showed a period of 15.3 s [252, 253] and a flux in the 0.1–2 keV band of 2.6×10^{-11} erg cm^{-2} s^{-1}. Covino *et al.* [207] reported the discovery and confirmation of the optical counterpart of this transient X-ray pulsar. They found a $V = 14.6$ O9.5IIIe star (a classification as a B0Ve star is also possible since the luminosity class depends on the uncertainty in the adopted reddening).

J0052-725 (XTE J0052-725). This X-ray pulsar was originally detected by RXTE in 2002 [254]. Timing analysis revealed a period of 82.46 ± 0.18 s at a confidence level of more than 99%. The lower energy band (0.3–2.5 keV) contained about 60% of the photons but had a pulsed fraction of only 28 ± 2% compared with 42 ± 3% in the higher energy band (2.5–10 keV) [200]. This source has been identified as the optical counterpart MACS J0052-726#004 [255].

J0052-723 (XTE J0052-723). Corbet *et al.* [256] discovered this transient X-ray pulsar in the direction of the SMC from RXTE proportional counter array observations made on 27 December 2000 and 5 January 2001. Pulsations were seen with a period of 4.782 ± 0.001 s and with a double-peaked pulse profile. Spectroscopy of selected optical candidates [208] has identified the probable counterpart, which is a B0V–B1Ve SMC member exhibiting a strong double-peaked $H\alpha$ emission line.

0051.1-7304 (2E 0051.1-7304, AzV 138). This source is listed as entry 31 in the Einstein Observatory imaging proportional counter catalogue [257]. The Be star AzV 138 [258] was proposed as an optical counterpart for 2E 0051.1-7304. 2E 0051.1-7304 was not detected in ROSAT observations.

J0052.9-7158 (2E 0051.1-7214, RX J0052.9-7158, XTE J0054-720, AX J0052.9-7157). This source was detected as an X-ray transient by Cowley *et al.* [249] during ROSAT high-resolution imager observations of Einstein Observatory imaging proportional counter source 32. The strong variability and the hard X-ray spectrum imply a Be–X-ray transient consistent with the suggested Be star counterpart [162]. The X-ray source was detected by ROSAT and is located near the edge of the error circle of XTE J0054-720. The transient pulsar XTE J0054-720 with a spin period of about 169 s was discovered with RXTE [191, 259], which detected coherent pulsations with a 167.8 s period from AX J0052.9-7157 and determined its position accurately. They found that AX J0052.9-7157 is located within the error circle of XTE J0054-720 and has a variable Be–X-ray binary, RX J0052.9-7158, as a counterpart. From the nearly equal pulse period and the positional coincidence, they concluded that the ASCA, ROSAT and RXTE sources are identical. The pulsed fraction, defined as pulsed flux divided by total flux without a background, is 44% at 2.0–7.0 keV [209].

J005323.8-722715 (CXOU J005323.8-722715, RX J0053.5-7227). A precise ROSAT high-resolution imager position coincident with the emission-line star 667 in [233] (it is the brightest object in the error circle) makes RX J0053.4-7227 a likely Be–X-ray binary [8]. The position of this pulsar is coincident also with MACHO object 207.16202.50. The latter shows evidence of a period of 125 ± 1.5 days. This period would be consistent with that predicted from the Corbet [101] diagram for a 138 s Be–X-ray pulsar.

XTE SMC 95. The source has been revealed during RXTE observations of the SMC. The pulsar was detected in three proportional counter array observations during an outburst [210]. The source is proposed to be a Be–neutron star system on the basis of its pulsations, transient nature and characteristically hard X-ray spectrum. The 2–10 keV X-ray luminosity implied by observations is greater than 2×10^{37} erg s^{-1}.

J0055-727 (XTE J0055-727). This source was detected with the proportional counter array of RXTE [211]. Regular monitoring of the SMC with the RXTE proportional counter array has revealed a periodicity of 34.8 days in the pulsed flux from this X-ray pulsar [212]. The regular nature of outbursts strongly suggests that they show the orbital period of this system. The combination of pulse and orbital periods is consistent with the fact that XTE J0055-727 is a Be-star system. Corbet *et al.* [211] noted the presence of the emission-line objects AzV164 and 829 in [233] close to the centre of the error box of this source.

J0053.8-7226 (RX J0053.9-7226, 1WGA J0053.9-7226, 1E 0052.1-7242, 2E 0052.1-7242, RX J0053.8-7226, 1WGA J0053.8-7226, XTE J0053-724). This object was serendipitously discovered as an X-ray source in the SMC in the ROSAT position-sensitive proportional counter archive and also was observed by the imaging proportional counter of the Einstein Observatory. Its X-ray properties, namely the hard X-ray spectrum, flux variability and column density, indicate a hard transient source with a luminosity of 3.8×10^{35} erg s^{-1} [260]. XTE and ASCA observations have confirmed the source to be an X-ray pulsar, with a 46 s spin period. Optical observations [260] revealed two possible counterparts to this source. Both exhibit strong $H\alpha$ and weaker $H\beta$ emission. Optical colours indicate that both objects are Be stars. The transient X-ray system XTE J0053-724 was also detected in one observation by RXTE. Pulsations of 46.6 ± 0.1 s were observed with a pulse fraction of about 25% [213]. Lochner [213] suggested a possible orbital period for this Be–X-ray system of about 139 days, which is determined from the periodicity of X-ray outbursts.

0053-739 (SMC X-2, 3A 0042-738, H 0052-739, 2S 0052-739, H 0053-739, RX J0054.5-7340). SMC X-2 was one of the first three X-ray sources which were discovered in the SMC [261]. It was also detected in the HEAO-1 A-2 experiment [262], but not in the Einstein imaging proportional counter survey [263]. In ROSAT observations this transient source was detected only once [232]. It is thought to be a Be–X-ray binary, since a Be star was found as its optical counterpart [214]. In early 2000, the RXTE all-sky monitor detected an outburst at the position of SMC X-2 [264] and a pulse period of 2.374 ± 0.007 s was determined [219, 265]. The source was in the low-luminosity state during the XMM-Newton observation [220]. In order to estimate the upper limit of the flux [220], Yokogawa *et al.* [266] used spectral parameters from the ASCA spectrum during the outburst. They obtained an upper limit for the unabsorbed flux of 1.5×10^{-14} erg cm^{-2} s^{-1}, corresponding to $L_{\mathrm{x}} = 6.5 \times 10^{33}$ erg s^{-1} (0.3–10.0 keV).

J0054.5-7228 (RX J0054.5-7228). Haberl and Sasaki [8] have found six emission-line objects from [233] as possible counterparts to this X-ray source. It is therefore a likely Be–X-ray binary but the optical counterpart remains ambiguous.

J0054.8-7244 (AX J0054.8-7244, RX J0054.9-7245, XMMU J005455.4-724512, CXOU J005455.6-724510, SXP 504). The small ROSAT error box of this source contains an emission-line star (809 in [233]) with typical Be-star characteristics; it is the brightest object in the area of localization. An X-ray flux variability by a factor of 5 strengthens the identification as Be–X-ray binary. A probable binary period of 268 days has been detected in the optical counterpart [215]. The relationship between this orbital period and the pulse period of 504 s is within the normal variance found in the Corbet [234] diagram.

J0054.9-7226 (2E 0053.2-7242, RX J0054.9-7226, 1WGA J0054.9-7226, SAX J0054.9-7226, RX J0054.9-7227, XTE J0055-724). RX J0054.9-7226 is known to be an X-ray binary pulsar with a pulse period of 59 s [132, 267]. Lochner *et al.* [216] have suggested that the orbital period equals 65 days from subsequent X-ray outbursts. Laycock *et al.* [204] have obtained an orbital period about 123 days based on the timing analysis. In the timing analysis of the XMM-Newton data, the pulse period was verified to be 59.00 ± 0.02 s [220]. The optical counterpart, a Be star, is identified as the variable star OGLE J005456.17-722647.6 [268].

J005517.9-723853 (XMMU J005517.9-723853, SXP 701). This bright X-ray source was detected during XMM-Newton observation of the SMC region around XTE J0055-727 [217]. The optical brightness and colours are consistent with expectations for a Be-star companion, and the X-ray spectra are consistent with a Be–X-ray binary. Using MACHO and OGLE-II data, Schmidtke and Cowley [193] obtained data showing a possible long-term period of 413 days, but further analysis is needed to confirm it.

J0055.4-7210 (RX J0055.4-7210, 2E 0053.7-7227, CXOU J005527.9-721058, WW 36). Timing analysis on this object revealed a period of 34.08 ± 0.03 s with a confidence of 98.5% [200]. The position of this pulsar is within $3''$ of the ROSAT source 2RXP J005527.1-721100. The latter is coincident with a 16.8 V magnitude optical source having a $B-V$ colour index of -0.116 [269] which would be consistent with the value expected from the optical companion in a Be–X-ray binary.

0054.4-7237 (2E 0054.4-7237, XMMU J005605.2-722200, WW 38). The error circle of the Einstein Observatory source 2E 0054.4-7237 contains an emission line object. Therefore, it was suggested as a Be–X-ray binary candidate [220]. In the XMM-Newton data, a source consistent with the position of the emission line object was detected (XMMU J005605.2-722200) and pulsations from this source were discovered [220]. XMMU J005605.2-722200 is most probably consistent with 2E 0054.4-7237. The pulsar period is 140.1 ± 0.3 s.

J0057.4-7325 (AX J0057.4-7325, RX J0057.4-7325). Six ROSAT observations have covered the position of AX J0057.4-7325. Coherent pulsations with a barycentric period of 101.45 ± 0.07 s were discovered by Yokogawa *et al.* [218] with ASCA. The flux variability, the hard X-ray spectrum and the long pulse period are consistent with the hypothesis that AX J0057.4-7325 is an X-ray binary pulsar with a companion which is a Be, an OB supergiant or a low-mass star. Yokogawa *et al.* [218] found only one optical source, MACS J0057-734 10, in the ASCA error circle. They note that OB supergiant X-ray binaries in the SMC (only SMC X-1 and EXO 0114.6-7361) are both located in the eastern wing and this fact may lead us to suspect that AX J0057.4-7325 would be the third example.

J005736.2-721934 (CXOU J005736.2-721934, XMMU J005735.6-721934, XMMU J005736.5-721936). CXOU J005736.2-721934 was originally discovered in Chandra observation in 2001 [224] where it was reported to have a pulse period of 565.83 s. This X-ray source was also found by Sasaki *et al.* [220] in XMM-Newton European photon imaging camera data. XMMU J005735.6-721934 has a hard spectrum and positionally coincides with the emission-line object 1020 in [233]. This source is very faint during the XMM-Newton observation and it is suggested as a new Be–X-ray candidate.

J0057.8-7202 (AX J0058-720, RX J0057.8-7202). The pulse period of AX J0058-720 was determined from the ASCA data as 280.4 ± 0.3 s [243]. Sasaki *et al.* [220] confirmed this value using the XMM-Newton data: 281.1 ± 0.2 s. The source has been suggested to be a Be–X-ray candidate because of a likely optical counterpart, which is an emission-line object.

J0057.8-7207 (CXOU J005750.3-720756, RX J0057.8-7207, XMMU J005749.9-720756, XMMU J005750.3-720758). This source is a Be–X-ray candidate with an emission-line object 1038 in [233] suggested as a likely optical counterpart [8]. Sasaki *et al.* [220] discovered pulsations in the new XMM-Newton data and derived a pulse period of 152.34 ± 0.05 s. For this source, a pulsar period was independently found in Chandra data by Macomb *et al.* [224].

J0057.9-7156 (RX J0057.9-7156). This source is a Be–X-ray binary candidate because of a positional coincidence with the emission-line object 1044 in [233], according to Haberl and Sasaki [8].

J0058.2-7231 (RX J0058.2-7231, RX J0058.3-7229). Schmidtke *et al.* [162] reported the detection of this very weak X-ray source by high-resolution imager of ROSAT. Its optical counterpart is a variable Be star in the SMC, OGLE 00581258-7230485 [268]. Schmidtke *et al.* [222] have proposed an orbital period of 59.72 days using V, R and I data from the MACHO and OGLE-II surveys.

J0059.2-7138 (RX J0059.2-7138). The supersoft source RX J0059.2-7138 was detected serendipitously with the position-sensitive proportional counter of ROSAT in 1993 and was seen almost simultaneously by ASCA [270, 271]. Previously, it had failed to be detected by either the Einstein Observatory or EXOSAT in the early 1980s, or in pointed ROSAT observations of 1991. The transient nature of this source is clearly established. The best fit to the X-ray spectrum consists of three components [271]; two power laws with indices 0.7 and 2.0 fit the spectrum in the greater than 3 keV and 0.5–3.0 keV bands respectively. Furthermore, the emission is pulsed with a period of about 2.7 s [270]. In [270] it was reported that pulsed fraction changes from nearly zero at low energies (0.07–0.4 keV) up to about 50% at 1–2.4 keV. Kohno *et al.* [223] reported an intermediate value of 37%. Southwell and Charles [272] identified the probable optical counterpart of this source as a fourteenth-magnitude B1III emission star lying within the X-ray error circle.

J0059.3-7223 (RX J0059.3-7223, XMMU J005921.0-722317). This X-ray pulsar was discovered by Majid *et al.* [190]. There are two variable stars in both the OGLE (OGLE 151891) and MCPS (MCPS 3345630) catalogues which are suggested as the optical counterparts for this X-ray source. The angular distance between these two catalogue stars is only $0.3''$, consistent with the fact that they are the same source [190]. The absolute B magnitude (-4.1) of this star is approximately consistent with a B0 star.

J010030.2-722035 (XMMU J010030.2-722035). This X-ray source was found by Sasaki *et al.* [220] in XMM-Newton European photon imaging camera data. XMMU J010030.2-722035 has a hard spectrum and positionally coincides with emission line object 1208 in [233]. This source was very faint during the XMM-Newton observation. It was suggested as a new Be–X-ray candidate.

J0101.0-7206 (RX J0101.0-7206, CXOU J010102.7-720658, XMMU J010103.1-720702, XMMU J010102.5-720659). The X-ray transient RX J0101.0-7206 was discovered in the course of ROSAT observations of the SMC in October 1990 [232] at a luminosity of 1.3×10^{36} erg s^{-1}. The source showed a luminosity of 3×10^{33} erg s^{-1} in the ROSAT band (0.1–2.4 keV) during two XMM-Newton observations [220]. Pulsations with a period of 304.49 ± 0.13 s were discovered in the Chandra data [224]. This period could not be verified in the

XMM-Newton observation because the source was too faint. Edge and Coe [221] presented results on the optical analysis of likely counterparts, discussing two objects 1 and 4 in the ROSAT position-sensitive proportional counter error circle. They conclude that the optical counterpart is object 1, which is confirmed to be a Be star.

J0101.3-7211 (RX J0101.3-7211). The source was detected in ROSAT observations and proposed by Haberl and Sasaki [8] as a Be–X-ray candidate. The optical counterpart (OGLE 01012064-7211187) is a Be star.

J0101.6-7204 (RX J0101.6-7204). Haberl and Sasaki [8] suggested the identification of RX J0101.6–7204 as object 1277 in [233] from two accurate positions from ROSAT high-resolution imager and position-sensitive proportional counter observations. The variability by a factor of 3 supports a Be–X-ray binary nature of this source.

J0101.8-7223 (AX J0101.8-7223, XMMU J010152.4-722336). Haberl and Sasaki [8] suggested this source to be a Be–X-ray binary. They proposed the emission-line star 1288 in [233] as a probable optical counterpart. This star exhibits magnitudes typical for a Be star in the SMC and is located near the overlapping area of the high-resolution imager and position-sensitive proportional counter error circles.

J0103-728 (XTE J0103-728). This source was detected with the RXTE proportional counter array [225].

J0103-722 (AX J0103-722, 2E 0101.5-7225, SAX J0103.2-7209, CXOU J010314.1-720915, 1E 0101.5-7226). For the Be–X-ray binary AX J0103-722 a pulse period of 345.2 ± 0.1 s was determined by Israel *et al.* [248]. In the XMM-Newton data, pulsations were confirmed with a period of 341.7 ± 0.4 s [221]. This source was detected with a nearly constant flux in all the Einstein Observatory, ROSAT and ASCA pointings which surveyed the relevant region of the SMC.

J0103.6-7201 (RX J0103.6-7201). Haberl and Sasaki [8] identified this source as object 1393 in [233]. RX J0103.6-7201 shows variability by a factor of 3 between the ROSAT observations, consistent with a Be–X-ray binary. Recently Haberl and Pietsch [226] reported the discovery of the 1323 s periodicity of this source.

J0104.1-7244 (RX J0104.1-7244). The most likely identification with emission-line star 1440 in [233] suggests that RX J0104.1-7244 is a Be–X-ray binary [8].

J0104.5-7221 (RX J0104.5-7221, RX J0105.5-7221). Haberl and Sasaki [8] reported that this source was not detected by the position-sensitive proportional counter of ROSAT but that the accurate high-resolution imager position included only the emission-line object 1470 from [233] as a bright object in the error circle. RX J0104.5-7221 is therefore very probably a Be–X-ray binary.

J0105-722 (AX J0105-722, RX J0105.3-7210, RX J0105.1-7211). Yokogawa and Koyama [273] reported AX J0105-722 as an X-ray pulsar with a period of 3.34 s. From ROSAT position-sensitive proportional counter images, Filipović *et al.* [236] resolved this source into several X-ray sources. They combined X-ray, radio-continuum and optical data to identify the sources: for RX J0105.1-7211 they proposed an emission-line star from the catalogue of Meyssonier and Azzopardi [233] in the X-ray error circle as a likely optical counterpart. This catalogue contains several known Be–X-ray binaries, strongly suggesting that RX J0105.1-7211 is a new Be–X-ray binary in the SMC.

J0105.9-7203 (RX J0105.9-7203, AX J0105.8-7203). A single bright object (the emission-line star 1557 in [233]) was found in the small ROSAT position-sensitive proportional counter error circle (source 120) [8], which made the identification of RX J0105.9-7203 as a Be–X-ray very likely.

J0106.2-7205 (SNR 0104-72.3, RX J0106.2-7205, 2E 0104.5-7221). SNR 0104-72.3 contains a point-like X-ray source with a blue optical counterpart and $H\alpha$ emission.

J0107.1-7235 (RX J0107.1-7235, AX J0107.2-7234,2E 0105.7-7251). Haberl and Sasaki [8] identified this source as the emission-line star 1619 in [233]. A Be–X-ray binary nature is likely.

0107-750 (1H 0103-762, H 0107-750). This source is a very bright ultraviolet object with prominent $H\alpha$ and $H\beta$ emission.

J0111.2-7317 (XTE J0111.2-7317, XTE J0111-732?). The X-ray transient XTE J0111.2-7317 was discovered by the RXTE X-ray observatory in November 1998 [274]. Analysis of ASCA observation [15, 275] identified this source as a 31 s X-ray pulsar with a flux in the 0.7–10 keV band of 3.6×10^{-10} erg cm^{-2} s^{-1} and a pulsed fraction of about 45%. The detection was also confirmed from the BATSE detectors on the CGRO satellite which detected the source in the hard 20–50 keV band with a flux ranging from 18 to 30 mCrab [276]. The source was not detected by ROSAT. In the X-ray error box of XTE J0111.2-7317, Covino *et al.* [207] found a relatively bright object ($V = 15.4$) which has been classified as a B0.5–B1Ve star and that was later confirmed by Coe *et al.* [277] as the most plausible counterpart for XTE J0111.2-7317. Coe *et al.* [187] gave a visual magnitude $V = 15.52$. There is also evidence for the presence of a surrounding nebula, possibly a supernova remnant [207].

J0117.6-7330 (RX J0117.6-7330). This X-ray transient was discovered by the position-sensitive proportional counter on board ROSAT [278, 279]. Soria [228] conducted spectroscopic and photometric observations of the optical companion of the X-ray transient RX J0117.6-7330 during a quiescent state. The primary component was identified as a B0.5IIIe star. Macomb *et al.* [280] reported the detection of pulsed broadband X-ray emission from this transient source. The pulse period of 22 s was detected by the ROSAT position-sensitive proportional counter instrument and by the Compton Gamma-Ray Observatory BATSE instrument. The total directly measured X-ray luminosity during the ROSAT observation was 1.0×10^{38} erg s^{-1}. The pulse frequency increased rapidly during the outburst with a peak spin-up rate of 1.2×10^{-10} Hz s^{-1} and a total frequency change of 1.8%. The pulsed percentage was 11.3% from 0.1 to 2.5 keV, increasing to at least 78% in the 20–70 keV band. These results established RX J0117.6-7330 as a transient Be binary system.

J0119.6-7330 (RX J0119.6-7330). This source was detected once in the 0.9–2.0 keV band of the ROSAT position-sensitive proportional counter. An emission-line object in the error circle suggests a Be–X-ray binary [8].

J0119-731 (XTE J0119-731). This source was detected in the RXTE proportional counter array observations with intensity about 0.625 mCrab, and a period of 2.1652 ± 0.0001 s [230]. Coe and Gaensicke [281] identified two emission-line optical counterparts which were first identified by searching the RXTE error box using SIMBAD: 1864 in [233] and Lin 526. The second source, Lin 526, exhibited strong $H\alpha$ and $H\beta$ emission. Coe and Gaensicke [281] proposed Lin 526 as the most likely counterpart to XTE J0119-731.

SXP 46.4 (SXP 46.4). This source was detected in the RXTE proportional counter array observations. The source position is not accurately known.

SXP 89 (SXP 89). This source was detected in the RXTE proportional counter array observations. The source position is not accurately known.

XTE SMC144s (XTE SMC144s). The source position is not accurately known. Corbet *et al.* [231] have detected this transient X-ray pulsar in the SMC with the RXTE proportional counter array. They interpreted the outburst recurrence period as the orbital period of a Be–neutron star binary with outbursts occurring at periastron passage.

SXP 165 (SXP 165). This source was detected in the RXTE proportional counter array observations. The source position is not accurately known.

3. Graphs and discussion

In this section, we present several useful plots based on the data from the tables above. In figure 1, we show the usual period – luminosity dependence. If luminosity is proportional to the accretion rate $\dot{M}$, then for each value of L it is possible to determine a critical period $P_{\rm A}$ (see details on the magnetorotational evolution of neutron stars, for example, in [285]). It is determined by the equality of the magnetospheric radius to the corotation radius, so $P_{\rm A}$ depends also on the magnetic field of a neutron star. If the spin period of a neutron star is shorter than $P_{\rm A}$; then the accretion rate is significantly reduced, and the neutron star is at the stage of *propeller*. Lines for $P_{\rm A}$ for two values of the magnetic field are shown in the figure. The situation can be more complicated for low accretion rates when the so-called *subsonic propeller* stage becomes important. In that case for a neutron star it is necessary to slow down to a new critical period $P_{\rm crit}$. Lines for this quantity are also shown (see the figure caption for other details).

In figure 2, we present the so-called 'Corbet [101] diagram'. For most Be–X-ray binaries the correlation between the spin period and the orbital period is strong, so that this dependence is even used to estimate orbital periods when only spins are known.

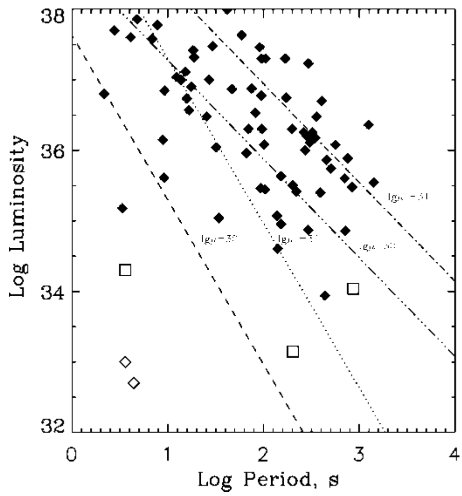

Figure 1. Period versus luminosity. Open symbols correspond to the quiescent state of the X-ray pulsar. Open squares represent three sources in quiescence from which pulsations were observed (namely 4U 0115 + 63 [282]; RX J0440.9 + 4431 [26] and RX J1037.5-564 [26]). Open diamonds show objects without pulsations in quiescence, which are assumed to be in the *propeller* state (4U 0115 + 63 and V0332 + 53 [84]). The graph is artificially truncated at $\log p = 0$ and $\log L = 38$. So here, we do not plot two systems with the most rapidly rotating neutron stars: J0635 + 0533 (small luminosity) and 0535-668 (large luminosity). Dashed and dotted lines correspond to the critical period $P_A = 2^{5/14}\pi(GM)^{-5/7}(\mu^2/\dot{M})^{3/7}$, for two values of the magnetic moment $\mu = 10^{30}$ and 10^{31} G cm^3. The dash-dotted line and the dash-triple-dotted line correspond for the same two values of the magnetic moment to the subsonic propeller – accretor transition which occurs at $P_{\rm crit} = 81.5\mu_{30}^{16/21}L_{36}^{-5/7}$ according to Ikhsanov [283]. We note that the multiplicative coefficient in Ikhsanov's formula is larger than in the classical formula of Davies and Pringle [284] by a factor of about 7.5.

The observational number distributions of Be–X-ray binaries over orbital characteristics are shown in figures 3 and 4. It is clear that Be systems do not have orbital periods longer than 1 year. There is a lack of systems with periods of 10–20 days. As it was shown in [245] the lack of short-period Be–X-ray binaries can be explained by the effect of tidal synchronization in

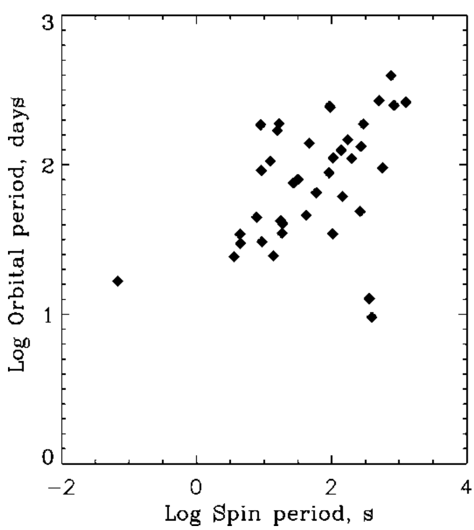

Figure 2. Spin period versus orbital period. Data points for 39 systems are shown. Three displaced systems are 2206 + 543 (large spin and short orbital periods), 2103.5 + 4545 (large spin and short orbital periods) and 0535-668 (very short spin period).

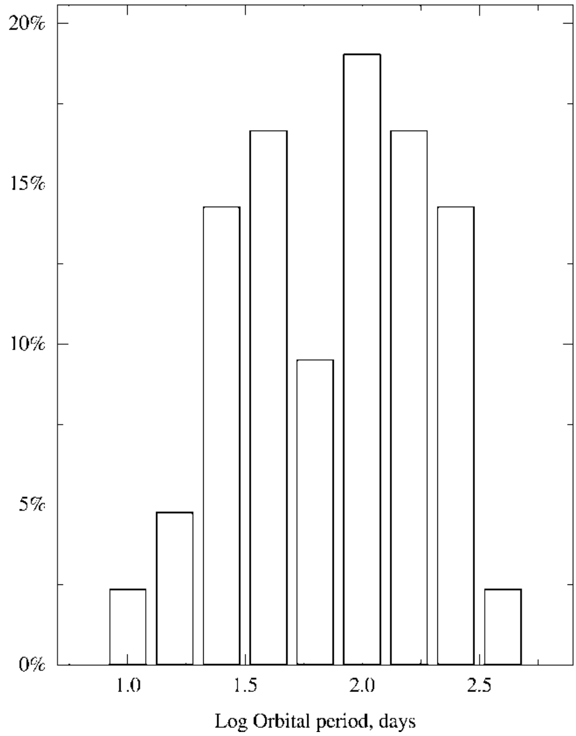

Figure 3. The observational number distribution of Be–X-ray binaries over the orbital period.

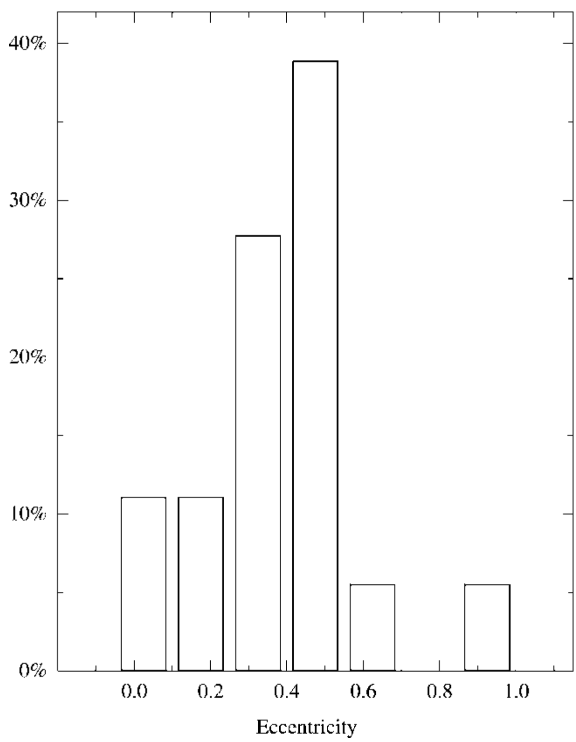

Figure 4. The observational number distribution of Be–X-ray binaries over the orbital eccentricity.

binaries. The peak of the observed number distribution of Be–X-ray systems over eccentricities falls in the range 0.4–0.5. In order to obtain better agreement with the observed parameters of Be–X-ray binaries there is no need for high recoil velocities. Moderate recoil velocities of the order 50 km s^{-1} are enough [245]. This can be a particular feature of Be–X-ray binaries [123].

Acknowledgements

We thank Dr M.E. Prokhorov for technical assistance. The work was supported by the Russian Foundation for Basic Research grants 06-02-16025 and 04-02-16720. S.P. thanks the 'Dynasty' Foundation (Russia).

References

[1] I. Negueruela, astro-ph/0411335 (2005).
[2] S.B. Popov and N.V. Raguzova, astro-ph/0405633 (2004).
[3] Q.Z. Liu, J. van Paradijs, E.P.J. van den Heuvel, Astron. Astrophys., Suppl. Ser. **147** 25 (2000).
[4] J. Ziolkowski, Mem. Soc. Astron. Ital., **73** 1038 (2002).
[5] J.H. Jeong, Inf. Bull. Variable Stars **5392** 1 (2003).
[6] P. Harmanec, P. Habuda, S. Štefl, *et al.*, Astron. Astrophys. **364** 85 (2000).
[7] M.A.C. Perryman, L. Lindegren, J. Kovalevsky *et al.*, Astron. Astrophys. **323** L49 (1997).
[8] F. Haberl and M. Sasaki, Astron. Astrophys. **359** 753 (2000).
[9] I. Negueruela and A.T. Okazaki, Astron. Astrophys. **369** 108 (2001).
[10] B.A. Harmon, C.A. Wilson, G.J. Fishman, *et al.*, Astrophys. J., Suppl. Ser. **154** 585 (2004).
[11] P. Reig, I. Negueruela, M.J. Coe, *et al.*, Mon. Not. R. Astron. Soc. **317** 205 (2000).
[12] J.B. Hutchings and D. Crampton, Pubs. Astron. Soc. Pacif. **93** 486 (1981).
[13] I. Negueruela, P. Roche, J. Fabregat, *et al.*, Mon. Not. R. Astron. Soc. **307** 695 (1999).
[14] H. Delgado-Marti, A.M. Levine, E. Pfahl, *et al.*, Astrophys. J. **546** 455 (2001).
[15] J. Yokogawa, K. Imanishi, M. Tsujimoto, *et al.*, Astrophys. J., Suppl. Ser. **128** 491 (2000).
[16] I. Negueruela, P. Reig, M.H. Finger, *et al.*, Astron. Astrophys. **356** 1003 (2000).
[17] V.V. Borkus, A.S. Kaniovsky, R.A. Sunyaev, *et al.*, Astronomy Lett. **24** 350 (1998).
[18] F. Frontera, D. dal Fiume, E. Morelli, *et al.*, Astrophys. J. **298** 585 (1985).
[19] P. Kaaret, S. Piraino, J. Halpern, *et al.*, Astrophys. J. **523** 197 (1999).
[20] G. Cusumano, M.C. Maccarone, L. Nicastro, *et al.*, Astrophys. J. **528** L25 (2000).
[21] R.H.D. Corbet, A.G. Peele, Astrophys. J. **489** L83 (1997).
[22] P. Reig, I. Negueruela, D.A.H. Buckley, *et al.*, Astron. Astrophys. **367** 266 (2001).
[23] P. Reig and P. Roche, Mon. Not. R. Astron. Soc. **306** 95 (1999).
[24] R.B. Wilson, B.A. Harmon, D.M. Scott, *et al.*, IAU Circ. **6586** 2 (1997).
[25] R. Petre and N. Gehrels, Astron. Astrophys. **282** L33 (1994).
[26] P. Reig and P. Roche, Mon. Not. R. Astron. Soc. **306** 100 (1999).
[27] T. Oosterbroek, M. Orlandini, A.N. Parmar, *et al.*, Astron. Astrophys. **351** L33 (1999).
[28] J.J.M. in't Zand, R.H.D. Corbet, *et al.*, Astrophys. J. **553** L165 (2001).
[29] R.L. Kelley, S. Rappaport and S. Ayasli, Astrophys. J. **274** 765 (1983).
[30] K. Torii, M. Sugizaki, T. Kohmura, *et al.*, Astrophys. J. **523** 65 (1999).
[31] D.M. Smith, D. Main, F. Marshall, *et al.*, Astrophys. J. **501** L181 (1998).
[32] C. Motch, F. Haberl, K. Dennerl, *et al.*, Astron. Astrophys. **323** 853 (1997).
[33] K. Torii, K. Kinugasa, K. Katayama, *et al.*, Astrophys. J. **508** 854 (1998).
[34] G.L. Israel, S. Covino, V.F. Polcaro, *et al.*, in *The Be Phenomenon in Early-Type Stars*. IAU Colloquium 175, ASP Conference Proceedings, edited by M. Smith, H. Henrichs and J. Fabregat, (2000), ASP, San Francisco p.739.
[35] F.E. Marshall, J.C. Lochner and T. Takeshima, IAU Circ. **6778** 1 (1997).
[36] K. Kinugasa, K. Torii, Y. Hashimoto, *et al.*, Astrophys. J. **495** 435 (1998).
[37] G.L. Israel, I. Negueruela, S. Campana, *et al.*, Astron. Astrophys. **371** 1018 (2001).
[38] S. Piraino, A. Santangelo, A. Segreto, *et al.*, Astron. Astrophys. **357** 501 (2000).
[39] T. Takeshima, R.H.D. Corbet, F.E. Marshall, *et al.*, IAU Circ. **6826** 1 (1998).
[40] C.A. Wilson, M.H. Finger, M.J. Coe, *et al.*, Astrophys. J. **584** 996 (2003).
[41] B. Paul, P.C. Agrawal, K. Mukerjee, *et al.*, Astron. Astrophys. **370** 529 (2001).
[42] S.S. Tsygankov and A.A. Lutovinov, Astronomy Lett. **31** 88 (2005).
[43] I. Negueruela, G.L. Israel, A. Marco, *et al.*, Astron. Astrophys. **397** 739 (2003).
[44] C.A. Wilson, M.C. Weisskopf, M.H. Finger, *et al.*, Astrophys. J. **622** 1024 (2005).
[45] P. Reig, I. Negueruela and J. Fabregat, Astron. Astrophys. **421** 623 (2004).
[46] M. Falanga, T. di Salvo, L. Burderi, *et al.*, Astron. Astrophys. **436** 313 (2005).
[47] C.A. Wilson, M.H. Finger and D.M. Scott, Astrophys. J. **511** 367 (1999).

[48] J.J.M. in't Zand, J. Swank, R.H.D. Corbet, *et al.*, Astron. Astrophys. **380** L26 (2001).
[49] K.O. Mason, N.E. White and P.W. Sanford, Nature, **260** 690 (1976).
[50] N.E. White, J.H. Swank, S.S. Holt, *et al.*, Astrophys. J. **263** 277 (1982).
[51] M.F. Corcoran, W.L. Waldron, J.J. Macfarlane, *et al.*, Astrophys. J. **436** L95 (1994).
[52] K. Koyama, Yo. Maeda, T. Tsuru, *et al.*, Publs. Astron. Soc. Japan **46** L93 (1994).
[53] T. Horaguchi, T. Kogure, R. Hirata, *et al.*, Publs Astron. Soc. Japan **46** 9 (1994).
[54] T. Murakami, K. Koyama, H. Inoue, *et al.*, Astrophys. J. **310** L31 (1986).
[55] S. Kubo, T. Murakami, M. Ishida, *et al.*, Publs Astron. Soc. Japan **50** 417 (1998).
[56] R.D. Robinson and M.A. Smith, Astrophys. J. **540** 474 (2000).
[57] R. Giacconi, S. Murray, H. Gursky, *et al.*, Astrophys. J. **178** 281 (1972).
[58] W. Forman, C. Jones, L. Cominsky, *et al.*, Astrophys. J., Suppl. Ser. **38** 357 (1978).
[59] L. Whitlock, D. Roussel-Dupre and W. Priedhorsky, Astrophys. J. **338** 381 (1989).
[60] W. Forman, H. Tananbaum and C. Jones, Astrophys. J. **206** 29 (1976).
[61] W.A. Wheaton, J.P. Doty, F.A. Primini, *et al.*, Nature, **282** 240 (1979).
[62] L.A. Rose, F.E. Marshall, S.S. Holt, *et al.*, Astrophys. J. **231** 919 (1979).
[63] K. Tamura, H. Tsunemi, S. Kitamoto, *et al.*, Astrophys. J. **389** 676 (1992).
[64] L. Bildsten, D. Chakrabarty, J. Chiu, *et al.*, Astrophys. J., Suppl. Ser. **113** 367 (1997).
[65] R.B. Wilson, B.A. Harmon and M.H. Finger, IAU Circ., **7116** 1 (1999).
[66] W.A. Heindl and W. Coburn, IAU Circ. **7126** 2 (1999).
[67] W. Coburn, R.E. Rotschild and W.A. Heindl, IAU Circ. **7487** 1 (2000).
[68] L. Cominsky, G.W. Clark, F. Li, *et al.*, Nature **273** 367 (1978).
[69] M. Johnston, H. Bradt, R. Doxsey, *et al.*, Astrophys. J. **223** 71 (1978).
[70] M. Johns, A. Koski, C. Canizares, *et al.*, IAU Circ. **3171** 1 (1978).
[71] J.B. Hutchings and D. Crampton, Astrophys. J. **247** 222 (1981).
[72] S. Rappaport, G.W. Clark, L. Cominsky, *et al.*, Astrophys. J. **224** L1 (1978).
[73] K. Makishima, T. Mihara, F. Nagase, *et al.*, Astrophys. J. **525** 978 (1999).
[74] S. Mereghetti, L. Stella and F. De Nile, Astron. Astrophys. **278** L23 (1993).
[75] C. Motch, T. Belloni, D. Buckley, *et al.*, Astron. Astrophys. **246** L24 (1991).
[76] N.E. White, K.O. Mason, P. Giommi, *et al.*, Mon. Not. R. Astron. Soc. **226** 645 (1987).
[77] M. Tapia, R. Costero, J. Echevarra, *et al.*, Mon. Not. R. Astron. Soc. **253** 649 (1991).
[78] F. Haberl, L. Angelini and C. Motch, Astron. Astrophys. **335** 587 (1998).
[79] P.C. Gregory, H.J. Xu, C.J. Backhouse, *et al.*, Astrophys. J. **339** 1054 (1989).
[80] P.C. Gregory, Astrophys. J. **520** 361 (1999).
[81] L. Stella, N.E. White, J. Davelaar, *et al.*, Astrophys. J. **288** L45 (1985).
[82] L. Stella, N.E. White and R. Rosner, Astrophys. J. **308** 669 (1986).
[83] K. Makishima, N. Kawai, K. Koyama, *et al.*, Publs Astron. Soc. Japan **679** 39 (1984).
[84] S. Campana, L. Stella, G.L. Israel, *et al.*, Astrophys. J. **580** 389 (2002).
[85] I. Kreykenbohm, N. Mowlavi, N. Produit, *et al.*, Astron. Astrophys. **433** 45 (2005).
[86] N.E. White, K.O. Mason, P.W. Sanford, *et al.*, Mon. Not. R. Astron. Soc. **176** 201 (1976).
[87] N.E. White, K.O. Mason and P.W. Sanford, Nature **267** 229 (1977).
[88] D.E. Mook, F.I. Boley, C.B. Foltz, *et al.*, Publs Astron. Soc. Pacif. **86** 894 (1974).
[89] P. Roche, V. Larionov, A.E. Tarasov, *et al.*, Astron. Astrophys. **322** 139 (1997).
[90] A. Slettebak, Astrophys. J., Suppl. Ser. **50** 55 (1982).
[91] J. Fabregat, V. Reglero, M.J. Coe, *et al.*, Astron. Astrophys. **259** 522 (1992).
[92] L.S. Lyubimkov, S.I. Rostopchin, P. Roche, *et al.*, Mon. Not. R. Astron. Soc. **286** 549 (1997).
[93] J.H. Telting, L.B.F.M. Waters, P. Roche, *et al.*, Mon. Not. R. Astron. Soc. **296** 785 (1998).
[94] P. Roche, M.J. Coe, J. Fabregat, *et al.*, Astron. Astrophys. **270** 122 (1993).
[95] W. Coburn, W.A. Heindl, D.E. Gruber, *et al.*, Astrophys. J. **552** 738 (2001).
[96] F.D. Rosenberg, C.J. Eyles, G.K. Skinner, *et al.*, Nature **256** 628 (1975).
[97] F. Li, G.W. Clark, J.G. Jernigan, *et al.*, Astrophys. J. **228** 893 (1979).
[98] K.S. Wood, J.F. Meekins, D.J. Yentis, *et al.*, Astrophys. J., Suppl. Ser. **56** 507 (1984).
[99] I. Negueruela, P. Roche, D.A.H. Buckley, *et al.*, Astron. Astrophys. **315** 160 (1996).
[100] R.H.D. Corbet, A.G. Peele, Astrophys. J. **530** L33 (2000).
[101] R.H.D. Corbet, Mon. Not. R. Astron. Soc. **220** 1047 (1986).
[102] F. Makino, IAU Circ. **5142** 1 (1990).
[103] F. Makino, IAU Circ. **5139** 1 (1990).
[104] F. Makino, G. Hasinger, W. Pietsch, *et al.*, IAU Circ. **5142** 2 (1990).
[105] F. Makino, IAU Circ. **5148** 2 (1990).
[106] T. Aoki, T. Dotani, K. Ebisawa, *et al.*, Publs Astron. Soc. Japan **44** 641 (1992).
[107] S. Grebenev and R. Sunyaev, IAU Circ. **5294** 2 (1991).
[108] C.A. Wilson, M.H. Finger, B.A. Harmon, *et al.*, Astrophys. J. **479** 388 (1997).
[109] G.L. Israel, S. Covino, S. Campana, *et al.*, Mon. Not. R. Astron. Soc. **314** 87 (2000).
[110] I. Negueruela and A.T. Okazaki, astro-ph/0011406 (2001).
[111] M.J. Coe, P. Roche, C. Everall, *et al.*, Mon. Not. R. Astron. Soc. **270** L57 (1994).
[112] C.J. Eyles, G.K. Skinner, A.P. Wilmore, *et al.*, Nature **254** 577 (1975).
[113] J.C. Ives, P.W. Sanford and S.J. Bell-Burnell, Nature **254** 580 (1975).

[114] C. Motch, E. Janot-Pacheco, M.W. Pakull, *et al.*, Astron. Astrophys. **201** 63 (1988).
[115] C. Chevalier and S.A. Ilovaisky, IAU Circ. **2778** 1 (1975).
[116] E. Janot-Pacheco, S.A. Ilovaisky and C. Chevalier, Astron. Astrophys. **99** 271 (1981).
[117] M. Villada, R. Giovannelli and V.F. Polcaro, Astron. Astrophys. **259** L1 (1992).
[118] M.J. Coe and B.J. Payne, Astrophys. Space Sci. **109** 175 (1985).
[119] K.M.V. Apparao, S. Naranan, R.L. Kelley, *et al.*, Astron. Astrophys. **89** 249 (1980).
[120] R.L. Kelley, R.E. Doxsey, J.G. Jernigan, *et al.*, Astrophys. J. **243** 251 (1981).
[121] J.E. Grindlay, L.D. Petro and J.E. McClintock, Astrophys. J. **276** 621 (1984).
[122] M.H. Finger, R.B. Wilson and D. Chakrabarty, Astron. Astrophys., Suppl. Ser. **120** 209 (1996).
[123] Ph. Podsiadlowski, N. Langer, A.J.T. Poelarends, *et al.*, Astrophys. J. **612** 1044 (2004).
[124] A.T. Okazaki and I. Negueruela, Astron. Astrophys. **377** 161 (2001).
[125] C. Motch, P. Guillout, F. Haberl, *et al.*, Astron. Astrophys., Suppl. Ser., **132** 341 (1998).
[126] D.M. Scott, M.H. Finger, R.B. Wilson, *et al.*, Astrophys. J. **488** 831 (1997).
[127] M.J.L. Turner, H.D. Thomas, B.E. Patchett, *et al.*, Publs Astron. Soc. Japan **41** 345 (1989).
[128] R.K. Manchanda, Mon. Not. R. Astron. Soc. **305** 409 (1999).
[129] F. Makino, IAU Circ. **4661** 2 (1988).
[130] M.H. Finger, L. Bildsten, D. Chakrabarty, *et al.*, Astrophys. J. **517** 449 (1999).
[131] R. Remillard, A. Levine, T. Takeshima, *et al.*, IAU Circ. **6826** 2 (1998).
[132] F.E. Marshall, J.C. Lochner, A. Santangelo, *et al.*, IAU Circ. **6818** 1 (1998).
[133] B. Paul and A.R. Rao, Astron. Astrophys. **337** 815 (1998).
[134] W. Coburn, W.A. Heindl, R.E. Rothschild, *et al.*, Astrophys. J. **580** 394 (2002).
[135] K.N. Borozdin, M. Gilfanov, R. Sunyaev, *et al.*, Astronomy Lett. **16** 345 (1990).
[136] D. Chakrabarty, T. Koh, L. Bildsten, *et al.*, Astrophys. J. **446** 826 (1995).
[137] D.K. Galloway, E.H. Morgan and A.M. Levine, Astrophys. J. **613** 1164 (2004).
[138] A.N. Parmar, N.E. White, L. Stella, *et al.*, Astrophys. J. **338** 359 (1989).
[139] A.N. Parmar, L. Stella, P. Ferri, *et al.*, IAU Circ. **4066** 1 (1985).
[140] C.A. Wilson, J. Fabregat and W. Coburn, Astrophys. J. **620** L99 (2005).
[141] C.A. Wilson, M.H. Finger, M.J. Coe, *et al.*, Astrophys. J. **570** 387 (2002).
[142] C.A. Wilson, M.H. Finger, B.A. Harmon, *et al.*, Astrophys. J. **499** 820 (1998).
[143] A.J. Castro-Tirado, IAU Circ. **6516** (1996).
[144] F. Hulleman, J.J.M. in't Zand and J. Heise, Astron. Astrophys. **337** L25 (1998).
[145] A. Baykal, M.J. Stark and J.H. Swank, Astrophys. J. **544** 129 (2000).
[146] P. Reig and F. Mavromatakis, Astron. Telegram **173** 1 (2003).
[147] A. Baykal, M.J. Stark and J.H. Swank, Astrophys. J. **569** 903 (2002).
[148] S.C. Inam, A. Baykal, I. Swank *et al.*, Astrophys. J. **616** 463 (2004).
[149] M.P. Ulmer, W.A. Baity, W.A. Wheaton, *et al.*, Astrophys. J. **184** L117 (1973).
[150] K. Koyama, M. Kawada, Y. Tawara, *et al.*, Astrophys. J. **366** L19 (1991).
[151] T. Mihara, K. Makishima, S. Kamijo, *et al.*, Astrophys. J. **379** L61 (1991).
[152] R.S. Warwick, N. Marshall, G.W. Fraser, *et al.*, Mon. Not. R. Astron. Soc. **197** 865 (1981).
[153] J.E. Steiner, A. Ferrara, M. Garcia, *et al.*, Astrophys. J. **280** 688 (1984).
[154] R.H.D. Corbet, R. Remillard and A.G. Peele, IAU Circ. **7446** (2000).
[155] M.J. Coe and J.A. Orosz, Mon. Not. R. Astron. Soc. **311** 169 (2000).
[156] I. Negueruela and P. Reig, Astron. Astrophys. **371** 1056 (2001).
[157] R.H.D. Corbet and A.G. Peele Astrophys. J. **562** 936 (2001).
[158] P. Blay, M. Ribo, I. Negueruela, *et al.*, Astron. Astrophys. **438** 963 (2005).
[159] N. Masetti, D. Dal Fiume, L. Amati, *et al.*, Astron. Astrophys. **423** 311 (2004).
[160] J.J.M. in't Zand, J. Halpern, M. Eracleous, *et al.*, Astron. Astrophys. **361** 85 (2000).
[161] I. Negueruela and M.J. Coe, Astron. Astrophys. **385** 517 (2002).
[162] P.C. Schmidtke, A.P. Cowley, J.D. Crane, *et al.*, Astron. J. **117** 927 (1999).
[163] W.R.T. Edge, M.J. Coe, J.L. Galache, *et al.*, Mon. Not. R. Astron. Soc. **349** 1361 (2004).
[164] L. Burderi, T. di Salvo, N.R. Robba, *et al.*, Astrophys. J. **498** 831 (1998).
[165] P.C. Schmidtke, A.P. Cowley, L.M. Frattare, *et al.*, Publs Astron. Soc. Pacif. **106** 843 (1994).
[166] P.C. Schmidtke, A.P. Cowley, P.H. Hauschildt, *et al.*, Publs Astron. Soc. Pacif. **108** 668 (1996).
[167] A.P. Cowley, D. Crampton, J.B. Hutchings, *et al.*, Astrophys. J. **286** 196 (1984).
[168] P.C. Schmidtke, A.P. Cowley, T.K. McGrath *et al.*, Publs Astron. Soc. Pacif. **107** 450 (1995).
[169] R. Wooley, R. Obs. Bull. **66** 263 (1963).
[170] M.J. Coe, I. Negueruela, D.A.H. Buckley, *et al.*, Mon. Not. R. Astron. Soc. **324** 363 (2001).
[171] F. Haberl, K. Dennerl, W. Pietsch, *et al.*, Astron. Astrophys. **318** 494 (1997).
[172] M. Pakull, H. Brunner, A. Staubert, *et al.*, Space Sci. Rev. **40** 371 (1985).
[173] F. Haberl, K. Dennerl and W. Pietsch, Astron. Astrophys. **302** L1 (1995).
[174] F. Haberl and W. Pietsch, Astron. Astrophys. **344** 521 (1999).
[175] N. Reid, I.S. Glass and R.M. Catchpole, Mon. Not. R. Astron. Soc. **232** 53 (1988).
[176] N.E. White and G.F. Carpenter, Mon. Not. R. Astron. Soc. **183** 11 (1978).
[177] P.A. Charles, L. Booth, R.H. Densham, *et al.*, Mon. Not. R. Astron. Soc. **202** 657 (1983).
[178] G.K. Skinner, D.K. Bedford, R.F. Elsner, *et al.*, Nature **297** 568 (1982).
[179] G.K. Skinner, S. Shulman, G. Share, *et al.*, Astrophys. J. **240** 619 (1980).

[180] F. Mavromatakis and F. Haberl, Astron. Astrophys. **274** 304 (1993).
[181] R.H.D. Corbet, A.P. Smale, P.A. Charles *et al.*, Bull. Am. Astron. Soc. **186** 4807 (1995).
[182] C. Alcock, R.A. Allsman, D.R. Alves, *et al.*, Mon. Not. R. Astron. Soc. **321** 678 (2001).
[183] M.D. Johnston, H.V. Bradt and R.E. Doxsey, Astrophys. J. **233** 514 (1979).
[184] M. van der Klis, I. Tuohy, J. Elso, *et al.*, Mon. Not. R. Astron. Soc. **203** 279 (1983).
[185] J.B. Stevens, M.J. Coe and D.A.H. Buckley, Mon. Not. R. Astron. Soc. **309** 421 (1999).
[186] G. Cusumano, G.L. Israel, F. Mannucci, *et al.*, Astron. Astrophys. **337** 772 (1998).
[187] M.J. Coe, W.R.T. Edge, J.L. Galache, *et al.*, Mon. Not. R. Astron. Soc. **356** 502 (2004).
[188] F. Haberl and W. Pietsch, Astron. Astrophys. **414** 667 (2004).
[189] W.R.T. Edge, M.J. Coe and J.L. Galache, Astron. Telegram **405** 1 (2005).
[190] W.A. Majid, R.C. Lamb and D.J. Macomb, Astrophys. J. **609** 133 (2004).
[191] J. Yokogawa, K. Imanishi, M. Tsujimoto, *et al.*, Publs Astron. Soc. Japan **55** 161 (2003).
[192] J. Yokogawa and K. Koyama, IAU Circ. **6835** 1 (1998).
[193] P.C. Schmidtke and A.P. Cowley, Am. Astron. Soc. **205** 10213 (2004).
[194] J. Yokogawa, K. Imanishi, M. Tsujimoto, *et al.*, Publs Astron. Soc. Japan **51** 547 (1999).
[195] M. Ueno, J. Yokogawa, K. Imanishi, *et al.*, Publs Astron. Soc. Japan **52** L63 (2000).
[196] P.C. Schmidtke, A.P. Cowley, L. Levenson, *et al.*, Astron. J. **127** 3388 (2004).
[197] M. Ueno, J. Yokogawa, K. Imanishi, *et al.*, IAU Circ. **7442**, 1 (2000).
[198] M.J. Coe, N.J. Haigh, S.G.T. Laycock, *et al.*, Mon. Not. R. Astron. Soc. **332** 473 (2002).
[199] K. Imanishi, J. Yokogawa, M. Tsujimoto, *et al.*, Publs Astron. Soc. Japan **51** L15 (1999).
[200] W.R.T. Edge, M.J. Coe, J.L. Galache, *et al.*, Mon. Not. R. Astron. Soc. **353** 1286 (2004).
[201] R.H.D. Corbet, C.B. Markwardt, M.J. Coe, *et al.*, Astron. Telegram **273** 1 (2004).
[202] R.C. Lamb, D.J. Macomb, T.A. Prince, *et al.*, Astrophys. J. **567** L129 (2002).
[203] J. Yokogawa, K. Torii, K. Imanishi, *et al.*, Publs Astron. Soc. Japan **52** L37 (2000).
[204] S. Laycock, R.H.D. Corbet, M.J. Coe, *et al.*, Astrophys. J. Suppl. Ser. **161** 96 (2005).
[205] G.L. Israel, L. Stella, L. Angelini, *et al.*, IAU Circ. **6277** 1 (1995).
[206] F. Li, G. Jernigan and G. Clark, IAU Circ. **3125** 1 (1977).
[207] S. Covino, I. Negueruela, S. Campana, *et al.*, Astron. Astrophys. **374** 1009 (2001).
[208] S. Laycock, R.H.D. Corbet, M.J. Coe, *et al.*, Mon. Not. R. Astron. Soc. **339** 435 (2003).
[209] J. Yokogawa, K. Torii, T. Kohmura, *et al.*, Publs Astron. Soc. Japan **53** L9 (2001).
[210] S. Laycock, R.H.D. Corbet, D. Perrodin, *et al.*, Astron. Astrophys. **385** 464 (2002).
[211] R.H.D. Corbet, C.B. Markwardt, M.J. Coe, *et al.*, Astron. Telegram **214** 1 (2003).
[212] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, Astron. Telegram **347** 1 (2004).
[213] J.C. Lochner, IAU Circ. **7007** 2 (1998).
[214] P. Murdin, D.C. Morton, R.M. Thomas, Mon. Not. R. Astron. Soc. **186** 43 (1979).
[215] W.R.T. Edge, M.J. Coe and J.L. Galache, Astron. Telegram **426** 1 (2005).
[216] J.C. Lochner, L.A. Whitlock, R.H.D. Corbet, *et al.*, Bull. Am. Astron. Soc. **31** 905 (1999).
[217] F. Haberl, W. Peitsch, N. Schartel, *et al.*, Astron. Astrophys. **420** 19 (2004).
[218] J. Yokogawa, K. Torii, T. Kohmura, *et al.*, Publs Astron. Soc. Japan **52** 53 (2000).
[219] K. Torii, T. Kohmura, J. Yokogawa, *et al.*, IAU Circ. **7441** 2 (2000).
[220] M. Sasaki, W. Pietsch and F. Haberl, Astron. Astrophys. **403** 901 (2003).
[221] W.R.T. Edge and M.J. Coe, Mon. Not. R. Astron. Soc. **338** 428 (2003).
[222] P.C. Schmidtke, A.P. Cowley, L. Levenson, *et al.*, Rev. Mex. Astron. y Astrofisi. **20** 215 (2004).
[223] M. Kohno, J. Yokogawa and K. Koyama, Publs Astron. Soc. Japan **52** 299 (2000).
[224] D.J. Macomb, D.W. Fox, R.C. Lamb, *et al.*, Astrophys. J. **584** L79 (2003).
[225] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, Astron. Telegram **163** 1 (2003).
[226] F. Haberl and W. Pietsch, Astron. Astrophys. 211 (2005).
[227] J.P. Hughes and R.C. Smith, Astron. J. **107** 1363 (1994).
[228] R. Soria, Publs Astron. Soc. Aust. **16** 147 (1999).
[229] D.J. Macomb, M. Finger, Harmon, *et al.*, Bull. Am. Astron. Soc. **31** 670 (1998).
[230] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, IAU Circ. **8064** 4 (2003).
[231] R.H.D. Corbet, S. Laycock, F.E. Marshall, *et al.*, Astron. Telegram **209** 1 (2003).
[232] P. Kahabka and W. Pietch, Astron. Astrophys. **312** 919 (1996).
[233] N. Meyssonnier and M. Azzopardi, Astron. Astrophys. **102** 451 (1993).
[234] R.H.D. Corbet, Astron. Astrophys. **141** 91 (1984).
[235] P. Kahabka and W. Pietch, IAU Circ. **6840** 1 (1998).
[236] M.D. Filipović, F. Haberl, W. Pietsch, *et al.*, Astron. Astrophys. **353** 129 (2000).
[237] K. Imanishi, J. Yokogawa and K. Koyama, IAU Circ. **7040** 1 (1998).
[238] F. Haberl, M.D. Filipovic, W. Pietsch, *et al.*, Astron. Astrophys. Suppl. Ser. **142** 41 (2000).
[239] M.D. Filipović, W. Pietsch and F. Haberl, Astron. Astrophys. **361** 823 (2000).
[240] J. Yokogawa, K. Imanishi, M. Ueno, *et al.*, Publs Astron. Soc. Japan **52** L73 (2000).
[241] A.P. Cowley and P.C. Schmidtke, Astron. J. **126** 2949 (2003).
[242] M.J. Coe and W.R.T. Edge, Mon. Not. R. Astron. Soc. **350** 756 (2004).
[243] J. Yokogawa and K. Koyama, IAU Circ. **6853** 2 (1998).
[244] K. Cook, IAU Circ. **6860** 1 (1998).
[245] N.V. Raguzova and V.M. Lipunov, Astron. Astrophys. **340** 85 (1998).

[246] R.H.D. Corbet, F.E. Marshall, J.C. Lochner, *et al.*, IAU Circ. **6788** 1 (1998).
[247] D.A.H. Buckley, M.J. Coe, J.B. Stevens, *et al.*, IAU Circ. **6789** 1 (1998).
[248] G.L. Israel, L. Stella, S. Campana, *et al.*, IAU Circ. **6999** 1 (1998).
[249] A.P. Cowley, P.C. Schmidtke, T.K. McGrath, *et al.*, Publs Astron. Soc. Pacif. **109** 21 (1997).
[250] G.L. Israel, L. Stella, L. Angelini, *et al.*, Astrophys. J. **484** 141 (1997).
[251] R.C. Lamb, T.A. Prince, D.J. Macomb, *et al.*, IAU Circ. **7081** 1 (1999).
[252] P. Kahabka, IAU Circ. **7082** 1 (1999).
[253] P. Kahabka, IAU Circ. **7087** 1 (1999).
[254] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, IAU Circ. **7932** 2 (2002).
[255] H.-J. Tucholke, K.S. de Boer and W.C. Seitter, Astron. Astrophys. Suppl. Ser. **119** 91 (1996).
[256] R.H.D. Corbet, F.E. Marshall and C.B. Markwardt, IAU Circ. **7562** 1 (2001).
[257] Q. Wang and X. Wu, Astrophys. J., Suppl. Ser. **78** 391 (1992).
[258] C.D. Garmany and R.M. Humphreys, Astron. J. **90** 2009 (1985).
[259] J.C. Lochner, F.E. Marshall, L.A. Whitlock, *et al.*, IAU Circ. **6814** 1 (1998).
[260] D.A.H. Buckley, M.J. Marshall, L.A. Whitlock, *et al.*, Mon. Not. R. Astron. Soc. **320** 281 (2001).
[261] G. Clark, R. Doxsey, F. Li, *et al.*, Astrophys. J. **221** L37 (1978).
[262] F.E. Marshall, E.A. Boldt, S.S. Holt, *et al.*, Astrophys. J., Suppl. Ser. **40** 657 (1979).
[263] F.D. Seward and M. Mitchell, Astrophys. J. **243** 736 (1981).
[264] R.H.D. Corbet, F.E. Marshall, M.J. Coe, *et al.*, Astrophys. J. **548** L41 (2001).
[265] R.H.D. Corbet and F.E. Marshall, IAU Circ. **7402** 3 (2000).
[266] J. Yokogawa, K. Torii, T. Kohmura, *et al.*, Publs Astron. Soc. Japan **53** 227 (2001).
[267] A. Santangelo, G. Cusumano, D. dal Fiume, *et al.*, Astron. Astrophys. **338** L59 (1998).
[268] K. Zebrun, I. Soszynski, P.R. Wozniak, *et al.*, Acta Astron. **51** 317 (2001).
[269] D. Zaritsky, J. Harris, I.B. Thompson, *et al.*, Astron. J. **123** 855 (2002).
[270] J.P. Hughes, Astrophys. J. **427** L25 (1994).
[271] N.D. Kylafis, in *Supersoft X-ray Sources*, Lecture Notes in Physics, Vol. 472, edited by J. Greiner (Springer, Berlin, 1996) p. 41.
[272] K.A. Southwell and P.A. Charles, Mon. Not. R. Astron. Soc. **281** L63 (1996).
[273] J. Yokogawa and K. Koyama, IAU Circ. **7028** 1 (1998).
[274] D. Chakrabarty, A.M. Levine, G.W. Clark, *et al.*, IAU Circ. **7048** 1 (1998).
[275] D. Chakrabarty, T. Takeshima, M. Ozaki, *et al.*, IAU Circ. **7062** 1 (1998).
[276] C.A. Wilson and M.H. Finger, IAU Circ. **7048** 1 (1998).
[277] M.J. Coe, N.J. Haigh and P. Reig, Mon. Not. R. Astron. Soc. **314** 290 (2000).
[278] G.W. Clark, R.A. Remillard and J.W. Woo, IAU Circ. **6282** 1 (1996).
[279] G.W. Clark, R.A. Remillard and J.W. Woo, Astrophys. J. **474** 111 (1997).
[280] D.J. Macomb, M.H. Finger, B.A. Harmon, *et al.*, Astrophys. J. **518** L99 (1999).
[281] M.J. Coe and B.T. Gaensicke, Astron. Telegram **123** 1 (2003).
[282] S. Campana, F. Gastaldello, L. Stella, *et al.*, Astrophys. J. **561** 924 (2001).
[283] N.R. Ikhsanov, Astron. Astrophys. **399** 1147 (2003).
[284] R.E. Davies and J.E. Pringle, Mon. Not. R. Astron. Soc. **196** 209 (1981).
[285] V.M. Lipunov, *Astrophysics of neutron stars* (Springer, Berlin, 1992).