Be/X-ray binaries and candidates

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Abstract

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, 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: Catalogs – X-rays: binaries – stars: emission-line, Be

1 Introduction

Be/X-ray binaries form the largest subclass of High Mass X-ray Binaries (HMXBs). These objects attract interests of specialists in several branches of astrophysics: stellar astrophysics, accretion theory, close binary evolution, etc. In recent years thanks to new X-ray satellites data on these sources 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, systems in Large Magellanic Cloud (LMC) and in the Small Magellanic Cloud (SMC). In each table sources are ordered according to right ascension. In the first column we give sources names. When possible, the first name corresponds to notation in [3]. In the second and third columns we present spectral type of the massive companion and its magnitude. In the forth column we give spin period, and in the fifth — orbital period. Then we give orbital eccentricity and distance to the source. In the 8th column we give $L_{\max}$ – the maximal observed luminosity. In the last column pulse fractions

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are given. For sources in LMC and SMC we do not show distances, also as for systems in SMC orbital eccentricities are not known we omit this column for them, too. Some comments and more detailed description of each object can be found in subsections "Comments to the tables" below (each subsection refers to galactic, LMC or SMC sources). References in the tables are given in square brackets after each quantity (in 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 the table 1 and table 2

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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 Cassiopeiae is one of the best known Be stars; it was the first emission-line star discovered by Angelo Secchi in 1866, and it has spectral classification of B0.5 IVe [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 $10^{33} - 10^{34}\,\mathrm{erg\ s^{-1}}$ [49, 50, 8]. 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 a similar luminosity [51, 52]. However, the hardness of the X-ray emission of γ Cas is extraordinarily high in comparison with 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]. It is not common for early type stars, and resembles more 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 onto a white dwarf companion and the other is that X-rays originate due to some physical processes in the outer atmosphere of γ Cas itself. Arguments for and against these two hypotheses are 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], though a search in the Vela 5B data base 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/Batse [64], RXTE [65, 66, 67] and reoccured with intervals from one 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. Due to 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. Magnetic field of the neutron star is $1.3 \cdot 10^{12}$ G [73]. 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 of any X-ray pulsar in a Be-star system. This fact was realized [74] only after the re-discovery of this source in the ROSAT All Sky Survey and its identification with the 11th 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 $\sim 10^{36}$ erg s^{-1} [74]. All the observations of RX J0146.9+6121 carried out after its re-discovery yielded lower luminosities, of the order of a few 10^{34} erg s^{-1} , until an observation with the Rossi XTE satellite showed that in July 1997 the flux started to rise again [78], though 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 d. The radio outburst peak and the outburst phase are known to vary over a time scale of $\sim$ 4 yr [79, 80]. The 26.5 d period is believed to be the orbital period. Hutchings and Crampton [12] confirmed the radio period by analysis of three-year observation of radial velocity. They concluded that the optical spectrum corresponds to a rapidly rotating B0 V star. The 4 yr 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 V0332+53 between 1983 November and 1984 January. Two properties of the system were discovered: the 4.4 s spin period and a sudden decrease of luminosity at the end of $\sim$ 1 month long recurrent outbursts. The latter was interpreted as an onset of the centrifugal barrier [81, 82]. An upper limit of $\sim 5{\cdot}10^{33}$ 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 indicate 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 $3 \cdot 10^{12}$ G magnetic field [83]. BeppoSAX and Chandra observations allowed to study this transient at the faintest flux levels thus far [84]. Campana et al. [84] concluded that the quiescent emission of this X-ray transient likely originates from accretion onto 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 authors confirm the existence of cyclotron lines: the fundamental line at 24.9$\pm$0.1 kev, the first harmonic at 50.5$\pm$0.1 kev as well as the second harmonic at 71.7$\pm$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 Persei (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 ([64], and references therein). X Per is a bright and highly variable star with a visual magnitude that ranges from ~ 6.1 to ~ 6.8 [88, 89]. The spectral class has been estimated to be O9.5 III to B0 V [90, 91, 92]. Based on spectroscopic parallax, distance estimates range from 700 ± 300 pc up to 1.3 ± 0.4 kpc [91, 92, 89, 93]. The X-ray luminosity varies on long timescales (years) from $\sim 3 \cdot 10^{35}$ erg s^{-1} to $\sim 5 \cdot 10^{34}$ 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 the Rossi X-ray Timing Explorer (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 the RXTE. The cyclotron resonant scattering feature energy implies a magnetic field strength at the polar cap of $3.3 \cdot 10^{12}$ 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 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 5 [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 energy, reaching 100% at 100 keV [18]. Magnetic field of the neutron star is $4.3 \cdot 10^{12}$ G [73].

0556+286. (4U 0548+29, 1H 0556+286) The X-ray source was detected by HEAO1. 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) Discovered by BeppoSAX [19]. Ziolkowski [4] gives the spectral classification of the optical counterpart as B0.5 IIIe. X-ray luminosity is $(9 - 35) \cdot 10^{33}$ erg s^{-1} (2-10 keV) for $d = 2.5 - 5$ kpc [19]. Bolometric luminosity (0.1-40 keV) was estimated to be $1.2 \cdot 10^{35}$ erg s^{-1} for $d = 5$ kpc [20]. Pulse fraction was obtained by BeppoSAX (2-10 keV). The source can be identified with the gamma-ray source 2EG J0635+0521. Low luminosity together with very fast rotation propose 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) Detected by many experiments (UHURU, HEAO1, Ariel 5, ROSAT, RXTE). Pulse fraction was estimated as $(I_{\max} - I_{\min})/(I_{\max} + I_{\min})$ from the graph in [21] (RXTE 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) Detected by HEAO1 [98].

0749-600. (1H 0749-600) Detected by HEAO1 [98]. 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 SIMBAD OB star catalogs 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 B0.2 IVe, while in [3] it is classified as B0.5 III-Ve. The X-ray light curve of LS 992/RX J0812.4-3114 is characterized by 31.88 second pulsations, while the X-ray spectrum is best represented by an absorbed power-law component with a exponentially 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 (ASM) on-board the Rossi X-ray Timing Explorer. 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 ~ 80 day period in the ASM 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 periastron passage of a neutron star. The orbital period of ~ 80 days combined with the ~ 32 second pulse period is consistent with the correlation between orbital and 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 (see [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 [105, 106, 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 till June 1993 with a peak and intra-outburst flux of about 300 mCrab and < 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 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 optical counterpart of this X-ray pulsar is most likely a B0-2 V-IIIe star at a distance of 3-5 kpc. Pulse fraction was obtained by BATSE (20-50 keV).

J1008-57. (GRO J1008-57) Discovered by BATSE in 1993. Pulse fraction $\sim 60\%$ was obtained by ROSAT (0.1-2.4 keV) [10]. High-energy data (BATSE: 20-70 keV) gives nearly the same value about 67% [10]. Orbital period is uncertain. An estimate of 247.5 days comes 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) Probably the same object as J1037.5-5647.
J1037.5-5647. (LS 1698, RX J1037.5-5647) Discovered by ROSAT in 1997. Probably the same source as 4U1036-56/3A1036-565. The source was observed in quiescence [26]. $L_{\rm min} = 1.1 \cdot 10^{34}$ erg s^{-1}. 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 Ariel-5 satellite, and from December 1991 to February 1992 [64]. The source was observed by Motch et al. [114] using the Einstein and EXOSAT observatories 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 O9.5 III-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 UV wavelengths using the IUE satellite. They confirmed the identification of the counterpart and reported prominent UV lines characteristic of a Be star. Despite the large observational efforts made during last 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 pulse period/orbital period diagram [101] gives an orbital period estimate of ~ 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) Initially observed by UHURU (together with 1145.1-9141). Two sources were distinguished by Einstein observatory (HEAO2). In the paper by Liu et al. [3] the optical counterpart was classified as B1 Vne. Pulse fraction was obtained by BATSE (20-50 keV).
1249-637. (1H 1249-637, 2E 1239.8-6246, BZ Cru) Detected by HEAO1 [98]. Probably a white dwarf accretor.
1253-761. (1H 1253-761) Detected by HEAO1 [98]. Probably a white dwarf accretor.
1255-567. (1H 1255-567, μ^2 Cru) Detected by HEAO1 [98].
1258-613. (GX 304-1, 4U 1258-61, V850 Cen, H 1258-613, 2S 1258-613, 3A 1258-613) Discovered by UHURU. In [4] classified as B0.7Ve. In [3] classified as B2 Vne.

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 ~ 57 mHz pulsations [120]. Einstein 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 spin-up rate and pulsed flux [122]. 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. 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 >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 PCA observation 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 d. The mass function and position in the pulse period versus orbital period diagram are consistent with XTE J1543-568 being a Be/X-ray binary. The eccentricity is less than 0.03, so it is among the lowest for twelve Be/X-ray binaries whose orbits have now been well measured. This confirms the suspicion that small kick velocities of neutron stars in HMXBs are more common for these systems than it is generally expected for neutron stars [28, 123]. There is only a lower limit for its distance. Optical component is unknown, 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]). Pulse fraction (RXTE) 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]. 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) Detected by HEAO1 [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 ± 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 Persei (4U 0352+309), but the possibility that it is a white dwarf binary cannot be completely excluded. Not marked as a Be-candidate in [3]. 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 (PCA) of the Rossi X-Ray Timing Explorer [31]. Luminosity estimated for a 2-100 keV range with an assumption, that the source is at the Galactic center. Smith et al. [31] tentatively identified XTE J1739-302 as a Be/NS binary because its spectral shape is similar to that of these systems: a gradual steepening over the 2-25 keV range.
J1739.4-2942. (RX J1739.4-2942) Discovered by ROSAT [125]. Probably identical with GRS 1736-297.
J1744.7-2713. (RX J1744.7-2713, GRO J1744-28, HD 161103, V3892 Sgr, LS 4356) Discovered by ROSAT [32]. The luminosity was estimated for the energy range 0.1-2.4 keV. The pulse fraction was taken from 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) Discovered by ASCA [33]. Not marked 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 (see [126]). Pulsations with a 4.45 s period were discovered on 1995 July 29 from the Galactic center region as part of the BATSE all-sky pulsar monitoring program [64]. An orbit with a period of 29.8 days was found by Scott et al. [126]. Large spin-up rate, spin period and orbital period together suggest that accretion is occurring from a disk and that the outburst is a “giant” one typical for 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 ~ 152 s were detected in the 2-10 keV flux of the source with a pulsed fraction of $\sim 33\%$. The pulse fraction is not strongly energy dependent. Both timing and spectral properties of AX J1820.5-1434 are typical for an accretion-driven X-ray pulsar. Israel et al. [34] proposed 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 per cent of the average flux. Pulse fraction was obtained by BATSE (20-50 keV). Luminosity estimates are the following: 1) $2 \cdot 10^{36}$ erg s^{-1} (20-200 keV, 10 kpc) [128]; 2) $3 \cdot 10^{37}$ 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 (see [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 spectra of X-ray pulsars. Observations were made immediately after this with the Proportional Counter Array (PCA) of the 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 $\sim 25\%$. 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 PCA [132]. From the RXTE target of opportunity (TOO) public archival data of the observations of XTE J1858+034, made in 1998, Paul and Rao [133] have discovered the presence of low frequency QPOs. Pulse fraction was obtained by RXTE (2-10 keV).

1936+541. (1H 1936+541) Detected by HEAO1 [98].

J1946+274. (XTE J1946+274, GRO J1944+26, 3A 1942+274, SAX J1945.6+2721) Pulse fraction obtained by Indian X-ray Astronomy Experiment - IXAE (2-18 keV). Coburn et al. [134] present a data on cyclotron feature in the spectrum of XTE J1946+274 which corresponds to the field $\sim 3.9 \cdot 10^{12}$ G. Wilson et al. [40] propose a distance 9.5 ± 2.9 kpc basing 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 [137] presented results which can indicate a glitch in that system. Based on the behavior of the pulsation period during the outburst of 2000-2001, they determined the parameters of the binary: the orbital period $P_{\rm orb} = 40.415 \pm 0.010$ d and the eccentricity $e = 0.033 \pm 0.013$. The optical counterpart is a B0 Ve star. Tsygankov and Lutovinov [42] estimated the magnetic field strength of the pulsar $\sim 2.5 \cdot 10^{13}$ G, and the distance to the binary $d = 9.5 \pm 1.1$ 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 1985 May with EXOSAT satellite during a large outburst phase [138]. This outburst was first detected at a 1-20 keV energy band and its luminosity is close to the Eddington limit (assuming 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 ~ 42 s pulsations and periodic ~ 46 days Type I outbursts, that are produced at each periastron passage of the neutron star, i.e. when the pulsar interacts with the disk of the Be star. Wilson et al. [140] presented results of observations of transition to global spin-up in this source somewhen between between June 2002 and September 2003. The source is not marked as a Be-candidate in [3]. Pulse fraction was obtained by BATSE in the range 30-70 keV (see [10]). See a detailed description in [141].

J2030.5+4751. (RX J2030.5+4751, SAO 49725) Discovered by ROSAT (see [32]). This object is marked 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 $L_{\rm x}/L_{\rm bol}$ ratio is close to $3 \cdot 10^{-6}$. This is rather strong evidence in favor 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 (see [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 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. 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 HMXB pulsar with a $\sim$ 358 s pulse period discovered with the WFC on-board BeppoSAX during an outburst in 1997 [144]. Its orbital period of 12.68 days has been found with the 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 (blackbody with a temperature of 1.9 keV) and a transient 22.7 s QPO during a XMM-Newton observation performed in 2003. The pulsed fraction increases with energy from $\sim 45\%$ at 5-40 keV to $\sim 80\%$ 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 till 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 $B = 2.3 \cdot 10^{12}(1+z)$ G. Pulse fraction strongly depends on energy and is highly variable with time from nearly 0 up to $> 80\%$ (see [47]). The RXTE pulse fraction is decreasing with 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 B0 - 2e 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 9.570 ± 0.004 d periodicity in the X-ray lightcurve. If this is the binary period, then it would be the shortest known for a Be/X-ray binary — unless the ~ 1.4 d periodicity in the optical lightcurve 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 H I, He I and He II lines and variability in the intensity of many lines of metals [156]. Strong wind troughs in the UV resonance lines suggest a large mass loss rate. These properties might indicate that the star displays at the same time the Of and Oe phenomena or even a hint of the possibility that it could be a spectroscopic binary consisting of two massive stars in addition to the compact object [156]. With all certainty there is an O9.5V star in the system which is probably a mild Of star, and which likely feeds the compact object with its stellar wind [156]. See also recent data and discussion in [157]. These authors confirm the orbital period of ~ 9.6 days. This value is surprisingly short if one takes into account long spin period of the neutron star (see fig. 2, where this system is definitely displaced from the normal trend). Spin period was not detected in many observations. Corbet and Peele [157] discuss several possibilities other than 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 to the existence of a cyclotron resonance scattering feature, which implies a magnetic field of $3.6 \cdot 10^{12}$ G [158]. A tentative detection of a cyclotron resonant feature in absorption was also earlier presented by Masetti et al. [159].

2214+589. (1H 2214+589) Detected by HEAO1 [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) Discovered by BeppoSAX (see [48]). SAX J2239.3+6116 is an X-ray transient which often recurs with a periodicity of 262 d [160]. Because of the Be-star nature of the likely optical counterpart the periodicity may be identified with the orbital period of the binary. Pulse fraction was determined from the graph in [48] as $(I_{\max} - I_{\min})/(I_{\max} + I_{\min})$. It corresponds to the energy range $\sim 1 - 10$ 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 LMC: comments to the table 3

insert Table 3 here <——————————————————>

J0501.6-7034. (RX J0501.6-7034, 2E 0501.8-7038, 1E 0501.8-7036, HV 2289, CAL 9) This Einstein 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 $\sim 3 \cdot 10^{36}$ erg s^{-1}. The source was detected three times with the ROSAT PSPC at luminosities $\sim 10^{35} - 10^{36}$ erg s^{-1} and once with the HRI during a bright outburst at $4 \cdot 10^{37}$ erg s^{-1} [168]. During the outburst, pulsations at 4.0635 s were detected. 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 ($5 \cdot 10^{34}$ erg s^{-1}) in early 90-s by ROSAT [165]. The light curve of the optical counterpart exhibits significant modulation with a period of 24.4 d, 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] present new optical and IR 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_α 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 outburst observed with BeppoSAX. The pulsed fraction is nearly constant in the whole energy range. The source shows pulsations from 0.1 up to 60 keV. In the MECS (Medium Energy Concentrator Spectrometer) pulse profile in the 1.8-10.5 keV band the pulsed fraction is 0.54 ± 0.05. In the LECS (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 pulsed fraction is 0.78 ± 0.28. The PDS (Phoswich Detection System) pulse profile (15-60 keV energy band) still shows a double-peaked structure (pulsed fraction is 0.64 ± 0.16) in phase with the previous ones. Although the statistics is poor, the pulsed fraction does not seem to decrease with energy [164].

J0531.5-6518. (RX J0531.5-6518) This source was detected with the ROSAT PSPC 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 disk-less phase [161].

J0535.0-6700. (RX J0535.0-6700) This source was observed by the ROSAT PSPC at a luminosity $\sim 3 \cdot 10^{35}$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 likely it is the optical counterpart to RX J0535.0-6700

[161]. The star displays periodic variability in its I-band lightcurve at 241 d, 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 5 satellite in June 1977, during outburst in which the flux peaked at $\sim 9 \cdot 10^{38}$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-Cygni-like emission lines, and brightening by more than 2 mag in the V band [177]. The Be star has a V magnitude of $\sim$ 14.9 during the X-ray quiescent periods. The magnitude reaches a peak of 12.3 mag 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 luminosity around 10^{39} ergs^{-1}. ROSAT [180] and ASCA observations [181] have revealed low-level outbursts with luminosities of $4 \cdot 10^{37}$ erg s^{-1} and $2 \cdot 10^{37}$ erg s^{-1} in the two ROSAT observations and $\sim 5.5 \cdot 10^{36}$ erg s^{-1} in the ASCA observation. Due to 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 > 1000. Alcock et al. [182] reported the discovery of 421 day periodicity.

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 B0-1 V 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 B0 Ve. van der Klis et al. [184] published photometry which showed a negative correlation between optical magnitudes and color 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 the state of low activity. They detected H_α and H_β 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 lightcurve and H_α in emission. An approximate spectral type of B0 Ve was proposed.

2.3 Sources in the SMC: comments to the table 4, 5 and 6

In this subsection we often refer to the well known "A New Catalogue of H_α Emission Line Stars and Small Nebulae in the Small Magellanic Cloud" by Meyssonnier and Azzopardi [187]; below we use an abbreviation MA93 for this catalogue in the comments for particular objects.

insert Table 4, 5 and 6 here <——————————————————>

J0032.9-7348. (RX J0032.9-7348) This source was discovered by Kahabka and Pietch [233] in ROSAT pointed observations made in 1992 December and 1993 April. Stevens et al. [185] identified two Be stars within PSPC 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 ROSAT PSPC. 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 with a factor of 9 and has an emission-line object 172 in MA93 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 diagram [234].

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 with a factor of ~ 5 [192]. An emission-line object, No. 215 in MA93, 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 MA93 is the brightest optical object in the error circle of RX J0048.5-7302 [8]. A Be/X-ray binary interpretation is 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 [233] in pointed observations. Yokogawa and Koyama [193] reported X-ray pulsations in ASCA data of this source. The X-ray flux in the band 0.7-10 keV was $1.2 \cdot 10^{-11}$ 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 arcsec from the X-ray position and one just outside the error circle given by Kahabka and Pietch [233]. Yokogawa et al. [195] reported on the results of two ASCA observations of this X-ray source. The pulse fraction was $\sim 70\%$ independent of the X-ray energy. Using MACHO and OGLE-II data, Schmidtke and Cowley [194] found a strong periodicity at $P = 33.3$ days, which is likely 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

H_α bright object coincides with this X-ray source. Coe et al. [188] proposed this object as a more likely counterpart to the ASCA SXP9.13 pulsar. However, other authors have proposed RX J0049.4-7310, as the correct identification for SXP9.13 pulsar [236, 197].

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 $8 \cdot 10^{-13}$ 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 these two possibilities can be obtained by measuring the pulse period derivative and its orbital modulation. Two sources, No. 427 and No. 430, in the ROSAT PSPC 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 No. 427, but found no counterpart for source No. 430. Hence, they suggest that source No. 427 is more likely to be a counterpart of AX J0049-732. However, the angular separation of these sources of 1.43 arcmin is significantly larger than the ASCA error radius. And Ueno et al. [196] propose that No. 430 is a more likely counterpart. Schmidtke et al. [197] 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 is most likely identified with the emission-line object 302 in MA93 [8].

J0049.7-7323. (AX J0049.4-7323, AX J0049.5-7323, RX J0049.7-7323) This X-ray source has been detected 5 times to date, 3 times by the ASCA observatory [240] and 2 times by the RossiXTE spacecraft [205]. Ueno et al. [198] reported an ASCA observation which revealed coherent pulsations of period 755.5 ± 0.6 s from a new source in the Small Magellanic Cloud. The spectrum was characterized by a flat power-law function with photon index 0.7 and X-ray flux $1.1 \cdot 10^{-12}$ 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 [222] reported on the spectroscopic and photometric analysis of possible optical counterparts to AX J0049.4-7323. They detected strong H_α 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] analyzed the long term light curve of the optical counterpart obtained from the MACHO date base. They showed that the optical object exhibited outbursts every 394 d which they proposed to be the orbital period of the system. They also showed the presence of a quasi-periodic modulation with a period $\sim$ 11d which they associated with the rotation of the Be star disk. The phase of two RXTE detections is exactly syncronised with the ephemeris derived from the optical outbursts. Therefore, as Coe and Edge [242] concluded, the period of 394 d can represent the binary period of a system with X-ray outbursts syncronised 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 Einstein IPC, ROSAT PSPC and HRI archival data and 18 year history shows flux variations by at least a factor of 10 [200]. The source was reported as a 323 s pulsar by Yokogawa and Koyama [243] and Imanishi et al. [200]. Subsequently Cook [244] identified a 0.7 d optically variable object within the ASCA X-ray error circle. Long term optical data from over 7 years revealed both a 1.4d modulation and an unusually rapid change in this possible binary period [199]. 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 modeled 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 d and it would be an extremely compact system. In addition, the combination of the pulse period and such a binary period violates the Corbet relationship for such systems [101]. Raguzova and Lipunov [245] calculated the critical orbital period for the existence of a Be+X-ray pulsar binary, which is $\sim 10-20$ d. They proposed an explanation for the lack of Be stars with accreting neutron star as companions with orbital periods less than 10 days as caused by synchronization of Be star during its evolution. Coe et al. [199] reported on extensive new data sets from both OGLE and MACHO, as well as on detailed photometric study of the field. Their results reveal many complex observational features that are hard to explain in the traditional Be/X-ray binary model.

J0050.7-7332. (RX J0050.7-7332) This source was only once detected by the ROSAT PSPC. 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 is most likely identified with the emission-line object 414 in MA93, suggesting a Be/X-ray binary [8].

J0051-722. (AX J0051-722, RX J0051.3-7216) This source was at 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. [197] 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 RX J0051.3-7250 as Be/X-ray binary,

J0051-727. (XTE J0051-727) Corbet et al. [202] have detected this new transient X-ray pulsar in the direction of the SMC with the RXTE Proportional Counter Array. The object showed the $1.6-1.7$ mCrab flux in the 2-10 keV band.

J0050-732#1. (XTE J0050-732#1) This source was discovered by Lamb et al. [203] from archival data of RXTE.

J0050-732#2. (XTE J0050-732#2) This source was discovered by Lamb et al. [203] 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 HRI observations of Einstein IPC source 25 and identified with 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 observations. The X-ray luminosity, time variability and hard spectrum led Kahabka and Pietch [233] to suggest a Be/X-ray binary nature for the source. Israel et al. [206] discovered 8.9 s X-ray pulsations in 2E 0050.1-7247 during a systematic search for periodic signals in a sample of ROSAT PSPC light curves. The signal had a nearly sinusoidal shape with a 25-percent pulsed fraction. The source was detected several times between 1979 and 1993 at luminosity levels ranging from $5 \cdot 10^{34}$erg s^{-1} up to $1.4 \cdot 10^{36}$erg s^{-1} with both the Einstein IPC and ROSAT PSPC. 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_α 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. [188] 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 have found two emission-line objects 521 and 487 from MA93 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, Jernigan and Clark [207] with SAS 3. This long-known X-ray source was not detected by the ROSAT PSPC. But it is included in the HRI catalogue. SMC X-3 has been identified with a previously detected 7.78s RXTE pulsar by using archive Chandra Data [201] . The Be star counterpart corresponds to object 531 in MA93.

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] with the analysis of ROSAT HRI 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 $2.6 \cdot 10^{-11}$ erg cm^{-2}s^{-1}. Covino et al. [208] reported on the discovery and confirmation of the optical counterpart of this transient X-ray pulsar. They found a $V = 14.6$ O9.5 IIIe star (a classification as a B0Ve star is also possible since the luminosity class depends on the uncertainty on 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 $> 99\%$. The lower energy band (0.3-2.5 keV) contained about 60% of the photons but had a pulsed fraction of only $28\% \pm 2\%$ as compared to $42\% \pm 3\%$ in the higher energy band (2.5-10 keV) [201]. This source has been identified with the optical counterpart MACS J0052-726#004 [255].

J0052-723. (XTE J0052-723) Corbet, Marshall and Markwardt [256] discovered this transient X-ray pulsar in the direction of the Small Magellanic Cloud from RXTE PCA observations made on 2000 December 27 and 2001 January 5. Pulsations were seen with a period of 4.782 ± 0.001 s and with a double-peaked pulse profile. Spectroscopy of selected optical candidates [209] has identified the probable counterpart which is a B0V-B1Ve SMC member exhibiting a strong, double peaked H_α emission line.

0051.1-7304. (2E 0051.1-7304, AzV 138) This source is listed as entry 31 in the Einstein IPC 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 HRI observations of Einstein IPC 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 spin period $\sim$ 169 s was discovered with RXTE [259, 192] detected coherent pulsations with 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)/(total flux) without background, is 44% in 2.0-7.0 keV [210].

J005323.8-722715. (CXOU J005323.8-722715, RX J0053.5-7227) A precise ROSAT HRI position coincident with the emission-line star 667 in MA93 (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 an evidence of a period of 125 ± 1.5 days. This period would be consistent with that predicted from the Corbet diagram [101] for a 138s Be/X-ray pulsar.

XTE SMC 95. The source has been revealed during RXTE observations of the Small Magellanic Cloud. The pulsar was detected in three Proportional Counter Array (PCA) observations during an outburst [211]. 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 $> 2 \cdot 10^{37}$ erg s^{-1}.

J0055-727. (XTE J0055-727) This source was detected with the RXTE PCA [212]. Regular monitoring of the Small Magellanic Cloud with the RXTE PCA has revealed a periodicity of 34.8 days in the pulsed flux from this X-ray pulsar [213]. 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 XTE J0055-727 being a Be star system. Corbet et al. [212] noted the presence of the emission line objects AzV164 and 829 in MA93 close to the center 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 PSPC archive and also was observed by the Einstein IPC. Its X-ray properties, namely the hard X-ray spectrum, flux variability and column density indicate a hard, transient source with a luminosity of $3.8 \cdot 10^{35}$ 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_α and weaker H_β emission. Optical colors 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 about 25% [214]. Lochner [214] suggested a possible orbital period of this Be/X-ray system 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 IPC survey [263]. In ROSAT observations this transient source was detected only once ([233]). It is thought to be a Be/X-ray binary, since a Be star was found as its optical counterpart [215]. 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 [265, 220]. The source was in low luminosity state during the XMM-Newton observation [221]. In order to estimate the flux upper limit [221] used spectral parameters derived by Yokogawa et al. [266] from the ASCA spectrum during the outburst. They obtained an upper limit for the un-absorbed flux of $1.5 \cdot 10^{-14}$ erg cm^{-2}s^{-1}, corresponding to $L_{\rm x} = 6.5 \cdot 10^{33}$ 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 MA93 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) Small ROSAT error box of this source contains an emission-line star (809 in MA93) with typical Be star characteristics, it is the brightest object in the area of localization. A factor of five X-ray flux variability strengthens the identification as Be/X-ray binary. A probable binary period of 268 days has been detected in the optical counterpart [216]. The relationship between this orbital period and the pulse period of 504s is within the normal variance found in the Corbet diagram [234].

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 59s [132, 267]. Lochner et al. [217] have suggested the orbital period equal to 65 days from subsequent X-ray outbursts. Laycock et al. [205] have obtained the 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 [221]. The optical counterpart, a Be star, is identified with 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 [218]. The optical brightness and colors are consistent with expectations for a Be star companion, and the X-ray spectra are consistent with

Be/X-ray binary. Using MACHO and OGLE-II data, Schmidtke and Cowley [194] obtained the 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% [201]. The position of this pulsar is within 3 arcsec of the ROSAT source 2RXP J005527.1-721100. The latter is coincident with a 16.8 V magnitude optical source having a B-V color 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 source 2E 0054.4-7237 cintains an emission line object. Therefore, it was suggested as a Be/X-ray binary candidate [221]. 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 [221]. XMMU J005605.2-722200 is most likely 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. [219] 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 either a Be, an OB supergiant, or a low-mass star. Yokogawa et al. [219] 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 [225] where it was reported to have a pulse period of 565.83s. This X-ray source was also found by Sasaki, Pietsch and Haberl [221] in XMM-Newton EPIC data. XMMU J005735.6-721934 has a hard spectrum and positionally coincides with emission line object 1020 in MA93. 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, Pietsch and Haberl [221] 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 due to 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 MA93 suggested as a likely optical counterpart [8]. Sasaki, Pietsch and Haberl [221] 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. [225].
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 MA93 [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 ROSAT HRI. Its optical counterpart is a variable Be star in the SMC, OGLE 00581258-7230485 [268]. Schmidtke et al. [223] have proposed the 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 ROSAT PSPC 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 > 3 KeV and 0.5-3.0 keV bands respectively. Furthermore, the emission is pulsed with a period of ~ 2.7 s [270]. In [270] it is reported that pulsed fraction chenages from nearly zero at low energies (0.07–0.4 keV) up to $\sim 50\%$ at 1-2.4 keV. Kohno et al. [224] reported intermediate value $\sim 37\%$. Southwell and Charles [272] identified the probable optical counterpart of this source with a 14th-magnitude B1 III 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, Lamb and Macomb [191]. There are two variable stars in both the OGLE (OGLE 151891) and MCPS (MCPS 3345630) catalogs which are suggested as the optical counterparts for this X-ray source. The angular distance between these two catalog stars is only 0.3 arcseconds, consistent with being the same source [191]. 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, Pietsch and Haberl [221] in XMM-Newton EPIC data. XMMU J010030.2-722035 has a hard spectrum and positionally coincides with emission line object 1208 in MA93. 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 [233] at a luminosity of $1.3 \cdot 10^{36}$ erg s^{-1}. The source showed a luminosity of $3 \cdot 10^{33}$ ergs^{-1} in the ROSAT band (0.1-2.4 keV) during two XMM-Newton observations [221]. Pulsations with a period of 304.49 ± 0.13 s were discovered in Chandra data [225]. This period could not be verified in the XMM-Newton observation, because the source was too faint. Edge and Coe [222] presented results on the optical analysis of likely counterparts, discussing two objects (Nos. 1 and 4) in the ROSAT PSPC error circle. They conclude that the optical counterpart is object No. 1 which is confirmed to be a Be star.
J0101.3-7211. (RX J0101.3-7211) The source was detected in ROSAT obser-

vations 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 J0101.67204 with object 1277 in MA93 from two accurate positions from ROSAT HRI and PSPC observations. The factor of three variability 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 as a Be/X-ray binary. They proposed the emission-line star 1288 in MA93 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 HRI and PSPC error circles.

J0103-728. (XTE J0103-728) This source was detected with the RXTE Proportional Counter Array [226].

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, 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 with object 1393 in MA93. RX J0103.6-7201 shows variability by a factor of three between the ROSAT observations, consistent with a Be/X-ray binary. Recently Haberl and Pietsch [227] reported the discovery of 1323 s periodicity of this source.

J0104.1-7244. (RX J0104.1-7244) The most likely identification with emission-line star 1440 in MA93 suggests RX J0104.1-7244 as 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 ROSAT PSPC but the accurate HRI position included only the emission-line object 1470 from MA93 as a bright object in the error circle. RX J0104.5-7221 is therefore very likely 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 PSPC 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 & Azzopardi in the X-ray error circle as a likely optical counterpart. This catalogue contains several known Be/X-ray binaries strongly suggesting RX J0105.1-7211 as 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 MA93) was found in the small ROSAT PSPC error circle (source 120) [8], which made the identification of RX J0105.9-7203 as 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 pointlike X-ray source with a blue optical counterpart and H_α

emission.
J0107.1-7235. (RX J0107.1-7235, AX J0107.2-7234,2E 0105.7-7251) Haberl and Sasaki [8] have identified this source with the emission-line star 1619 in MA93. A Be/X-ray binary nature is likely.
0107-750. (1H 0103-762, H 0107-750) This source is a very bright UV object with prominent H_α and H_β 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 [275, 15] identified this source as a 31 s X-ray pulsar with a flux in the 0.7-10 keV band of $3.6 \cdot 10^{-10}$ erg cm^{-2}s^{-1} and $\sim 45\%$ pulsed fraction. 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. [208] 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, Haigh and Reig [277] as the most plausible counterpart for XTE J0111.2-7317. Coe et al. [188] give visual magnitude $V = 15.52$. There is also evidence for the presence of a surrounding nebula, possibly a supernova remnant [208].
J0117.6-7330. (RX J0117.6-7330) This X-ray transient was discovered by the PSPC on board ROSAT [278, 279]. Soria [229] 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 B0.5 IIIe star. Macomb et al. [280] reported on the detection of pulsed, broadband, X-ray emission from this transient source. The pulse period of 22 s was detected by the ROSAT/PSPC instrument and by the Compton Gamma-Ray Observatory/BATSE instrument. The total directly measured X-ray luminosity during the ROSAT observation was $1.0 \cdot 10^{38}$ erg s^{-1}. The pulse frequency increased rapidly during the outburst with a peak spin-up rate of $1.2 \cdot 10^{-10}$ Hz s^{-1} and a total frequency change of 1.8%. The pulsed percentage was 11.3% from 0.1-2.5 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 PSPC. An emission-line object in the error circle suggests an 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 [231]. Coe and Gaensicke [281] identified two emission-line optical counterparts were first identified by searching the XTE error box using SIMBAD : 1864 in MA93 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. [232] have detected this transient X-ray pulsar in the Small Magellanic Cloud with the RXTE Proportional Counter Array. They interpreted the outburst recurrence period as the orbital period of a neutron/Be 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 the first figure we show a usual period – luminosity dependence. If luminosity is proportional to $\dot{M}$ – an accretion rate – then for each value of L it is possible to determine a critical period, $P_{\rm A}$ (see details on the magneto-rotational evolution of neutron stars, for example, in [282]). It is determined by an equality of the magnetospheric radius to the corotation radius, so $P_{\rm A}$ depends also on the magnetic field of a neutron star. If a spin period of a neutron star is shorter than $P_{\rm A}$ then 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. 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 figure caption for other details).

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

insert Figure 1 and 2 here <————————————————————>

The observational number distributions of Be/X-ray binaries over orbital characteristics are shown in figs. 3 and 4. It is clear that Be-systems do not have orbital periods longer than one year. There is a lack of systems with periods 10–20 days. As it was shown in the paper by [245] the lack of short-period Be/X-ray binaries can be explained by the effect of tidal synchronization in 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 get a better agreement with the observed parameters of Be/X-ray binaries there is no necessity of high kicks. Moderate recoil velocities of the order 50 km s^{-1} are enough (see [245]). It can be a particular feature of Be/X-ray binaries [123].

insert Figure 3 and 4 here <————————————————————>

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References

[1] I. Negueruela, astro-ph/0411335 (2005).

[2] S.B. Popov S.B. and N.V. Raguzova, astro-ph/0405633 (2004).

[3] Q.Z. Liu, J. van Paradijs and 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, Information Bulletin on 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, J. Fabregat, A.E. Tarasov and R.K. Zamanov, Mon. Not. R. Astron. Soc. **317** 205 (2000).

[12] J.B. Hutchings and D. Crampton, Pub. Astron. Soc. Pac. **93** 486 (1981).

[13] I. Negueruela, P. Roche, J. Fabregat and M.J. Coe, Mon. Not. R. Astron. Soc. **307** 695 (1999).

[14] H. Delgado-Marti, A.M. Levine, E. Pfahl and S.A. Rappaport, Astrophys. J. **546** 455 (2001).

[15] J. Yokogawa, K. Imanishi, M. Tsujimoto, M. Nishiuchi, K. Koyama, F. Nagase and R.H.D. Corbet, Astrophys. J. Suppl. Ser. **128** 491 (2000).

[16] I. Negueruela, P. Reig, M.H. Finger and P. Roche, Astron. Astrophys. **356** 1003 (2000).

[17] V.V. Borkus, A.S. Kaniovsky, R.A. Sunyaev, *et al.*, Astron. Lett. **24** 350 (1998).

[18] F. Frontera, D. dal Fiume, E. Morelli and G. Spada, Astrophys. J. **298** 585 (1985).

[19] P. Kaaret, S. Piraino, J. Halpern and M. Eracleous, Astrophys. J. **523** 197 (1999).

[20] G. Cusumano, M.C. Maccarone, L. Nicastro, B. Sacco and P. Kaaret, Astrophys. J. **528** L25 (2000).

[21] R.H.D. Corbet and A.G. Peele, Astrophys. J. **489** L83 (1997).

[22] P. Reig, I. Negueruela, D.A.H. Buckley, M.J. Coe, J. Fabregat and N.J. Haigh, Astron. Astrophys. **367** 266 (2001).

[23] P. Reig and P. Roche, Mon. Not. R. Astron. Soc. **306** 95 (1999).

[24] Wilson R.B., B.A. Harmon, D.M. Scott, M.H. Finger, C.R. Robinson, D. Chakrabarty and T.A. Prince, 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 and F.E. Marshall, 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, M. Pakull and E. Janot-Pacheco, 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, edited by M. Smith, H. Henrichs and J. Fabregat, ASP Conference Proceedings **214** p. 739 (2000).

[35] F.E. Marshall, J.C. Lochner and T. Takeshima, IAU Circ., **6777** 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, J. Swank and D. Chakrabarty, IAU Circ. **6826** 1 (1998).

[40] C.A. Wilson, M.H. Finger, M.J. Coe and I. Negueruela, Astrophys. J. **584** 996 (2003).

[41] B. Paul, P.C. Agrawal, K. Mukerjee, A.R. Rao, S. Seetha and K. Kasturirangan, Astron. Astrophys. **370** 529 (2001).

[42] S.S. Tsygankov and A.A. Lutovinov, Astron. 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, M.J. Coe, J. Greiner, P. Reig and G. Papamastorakis, 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 and C.B. Markwardt, 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 and A.N. Parmar, 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, F. Nagase and S. Skinner, Publ. Astron. Soc. Jap. **46** L93 (1994).

[53] T. Horaguchi, T. Kogure, R. Hirata, *et al.*, Publ. Astron. Soc. Jap. **46** 9 (1994).

[54] T. Murakami, K. Koyama, H. Inoue and P.C. Agrawal, Astrophys. J. **310** L31 (1986).

[55] S. Kubo, T. Murakami, M. Ishida and R.H.D. Corbet, Publ. Astron. Soc. Jap. **50** 417 (1998).

[56] R.D. Robinson and M.A. Smith, Astrophys. J. **540** 474 (2000).

[57] R. Giacconi, S. Murray, H. Gursky, E. Kellogg, E. Schreier and H. Tananbaum, Astrophys. J. **178** 281 (1972).

[58] W. Forman, C. Jones, L. Cominsky, *et al.*, Astrophys. J.S **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, K. Hayashida and F. Nagase, Astrophys. J. **389** 676 (1992).

[64] L. Bildsten, D. Chakrabarty, J. Chiu, *et al.*, Astrophys. J.S **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, W. Mayer, and S. Rappaport, Nature **273** 367 (1978).

[69] M. Johnston, H. Bradt, R. Doxsey, H. Gursky, D. Schwartz and J. Schwarz, Astrophys. J. **223** 71 (1978).

[70] M. Johns, A. Koski, C. Canizares and J. McClintock, 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, F. Li and P.C. Joss, Astrophys. J. **224** L1 (1978).

[73] K. Makishima, T. Mihara, F. Nagase and Y. Tanaka, 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 and M. Roth, 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 and A. Reid, Astrophys. J. **339** 1054 (1989).

[80] P.C. Gregory, Astrophys. J. **520** 361 (1999).

[81] L. Stella, N.E. White, J. Davelaar, A.N. Parmar, R.J. Blissett and M. van der Klis, 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.*, Publ. Astron. Soc. Jap. **36** 679 (1984).

[84] S. Campana, L. Stella, G.L. Israel, A. Moretti, A.N. Parmar and M. Orlandini, 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 and P. Murdin, 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 and D. Westpfahl, Pub. Astron. Soc. Pac. **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 and A.E. Tarasov, Mon. Not. R. Astron. Soc. **286** 549 (1997).

[93] J.H. Telting, L.B.F.M. Waters, P. Roche, A.C.A. Boogert, J.S. Clark, D. de Martino and P. Persi, 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,R.E. Rothschild, R. Staubert, J. Wilms, and I. Kreykenbohm, Astrophys. J. **552** 738 (2001).

[96] F.D. Rosenberg, C.J. Eyles, G.K. Skinner and A.P. Willmore, Nature **256** 628 (1975).

[97] F. Li, G.W. Clark, J.G. Jernigan and S. Rappaport, 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, D. Chakrabarty, M.J. Coe, J. Fabregat, and P. Reig, Astron. Astrophys. **315** 160 (1996).

[100] R.H.D. Corbet and 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] G. Hasinger, W. Pietsch and T. Belloni, IAU Circ. **5142** 2 (1990).

[105] F. Makino, IAU Circ. **5148** 2 (1990).

[106] T. Aoki, T. Dotani, K. Ebisawa, *et al.*, Publ. Astron. Soc. Jap. **44** 641 (1992).

[107] S. Grebenev and R. Sunyaev, IAU Circ. **5294** 2 (1991).

[108] C.A. Wilson, M.H. Finger, B.A. Harmon and D.M. Scott, 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 and F.D. Rosenberg, 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 and M. Mouchet, 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 and H.V. Bradt, Astron. Astrophys. **89** 249 (1980).

[120] R.L. Kelley, R.E. Doxsey, J.G. Jernigan, S. Rappaport, K.M.V. Apparao and S. Naranan, 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, S. Rappaport, A. Heger and E. Pfahl, 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, D.T. Koh, T.A. Prince, B.A. Vaughan and D. Chakrabarty, Astrophys. J. **488** 831 (1997).

[127] M.J.L. Turner, H.D. Thomas, B.E. Patchett, *et al.*, Publ. Astron. Soc. Jap. **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, R.H.D. Corbet, F.E. Marshall, J.H. Swank and D. Chakrabarty, 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.*, Astron. 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, C. Izzo and P. Ferri, Astrophys. J. **338** 359 (1989).

[139] A.N. Parmar, L. Stella, P. Ferri and N.E. White, 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, S. Laycock and J. Fabregat, Astrophys. J. **570** 387 (2002).

[142] C.A. Wilson, M.H. Finger, B.A. Harmon, D. Chakrabarty and T. Strohmayer, 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. Astroph. **337**, L25 (1998).

[145] A. Baykal, M.J. Stark and J.H. Swank, Astrophys. J. **544** 129 (2000).

[146] P. Reig and F. Mavromatakis, 2003, The Astronomer's 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, J. Swank and M.J. Stark, Astrophys. J. **616** 463 (2004).

[149] M.P. Ulmer, W.A. Baity, W.A. Wheaton and L.E. Peterson, 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. Astroph. **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. Astroph. **438** 963 (2005).

[159] N. Masetti, D. Dal Fiume, L. Amati,*et al.*, Astron. Astroph. **423** 311 (2004).

[160] J.J.M. in't Zand, J. Halpern, M. Eracleous,*et al.*, Astron. Astroph. **361** 85 (2000).

[161] I. Negueruela and M.J. Coe, Astron. Astroph. **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 and A.B. Hill, Mon. Not. R. Astron. Soc. **349** 1361 (2004).

[164] L. Burderi, T. di Salvo, N.R. Robba, S. del Sordo, A. Santangelo and A. Segreto, Astrophys. J. **498** 831 (1998).

[165] P.C. Schmidtke, A.P. Cowley, L.M. Frattare, T.K. McGrath, J.B. Hutchings and D. Crampton,, Publ. Astron. Soc. Pac. **106** 843 (1994).

[166] P.C. Schmidtke, A.P. Cowley, P.H. Hauschildt, *et al.*, Publ. Astron. Soc. Pac. **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 and A.L. Anderson, Publ. Astron. Soc. Pac. **107** 450 (1995).

[169] R. Wooley, R. Obs. Bull. **66** 263 (1963).

[170] M.J. Coe, I. Negueruela, D.A.H. Buckley, N.J. Haigh, and S.G.T. Laycock, Mon. Not. R. Astron. Soc. **324** 623 (2001).

[171] F. Haberl, K. Dennerl, W. Pietsch and K. Reinsch, Astron. Astroph. **318** 494 (1997).

[172] M. Pakull, H. Brunner, A. Staubert, W. Pietsch, and K. Beuermann, Space Sci. Rev. **40** 379 (1985).

[173] F. Haberl, K. Dennerl and W. Pietsch, Astron. Astroph. **302** L1 (1995).

[174] F. Haberl F. and W. Pietsch, Astron. Astroph. **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, D. Leahy, M.C. Weisskopf and J. Grindlay, 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. Astroph. **274** 304 (1993).

[181] R.H.D. Corbet, A.P. Smale, P.A. Charles and K.A. Southwell, 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. Astroph. **337** 772 (1998).

[187] N. Meyssonnier and M. Azzopardi, Astron. Astroph. Supp. **102** 451 (1993).

[188] M.J. Coe, W.R.T. Edge, J.L. Galache and V.A. McBride, Mon. Not. R. Astron. Soc. **356** 502 (2005).

[189] F. Haberl and W. Pietsch, Astron. Astroph. **414** 667 (2004).

[190] W.R.T. Edge, M.J. Coe and J.L. Galache, The Astronomer's Telegram, **405** 1 (2005).

[191] W.A. Majid, R.C. Lamb and D.J. Macomb, Astrophys. J. **609** 133 (2004).

[192] J. Yokogawa, K. Imanishi, M. Tsujimoto, K. Koyama and M. Nishiuchi, Publ. Astron. Soc. Jpn. **55** 161 (2003).

[193] J. Yokogawa and K. Koyama, IAU Circ. **6835** 1 (1998)

[194] P.C. Schmidtke and A.P. Cowley, Bull. Am. Astron. Soc. **205** 10213 (2004).

[195] J. Yokogawa, K. Imanishi, M. Tsujimoto, M. Kohno and K. Koyama, Publ. Astron. Soc. Jpn. **51** 547 (1999).

[196] M. Ueno, J. Yokogawa, K. Imanishi and K. Koyama, Publ. Astron. Soc. Jpn. **52** L63 (2000).

[197] P.C. Schmidtke, A.P. Cowley, L. Levenson and K. Sweet, Astron. J. **127** 3388 (2004).

[198] M. Ueno, J. Yokogawa, K. Imanishi and K. Koyama, IAU Circ. **7442**, 3 (2000).

[199] M.J. Coe, N.J. Haigh, S.G.T. Laycock, I. Negueruela and C.R. Kaiser, Mon. Not. R. Astron. Soc. **332** 473 (2002).

[200] K. Imanishi, J. Yokogawa, M. Tsujimoto and K. Koyama, Publ. Astron. Soc. Jpn. **51** L15 (1999).

[201] W.R.T. Edge, M.J. Coe, J.L. Galache, *et al.*, Mon. Not. R. Astron. Soc. **353** 1286 (2004).

[202] R.H.D. Corbet, C.B. Markwardt, M.J. Coe, *et al.*, The Astronomer's Telegram, **273** 1 (2004).

[203] R.C. Lamb, D.J. Macomb, T.A. Prince and W.A. Majid, Astrophys. J. **567** L129 (2002).

[204] J. Yokogawa, K. Torii, K. Imanishi and K. Koyama, Publ. Astron. Soc. Jpn. **52** L37 (2000).

[205] S. Laycock, R.H.D. Corbet, M.J. Coe, *et al.*, Astrophys. J.S **161** 96 (2005).

[206] G.L. Israel, L. Stella, L. Angelini, N.E. White and P. Giommi, IAU Circ. **6277** 1 (1995).

[207] F. Li, G. Jernigan and G. Clark, 1977, IAU Circ., 3125, 1

[208] S. Covino, I. Negueruela, S. Campana, *et al.*, Astron. Astroph. **374** 1009 (2001).

[209] S. Laycock, R.H.D. Corbet, M.J. Coe, *et al.*, Mon. Not. R. Astron. Soc. **339** 435 (2003).

[210] J. Yokogawa, K. Torii, T. Kohmura and K. Koyama, Publ. Astron. Soc. Jpn. **53** L9 (2001).

[211] S. Laycock, R.H.D. Corbet, D. Perrodin, *et al.*, Astron. Astroph. **385** 464 (2002).

[212] R.H.D. Corbet, C.B. Markwardt, M.J. Coe *et al.*, The Astronomer's Telegram **214** 1 (2003).

[213] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, The Astronomer's Telegram, **347** 1 (2004).

[214] J.C. Lochner, IAU Circ. **7007** 2 (1998).

[215] P. Murdin, D.C. Morton and R.M. Thomas, Mon. Not. R. Astron. Soc. **186** 43 (1979).

[216] W.R.T. Edge, M.J. Coe and J.L. Galache, The Astronomer's Telegram **426** 1 (2005).

[217] J.C. Lochner, L.A. Whitlock, R.H.D. Corbet, *et al.*, Bull. Am. Astron. Soc. **31** 905 (1999).

[218] F. Haberl, W. Pietsch, N. Schartel, P. Rodriguez and R.H.D. Corbet, Astron. Astroph. **420** 19 (2004).

[219] J. Yokogawa, K. Torii, T. Kohmura, K. Imanishi and K. Koyama, Publ. Astron. Soc. Jpn. **52** 53 (2000).

[220] K. Torii, T. Kohmura, J. Yokogawa and K. Koyama, IAU Circ. **7441** 2 (2000).

[221] M. Sasaki, W. Pietsch and F. Haberl, Astron. Astroph. **403** 901 (2003).

[222] W.R.T. Edge and M.J. Coe, Mon. Not. R. Astron. Soc. **338** 428 (2003).

[223] P.C. Schmidtke, A.P. Cowley, L. Levenson, *et al.*, Revista Mexicana de Astronomia y Astrofisica **20** 215 (2004).

[224] M. Kohno, J. Yokogawa and K. Koyama, Publ. Astron. Soc. Jpn. **52** 299 (2000).

[225] D.J. Macomb, D.W. Fox, R.C. Lamb, *et al.*, Astrophys. J. **584** L79 (2003).

[226] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, The Astronomer's Telegram **163** 1 (2003).

[227] F. Haberl and W. Pietsch, Astron. Astroph. **438** 211 (2005).

[228] J.P. Hughes and R.C. Smith, Astron. J. **107** 1363 (1994).

[229] R. Soria, Publ. Astron. Soc. Aus. **16** 147 (1999).

[230] D.J. Macomb, M. Finger, A. Harmon, *et al.*, Bull. Am. Astron. Soc. **31** 670 (1998).

[231] R.H.D. Corbet, C.B. Markwardt, F.E. Marshall, *et al.*, IAU Circ. **8064** 4 (2003).

[232] R.H.D. Corbet, S. Laycock, F.E. Marshall, *et al.*, The Astronomer's Telegram **209** 1 (2003).

[233] P. Kahabka and W. Pietch, Astron. Astroph. **312** 919 (1996).

[234] R.H.D. Corbet, Astron. Astroph. **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. Astroph. **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. Astroph. Supp. **142** 41 (2000).

[239] M.D. Filipović, W. Pietsch and F. Haberl, Astron. Astroph. **361** 823 (2000).

[240] J. Yokogawa, K. Imanishi, M. Ueno and K. Koyama, Publ. Astron. Soc. Jpn. **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. Astroph. **340** 85 (1998).

[246] R.H.D. Corbet, F.E. Marshall, J.C. Lochner, *et al.*, IAU Circ. **6788** 2 (1997).

[247] D.A.H. Buckley, M.J. Coe, J.B. Stevens, *et al.*, IAU Circ. **6789** 2 (1997).

[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.*, Publ. Astron. Soc. Pac. **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. Astroph.S **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. **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. Coe, J.B. Stevens, *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. Supp. **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 and K. Koyama, Publ. Astron. Soc. Jpn. **53** 227 (2001).

[267] A. Santangelo, G. Cusumano, D. dal Fiume, *et al.*, Astron. Astroph. **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, edited by J. Greiner, Lecture Notes in Physics **472** p. 41 (Springer, Berlin, 1996).

[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, The Astronomer's Telegram **123** 1 (2003).

[282] V.M. Lipunov, Astrophysics of Neutron Stars (Springer-Verlag, Berlin, 1992).

[283] S. Campana, F. Gastaldello, L. Stella, *et al.*, Astrophys. J. **561** 924 (2001).

[284] N.R. Ikhsanov, Astron. Astroph. **399** 1147 (2003).

[285] R.E. Davies and J.E. Pringle, Mon. Not. R. Astron. Soc. **196** 209 (1981).

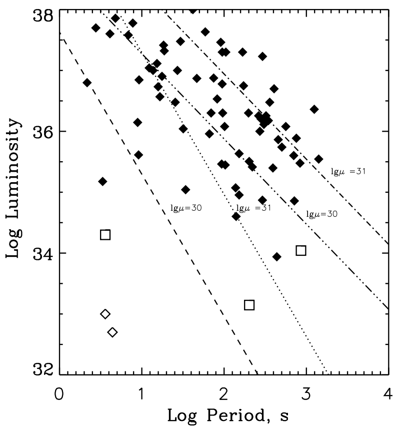

Figure 1: Period – Luminosity. Open symbols correspond to the quiescent state of the X-ray pulsar. Squares represent three sources in quiescence from which pulsations were observed (4U 0115+63 – Campana et al. [283]; RX J0440.9+4431 and RX J1037.5-564 – Reig and Roche [26]). Open diamonds show objects without pulsations in quiescence, which are supposed to be in the *propeller* state (4U 0115+63 and V0332+53 – Campana et al. [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 fastly rotating neutron stars: J0635+0533 (small luminosity) and 0535-668 (large luminosity). Dashed and dotted lines correspond to the critical period, $P_\mathrm{A} = 2^{5/14}\pi(GM)^{-5/7}(\mu^2/\dot{M})^{3/7}$, for two values of the magnetic moment, $\mu = 10^{30}$ G cm^3 and 10^{31} G cm^3. The two dashed-dotted lines correspond to subsonic propeller – accretor transition for the same two values of the magnetic moment which occurs at $P_\mathrm{crit} = 81.5\mu_{30}^{16/21}L_{36}^{-5/7}$ according to Ikhsanov [284]. We note that the multiplicative coefficient in Ikhsanov's formula is larger than in the classical formula of Davies and Pringle [285] by a factor ~ 7.5.

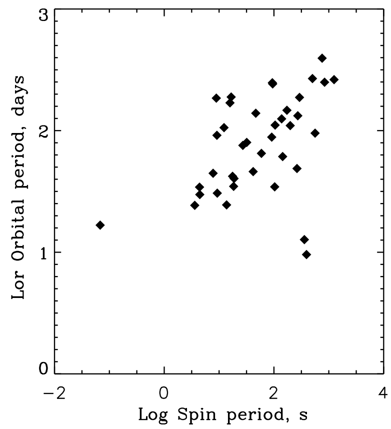

Figure 2: Spin period – Orbital period. Data points for 39 systems are shown. Three displaced systems are: 2206+543 (large spin and short orbital periods), 2103.5+4545 (large spin and short orbital periods) and 0535-668 (very short spin period).

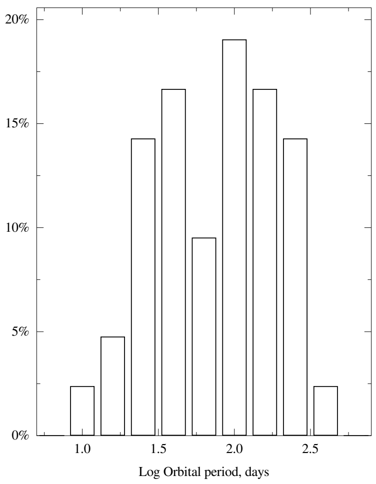

Figure 3: The observational number distribution of Be/X-ray binaries over orbital period.

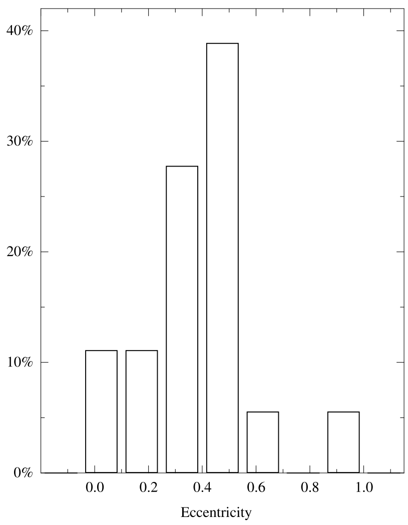

Figure 4: The observational number distribution of Be/X-ray binaries over orbital eccentricity