XRBcats: Galactic High Mass X-ray Binary Catalogue * **

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ABSTRACT

Context. We present a new catalogue of high mass X-ray binaries (HMXBs) in the Galaxy that we call the Galactic High Mass X-ray Binary Catalogue (XRBcats), which improves upon the most recent of such catalogues. We include new HMXBs discovered since previous publications and revise the classification for several objects previously considered HMXBs or HMXB candidates. The catalogue includes basic information (e.g. source names, coordinates, types), other data (e.g. distance and X-ray flux estimates, binary system parameters), and other characteristic properties of the 169 HMXBs catalogued. We also present finding charts in several bands

Aims. The aim of this catalogue is to provide a list of all currently known Galactic HMXBs, including basic information on both compact objects and non-degenerate counterpart properties (where available). We also include objects tentatively classified as HXMBs in the literature and give a brief motivation for the classification in each case.

Methods. The catalogue is compiled based on a search of known HMXBs and candidates in all publicly available databases and literature published before May 2023. The relevant properties in various wavelength bands were collected for all objects, either from the literature or using data provided by large-scale surveys. For the latter case, the counterparts in each individual survey were found by cross-correlating positions of identified HMXBs with relevant databases.

Results. An up-to-date catalogue of Galactic HMXBs is presented to facilitate research in this field. Our goal was to collect a larger set of relevant HMXB properties in a more uniform way compared to previously published works.

Key words. catalogues – binaries: close – stars: early-type – X-rays: binaries

Context. We present a new catalogue of high mass X-ray binari X-ray Binary Catalogue (XRBcats), which improves upon the mosince previous publications and revise the classification for several catalogue includes basic information (e.g. source names, coordinate system parameters), and other characteristic properties of the 169 H from the infrared to hard X-rays for each object.

Aims. The aim of this catalogue is to provide a list of all current compact objects and non-degenerate counterpart properties (where in the literature and give a brief motivation for the classification in Methods. The catalogue is compiled based on a search of know literature published before May 2023. The relevant properties in vertice that the literature or using data provided by large-scale surveys. For the literature or using data provided by large-scale surveys. For the cross-correlating positions of identified HMXBs with relevant data Results. An up-to-date catalogue of Galactic HMXBs is presented to of relevant HMXB properties in a more uniform way compared to Key words. catalogues – binaries: close – stars: early-type – X-ray binaries (XRBs) are still the focus of observational X-ray astronomy almost 60 years after their discovery. These systems consist of a compact object, which can be a neutron star (NS), a black hole (BH), or a white dwarf (WD), and a non-degenerate companion providing matter for the accretion powering the X-ray emission. Depending on the mass of the optical companion, XRBs can subdivided into two categories. Systems with low mass optical companions (M_{opt}) ≤ 1M_o are classified as low mass X-ray binaries (LMXBs Chaty 2022), whereas those with higher mass optical companions (M_{opt} ≥ 8M_o) are classified as high mass X-ray binaries (HMXBs, Chaty 2022). In the cases where X-ray binaries (LMXBs Chaty 2022), whereas those with higher mass optical companions ($M_{\rm opt} \gtrsim 8 M_{\odot}$) are classified as high mass X-ray binaries (HMXBs, Chaty 2022). In the cases where the compact object is either a NS or a BH, accretion is usually assumed. However, systems in which the compact object is a WD are commonly considered separately from the first two cases, and are most often referred to as cataclysmic variables (CVs) rather than XRBs due to both physical and historical reasons. The mass gap between LMXBs and HMXBs is populated by a handful of sources (e.g. Her X-1 with an optical companion with a mass of $M_{\rm opt} \sim 2 M_{\odot}$ (Tananbaum et al. 1972), often referred to as intermediate-mass X-ray binaries (IMXBs, Pfahl et al. 2003). Despite the mass of the optical companion, all of these binaries host a compact object, and thus represent endpoints of stellar evolution. Understanding the properties of this population is key

to understanding the evolution of the Galaxy as a whole. Due to their short characteristic lifetimes of $\sim 2 \times 10^7$ years, HMXBs can be considered young systems when compared to LMXBs ($\sim 10^{10}$ years), and are thus good tracers for star forming activity (Grimm et al. 2003). Within the Milky Way such systems are concentrated around the Galactic plane and are often localised within the spiral arms. Similarly to other astrophysical sources, there are still large uncertainties in the spatial distributions, luminosity distributions, numbers, physics, and evolutionary cycles for XRBs. This issue is exaggerated by the fact that we only observe a fraction of the overall population of these systems. However, the number of known objects is ever increasing. It is therefore essential to keep the census of known XRBs and their properties up to date, especially in the era of new large-scale surveys such as eRosita and Gaia that provide a wealth of new observational information across the entire sky. The goal of this paper is therefore to provide such an update for HMXBs. In parallel, similar efforts for LMXBs and IMXBs have been undertaken independently (Avakyan et al. 2023).

As already mentioned, HMXBs constitute a relatively broad class of objects defined based on the mass of the companion star. Depending on the properties of the companion, and the accretion mechanism, they can be divided into several sub-classes. Systems accreting via stellar winds of their optical companion with mass-loss rates of up to $\dot{M} \sim 10^{-6..-5} \rm M_{\odot} \ yr^{-1}$ (Kudritzki & Puls 2000) are usually persistent sources of X-rays and are referred to as supergiant X-ray binaries (SGXBs, Corbet 1986). Within the category of SGXBs are also the highly variable supergiant fast X-ray transients (SFXTs, Negueruela et al. 2006), which are non-accreting most of the time, but show occasional bright flares on timescales of minutes to days with peak fluxes comparable

^{*} The catalogue is available at CDS via anonymous ftp to cdsarc.ustrasbg.fr (130.79.128.5) or via http://cdsarc.u-strasbg.fr/ viz-bin/cat/J/A+A/677/A134

^{**} A web version is publicly accessible at http://astro. uni-tuebingen.de/~xrbcat/

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to other SGXBs. Depending on the mass ratio, accretion can be quasi-symmetric, or focused by gravity via the L1 point, as is the case of Vela X-1 (Kretschmar et al. 2021). In some cases Roche-lobe overflow (RLO) can also occur; the Galactic micro-quasar SS 433 and the first X-ray pulsar ever discovered, Cen X-3, are examples where this mechanism dominates. With mass-loss rates of $\dot{M} \sim 10^{-3} \rm M_{\odot} \, yr^{-1}$ (for a fully developed RLO) these systems have rather short lifetimes (of the order of the thermal timescale of the optical companion), and are thus rare. However, Savonije (1978) showed that an atmospheric RLO is feasible and could be sustained for thousands of years with mass-loss rates below $\dot{M} \sim 10^{-8} \rm{M}_{\odot} \rm{yr}^{-1}$, and indeed more HMXBs of this type are known to exist outside of our own Galaxy. However, the known HMXB population is dominated by Be X-ray binaries (BeXBs, Reig 2011). In these systems the optical companion is either an early-type B star (earlier than B3) or a late-type O star (later than O8), with an equatorial decretion disc. This disc is formed by the material released at the equator of the optical companion due to its high rotation velocity (Balona & Ozuyar 2020). Decretion disc size is known to be variable and can be traced by the characteristic emission lines in the optical spectra of Be star. Passage of the compact object (in the vast majority of cases a NS) through the disc leads to enhanced accretion, especially if the disc is in an expanding state. From an observational point of view, this leads to the appearance of two different kinds of outbursts that are characteristic of BeXB systems. Type I outbursts are periodically occurring events with a typical peak luminosity below 10³⁷erg s⁻¹, normally coinciding with the periastron passage of the compact object. Type II outbursts are more irregular, less frequent events, and are apparently associated with the expansion of the circumbinary disc. Peak luminosity can reach up to 10^{39} erg s⁻¹ (Doroshenko et al. 2020), thereby exceeding the Eddington luminosity of the neutron star. Outbursts of this type are usually referred to as giant outbursts and do not show any preferred orbital phase, and usually last longer than their type I counterparts. Importantly, all BeXBs are transients with relatively low duty cycles and are mostly observable only during their outbursts. They continue, therefore, to be discovered at a steady rate, and contribute to the increase in the number of known HMXBs.

Prior to the recent catalogue Fortin et al. (2023), the most commonly used catalogue of HMXBs, and the starting point of this work, was Liu et al. (2006), which was published ~16 years ago. Since then many new HXMBs have been discovered, and some previously categorised objects have lost their HMXB status. What is perhaps even more important, is that a wealth of additional observational data were collected with new facilities such as the X-ray Multi-Mirror Mission (XMM-Newton) (Jansen et al. 2001), the International Gamma-Ray Astrophysics Laboratory (INTEGRAL) (Winkler et al. 2003) or Gaia (Gaia Collaboration et al. 2016), to name but a few. In this work we present an updated catalogue of Galactic HMXBs including multi-wavelength information as well as the new sources discovered since the publication by Liu et al. (2006). The current catalogue only includes Galactic HMXBs and does not include objects from the Small or Large Magellanic Clouds; candidates within these regions often have poorly identified or characterised optical counterparts. For Galactic HMXBs, a concerted effort has been made within the field to collect all relevant and current multi-wavelength information including distances, optical magnitudes, variability information in soft and hard X-rays, and information on detection in radio band, amongst others. Such information ensures that the catalogue can

aid in the identification of new HMXBs in the ongoing and future X-ray surveys, population studies, and other investigations.

2. Definition of the sample and data sources

As a first step, we compiled a sample of 169 HMXBs (123 confirmed and 46 candidates) by searching the SIMBAD¹ and VizieR² archives hosted by the Centre de Données astronomiques de Strasbourg (CDS) databases and the literature. The largest fraction of this sample (105 objects) originates from Liu et al. (2006), the catalogue this work is based on. We also systematically searched the literature (including Astronomoner's Telegrams³) for reports of new HMXB discoveries. A large fraction of new HMXBs reported in the literature were discovered between 2006 and 2020 by both the INTEGRAL mission and the Neil Gehrels Swift Observatory (Swift) (Gehrels et al. 2004) (29 objects), as summarised in Kretschmar et al. (2019), which can therefore also be considered one of the main sources used in this work. As the next step, we considered all objects classified as HXMB or candidates in the SIMBAD and VizieR databases. Considering that the majority of objects not present in these databases or the literature are extragalactic, and the fact that HMXBs are strongly clustered towards the Galactic plane Grimm et al. (2002), we restricted our search to the Galactic latitude between $\pm 15^{\circ}$ in the latter case. As an aside, the recent HXMB catalogue Fortin et al. (2023) was published during the review process of this paper. We therefore utilised this catalogue as an additional source list, and cross-checked our own catalogue against this, which resulted in an additional five HMXBs. We note that although considerable effort was put into finding all possible HXMBs and candidates, it is still possible that some sources have been omitted, we therefore urge the reader to report such omissions to the corresponding author. We also note that some of the objects considered by Liu et al. (2006) as HMXBs or candidates are no longer accepted as such. In Section 3.2 we discuss these cases separately.

2.1. HMXB sample and classification

To reflect the variety among the properties of HMXBs, we include information on the origin of the donor star or compact object, system variability, and other relevant properties. These properties are then used to define a set of flags designed to represent the range of properties present in this catalogue. In general, the criteria for these flags are based on the classifications introduced in Liu et al. (2006). However, we have supplemented them with additional flags based on the information provided within Kretschmar et al. (2019), Staubert et al. (2019), and van den Eijnden et al. (2021, 2022). As a result, we converged on the set of flags listed below. The frequency of individual flags is provided in brackets and is also presented graphically in Fig. 1 to give a broad overview of the sample of known HMXBs. We note that the flags below are not meant as a basis for classification of HXMBs, but rather illustrate the range of different systems within the population considered in this catalogue, meaning a system may have multiple flags:

- 1. BH: black hole candidate (6);
- 2. EB: eclipsing or partially eclipsing binary system (9);
- 3. MQ: micro-quasar (4);
- 4. RS: radio emitting HMXB(13);

http://simbad.u-strasbg.fr/simbad/

https://vizier.cds.unistra.fr/viz-bin/VizieR

³ https://astronomerstelegram.org/

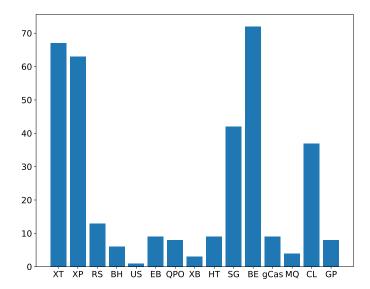


Fig. 1. HMXBs population of each type in the Galaxy.

- 5. XB: X-ray burst source (3);
- 6. XP: X-ray pulsar (63);
- 7. XT: transient X-ray source (67);
- 8. US: ultra-soft X-ray spectrum (1);
- 9. HT: hard transient (9);
- 10. Gcas: Gamma Cassiopeiae-like source (9);
- 11. QPO: quasi-periodic oscillation (8);
- 12. SG: supergiant optical companion (42);
- 13. BE: Be star companion (72);
- 14. CL: cyclotron resonance scattering feature in X-ray spectrum (37);
- 15. GP: high mass gamma-ray binary (8).

2.2. X-ray properties

Considering that the prime feature of XRBs is their X-ray emission, we attempted to compile the relevant X-ray properties of the HMXBs in the catalogue. This includes fluxes in the soft X-ray band as observed by XMM-Newton, the Chandra X-Ray Observatory (Chandra; Weisskopf et al. 2000), and the Swift X-Ray Telescope (Swift/XRT; Burrows et al. 2005), and in the hard X-ray bands as observed by INTEGRAL and the Swift Burst Alert Telescope (Swift/BAT; Barthelmy et al. 2005). We also compiled X-ray positions, in order to assess the reliability of optical counterpart identification or identify plausible counterparts, as described below. In the case of XMM-Newton we report flux in the 0.2-12 keV energy band (corresponding to EPIC_8 band in the XMM-Newton catalogues Webb et al. 2020). For Chandra⁵ (Evans et al. 2010) we preferentially used the broad ACIS band $(0.5-7.0 \,\mathrm{keV})$ or the wide HRC band $(0.1-10.0 \,\mathrm{keV})$ depending on the availability. In the case of Swift/XRT we used data that is available in the Swift X-ray telescope point source catalogue⁶ (2SXPS) (Evans et al. 2020), where for the flux we utilised the energy range 0.3 – 10.0keV, calculated from an assumed powerlaw spectrum (Evans et al. 2020). In the hard X-ray regime we

used an energy range of 14 - 145 keV for $Swift/BAT^7$ (Oh et al. 2018) data and an energy range of 17 - 60 keV for INTEGRAL data⁸ (Krivonos et al. 2012).

2.3. Optical position and astrometry

Most of the HMXBs in the sample have identified optical counterparts (an almost essential pre-requisite for HXMB classification). However, the optical positions reported in Liu et al. (2006) are often limited by the techniques of the time, and thus show discrepancies with modern observations. An effort was made to update these data with the updated astrometry provided by the Gaia mission. To achieve this, we first confirmed whether the SIMBAD database already contained identified Gaia DR39 (Gaia Collaboration et al. 2023) or Two Micron All Sky Survey¹⁰ (2MASS; Cutri et al. 2003) counterparts. If this was not the case, we matched the literature positions, which included V-band magnitudes, to Gaia DR3 using a large search radius of 10". Gaia counterparts that matched the literature positions and magnitudes within the uncertainties were then selected. In most cases this corresponded to an object closest to the literature position with V-band magnitude within 2 mag of the G-magnitude reported by Gaia. We note that most of the HMXBs are, to some extent, variable in the optical band so an exact comparison would be unfeasible. This meant that the threshold of two magnitudes was determined empirically by inspecting the observed difference between the literature and Gaia magnitudes for sources where the Gaia counterpart was already unambiguously identified.

For all HMXBs with a *Gaia* counterpart, we provide distance information from Gaia Collaboration et al. (2023), Bailer-Jones et al. (2021), ¹¹ and Anders et al. (2022). ¹² In addition, for objects without an identified *Gaia* counterpart, but with available distance estimates in the literature, we give those estimates and their corresponding references. If multiple distance estimates were available, the mean distance was calculated by using the arithmetic mean on all available distance estimations linked to the given source. The range of possible distances, calculated by taking the lowest and highest estimations of all distance estimates for a given system (from the literature or from *Gaia*) is also reported.

2.4. Additional information

We also attempted to include some extra information related to the properties of the optical counterparts and the compact objects. For instance, in addition to the G-band magnitudes of *Gaia* published in Gaia Collaboration et al. (2023), magnitudes in the J-, H-, and K-bands provided by Cutri et al. (2003) as well as magnitudes in the W1- and W2-bands of the Wide-field Infrared Survey Explorer mission (Wright et al. 2010) in CatWISE2020¹³ (Marocco et al. 2021) and available V-band magnitudes were

⁴ https://heasarc.gsfc.nasa.gov/W3Browse/xmm-newton/xmmssc.html

⁵ https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=IX/57/csc2master

⁶ https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=IX/58/2sxps

⁷ https://heasarc.gsfc.nasa.gov/W3Browse/swift/ swbat105m.html

⁸ https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=J/A%2bA/545/A27

⁹ https://vizier.cds.unistra.fr/viz-bin/VizieR-3?-source=I/355

¹⁰ https://vizier.cds.unistra.fr/viz-bin/VizieR?
-source=II/246

https://vizier.cds.unistra.fr/viz-bin/VizieR-3?
-source=I/352

¹² https://vizier.cds.unistra.fr/viz-bin/VizieR-3?
-source=I/354/starhorse2021

¹³ https://vizier.cds.unistra.fr/viz-bin/VizieR?
-source=II/365

included. Any luminosity estimates of the optical companions from Gaia Collaboration et al. (2023) were also added. Since the spectral type of the counterpart is also pertinent information, we attempted to include this information by using the following sources: Kretschmar et al. (2019), Staubert et al. (2019), Liu et al. (2006), Mauro Orlandini's website, 14 and SIMBAD. Due to the close connection between spectral type and effective stellar temperature, estimations of the temperatures provided by Anders et al. (2022) and Gaia Collaboration et al. (2023) were included. The catalogue includes only the mean stellar effective temperature. One of the key properties of NS systems is the magnetic field strength of the compact object. This can be measured using observed energies of the cyclotron resonance scattering features (CRSFs, or cyclotron lines). We therefore included the literature values of the observed CRSF energies where such features were claimed to be detected. This includes the fundamental line as well as harmonics. The line energies and corresponding references were sourced from the recent review by Staubert et al. (2019) and the X-ray pulsar properties database by Mauro Orlandini, which appears to cover all X-ray pulsars where a detection of a CRSF was claimed in the literature.

3. Catalogue content and quality assurance

3.1. Description of the fields

The Galactic High Mass X-ray Binary catalogue (XRBcats) we present here contains a total of 169 HMXBs and candidates, sorted according to increasing right ascension (second column). The table consists of 66 columns, listing the various parameters and references for a given HMXB. The first column contains the source name, as decided by the most common name in the literature (number of mentions in NASA ADS system). The following seven columns are dedicated to the coordinates of the system, the second and third columns displaying the right ascension (RA) and declination (DEC) in degrees, followed by statistical uncertainties of the coordinates in arcseconds. The Coord_Ref column provides the reference of the catalogue or paper, which was used to extract the coordinates and uncertainties (e.g. Gaia Collaboration et al. (2023) for *Gaia* DR3), given as a NASA ADS bibcode. The sixth column indicates whether the optical counterpart is solidly identified in the literature (0), if it is a tentative optical counterpart identified as such in the literature (1) or if it is not yet identified (2). In the seventh and eighth columns the galactic longitude (GLON) and galactic latitude (GLAT) in degrees can be found. The following column displays the different X-ray flags related to HMXB classification, which were discussed in Sect. 2. Columns 10 and 11 provide the orbital period of the compact object in days and the spin period of the pulsar (where appropriate) in seconds, respectively. For NS HMXBs with CRSFs reported in the literature, line energies are listed in column 12 in units of keV regardless of if it is reporting on the fundamental line or any harmonics. In the Alt_name column, the second most-used identifier in the literature was selected as an alternative name for the HMXB. Column 14 displays the spectral type of the optical companion. If it was possible to identify the Gaia counterpart, the Gaia-DR3-ID is listed in column 15. Column 16 and 17 show the magnitude in the G-band as well as its uncertainty followed by the V-band magnitude in Column 18 and its uncertainty in Column 19. In Columns 20-29, the JHK-magnitudes as well as the W1and W2-magnitudes with their respective uncertainties are shown. The neutral hydrogen column density in units of 10²¹cm⁻² is

shown in column 30, which is available in Evans et al. (2020). In this reference hardness ratios were first taken and utilised to produce a power-law spectrum through interpolation; from this interpolated spectrum, the neutral hydrogen column density best fitting that spectrum was derived. The following 11 columns contain information on the X-ray flux. Columns 31 and 32 are the minimum and maximum flux values of the source in the XMM-Newton catalogue. Columns 33 and 34 are the flux values of the source in Chandra, due to the use of both Chandra HRC and ACIS; column 35 indicates which of these two instruments was used for the flux values. Columns 36 and 37 respectively display the minimum and maximum flux values of Swift/XRT of the source, columns 38 and 39 for Swift/BAT, and Columns 40 and 41 for INTEGRAL. In cases where only one observation was taken the same value was adopted for minimum and maximum flux values. Columns 42-44 contain mass estimates of the compact object, in particular mean mass, as well as the upper and lower mass limits reported in the literature (in M_{\odot}). Columns 45-47 contain distance estimates (in parsec) to a given source, including the mean distance and the upper and lower limits given in the literature. The stellar effective temperature and the luminosity of the optical counterpart can be found in columns 48 and 49, where T_{eff} is in Kelvin and the luminosity of the companion is in L_{\odot} . All SIMBAD identifiers associated with HMXBs are quoted in column 50. The next seven columns are dedicated to the references of CRSF, pulsation period, orbital parameter, spectral type, distance-estimation (if literature values were used), mass estimation, and miscellaneous references. Column 58 is dedicated to comments (e.g. if the source is considered an HMXB candidate or similar). The final eight columns contain the source name given in the following catalogues: 2MASS All-Sky Catalogue of Point Sources, CatWISE2020 catalogue, Second ROSAT all-sky survey (2RXS) source catalogue, XMM-Newton Serendipitous Source Catalogue, Chandra Source Catalogue (CSC) Release 2.0, 2SXPS Swift X-ray telescope point source catalogue, Swift/BAT 105-Month All-Sky Hard X-Ray Survey catalogue, and INTE-GRAL/IBIS 9-year Galactic Hard X-Ray Survey catalogue.

3.2. Finding charts and problematic cases

As part of the catalogue we provide finding charts, which consist of up to six different images ranging from near-infrared (NIR) to hard X-rays for all sources. For the majority of the finding charts, we used the Hierarchical Progressive Surveys (HiPS, Fernique et al. 2015); only in the case of Swift/XRT did we use the SkyView Query. Both HiPS and SkyView offer the possibility to query data automatically with Python. To access HiPS, and SkyView we used the astroquery.hips2fits¹⁵ package and the astroquery.skyview¹⁶ package, respectively. In the following we give details of the surveys used and provide their corresponding links as footnotes. The finding charts consist of up to six different surveys, which are mentioned below, along with their corresponding links as footnotes. In the top row we include the image taken from the Visible and Infrared Survey Telescope for Astronomy (VISTA) from their Variables in the the Via Lactea (VVV¹⁷) DR4 catalogue (Minniti et al. 2010). Alternatively, for the top row image, where

http://www.iasfbo.inaf.it/~mauro/pulsar_list.html

https://alasky.u-strasbg.fr/hips-image-services/ hips2fits

https://astroquery.readthedocs.io/en/latest/skyview/ skyview.html

http://alasky.cds.unistra.fr/VISTA/VVV_DR4/ VISTA-VVV-DR4-J/

VVV was not available we utilised 2MASS. 18 The central image is taken from unWISE¹⁹ (Schlafly et al. 2019) and for the righthand RGB image we utilised *Chandra*, ²⁰ *XMM-Newton*, ²¹ or the Roentgensatellit (*ROSAT*;²² Truemper 1982; Boller et al. 2016; Voges et al. 1999) (listed here in order of preference). In the left-hand corner of the bottom row we provide a soft X-ray image of Swift/XRT (SwiftXRTInt in astroquery.skyview). For hard Xrays we take images from Swift/BAT²³ (middle section of bottom row); and INTEGRAL²⁴ (right hand section of bottom row). A 1 arcmin field of view was used for the creation of the VVV, 2MASS, unWISE, XMM-Newton, and Chandra images. In the case of Swift/XRT and ROSAT, we used a field of view size of 5 arcmin and 15 arcmin, respectively. The field of view for Swift/BAT and INTEGRAL was chosen to be 10°. In each case, the size of the region was chosen considering the field of view and angular resolution of a given instrument. Every panel also shows the coordinates and uncertainties of all detected sources within their respective regions (position uncertainties are represented by error circles). A red cross indicates the position given by SIMBAD for the source, and a dodger-blue diamond for the coordinates described in the literature. The position of the source used by this catalogue is indicated with an orange star. In the case of the soft X-ray instruments, the position of the observations is indicated by the error circles to prevent overcrowding, a golden circle indicates the *Chandra* position, a red circle *XMM-Newton*, a green circle Swift/XRT, and a navy blue circle ROSAT. Swift/BAT and INTEGRAL are denoted by a deep pink pentagon and a lime green triangle, respectively. In the optical band we indicate CatWISE with an orange X, 2MASS with a cyan plus sign, and Gaia DR3 data with purple square. As an example, Figure 2 shows the finding chart of GRO J1008-57.

Based on visual inspection of the finding charts and literature research, several problematic cases were identified. We list these cases in their respective categories, in ascending order of their right ascension coordinates. Several sources initially assumed to be HMXBs were removed from the sample.

1E 1048.1-5937: 1E 1048.1-5937 is listed as an HMXB in *SIMBAD*; however, Dib et al. (2009) concluded that the source is actually a magnetar. The source is also listed as a magnetar in the McGill magnetar database²⁵ Olausen & Kaspi (2014).

IGR J18151-1052: IGR J18151-1052 was suggested to be an HMXB (Burenin et al. 2009); however, this was shown not to be the case by Lutovinov et al. (2012). The object might be associated with the magnetar candidate PSR J1845-0258 or be a CV, but in any case its identification as an HMXB is unlikely, so we decided not to include this source.

1E 2259+58.6: Another magnetar 1E 2259+58.6 (Gavriil & Kaspi 2002) was excluded using the same logic as for

1E 1048.1-5937.

Several objects have tentative or known optical counterparts in the literature, but they could not be found automatically through the procedure outlined above. For these objects, the literature was searched manually and the known counterparts and their coordinates were added to the catalogue.

RX J0148.9+6121: Not much is known about RX J0148.9+6121 which was only referred to once by Wang et al. (2014) as having HMXB status. We therefore consider it to be a candidate rather than a confirmed HMXB.

PSR J0635+0533: Fortin et al. (2022b) compiled a list of galactic HMXBs that contain a NS as their compact object, and made an effort to identify optical counterparts for the systems in Gaia DR3. The study only lists objects with unambiguously identified counterparts both in *Gaia* DR3 and 2MASS catalogues that are within 0.5" of each other. In the case of PSR J0635+0533, they identified *Gaia* DR3 3131755947406031104 as the counterpart.

1H 0749-600: For 1H 0749-600, Torrejón & Orr (2001) posited that the proposed optical counterpart HD 65663 is not the real counterpart, but rather a single Be star spatially coincident with an X-ray transient. Torrejón & Orr (2001) also considered the possibility that the system is not an X-ray binary at all. We therefore classify this association as tentative.

1FGL J1018.6-5856: For 1FGL J1018.6-5856 the same procedure was performed as in the case of PSR J0635+0533. Here Fortin et al. (2022b) identified *Gaia* DR3 5255509901121774976 as the *Gaia* counterpart for 1FGL J1018.6-5856.

1ES 1210-64.6: Based on the coordinates of the soft X-ray counterpart of 1ES 1210-64.6 (Revnivtsev et al. 2007), Masetti et al. (2009) identified the optical counterpart (*Gaia* DR3 6053076566300433920) This conclusion was confirmed by follow-up optical spectroscopy.

IGR J12341-6143: A soft X-ray counterpart for IGR J12341-6143 was discovered quite recently by Sidoli et al. (2020) with *Swift*/XRT, which also led to the identification of a tentative optical counterpart (*Gaia* DR2 6054778507172454912).

1A 1238-59: We suggest classifying 1A 1238-59 as an HMXB candidate, due to an error radius of 30" (Dower et al. 1978) and because there is no detected optical counterpart.

IGR J14059-6116: We decided to classify IGR J14059-6116 as an HMXB candidate, due to a missing optical counterpart. Corbet et al. (2019) suggested that IGR J14059-6116 has a possible association with the HMXB 4FGL J1405.1-6119, and therefore we note that IGR J14059-6116 is likely to be the same source as 4FGL J1405.1-6119.

MAXI J1409-619: Kennea et al. (2010) located an uncatalogued X-ray source inside the MAXI error circle of MAXI J1409-619 using *Swift/XRT*. Inside the *Swift/XRT* error circle of this source,

http://alasky.cds.unistra.fr/2MASS/J/

 $^{^{19}}$ http://alasky.cds.unistra.fr/unWISE/W1/

²⁰ https://cdaftp.cfa.harvard.edu/cxc-hips/

²¹ http://skies.esac.esa.int/XMM-Newton/EPIC-RGB/

²² http://alasky.cds.unistra.fr/RASS/

²³ http://cade.irap.omp.eu/documents/Ancillary/4Aladin/ BAT_14_20/

²⁴ http://cade.irap.omp.eu/documents/Ancillary/4Aladin/ INTEGRAL_17_60/

²⁵ https://www.physics.mcgill.ca/~pulsar/magnetar/main. html

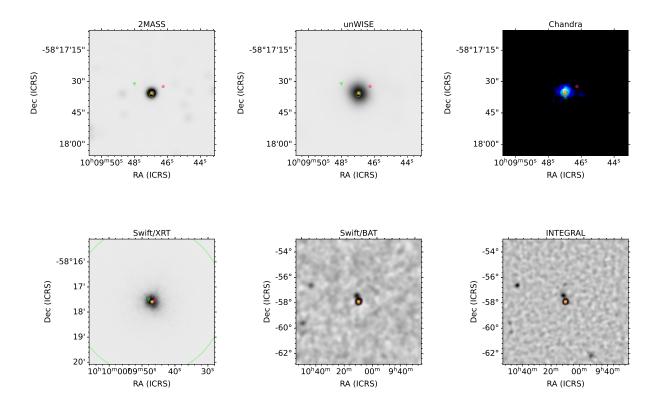


Fig. 2. Finding charts of GRO J1008–57. The finding charts are overlaid with symbols and error circles to indicate observations of different instruments. See text in Sect. 3.2 for an explanation of the finding charts and the symbols.

a catalogued IR source (2MASS J14080271-6159020) was also found which is considered a tentative optical counterpart.

IGR J14331-6112: *Gaia* DR3 5878377736381364608 is mentioned as the unambiguous optical counterpart of IGR J14331-6112 by Fortin et al. (2022b).

Cir X-1: Since its discovery, Cir X-1 has been referred to as an LMXB, until Heinz et al. (2013) determined the age of the system to be about 4500 yr. In addition, according to Jonker et al. (2007) this system contains an A0- to B5-type supergiant companion. However, Cir X-1 has also shown type I X-ray bursts (Tennant et al. 1986), which indicates that source is an LMXB. The possible LMXB origin is also supported by the fact that the companion star itself in Cir X-1 still cannot be unambiguously detected at optical wavelengths. Johnston et al. (2016) concluded that the donor could either be a low mass star that has not had time to evolve or a giant star still recovering from the impact of a supernova blast that happened less than 5000 yr ago. Taking into account all this obscurity around Cir X-1's nature we decided to add it to both LMXB and HMXB catalogues.

XTE J1543-568: In March 2012 *Swift*/BAT detected an increased flux from XTE J1543-568, which led to a more accurate determination of the source position. This allowed Krimm et al. (2012) to identify a tentative counterpart (2MASS J15440515-5645425) within the error box provided by *Swift*/XRT.

2S 1553-542: With the help of *Swift/XRT* and *Chandra* observations, Lutovinov et al. (2016) were capable of identifying a likely infrared counterpart for 2S 1553-542 at RA(J2000)=15h 57m 48.28s DEC(J2000)=-54°24′ 53.5″.

IGR J16374-5043: Inside the error circle around the *Swift*/XRT position of IGR J16374-5043, Sguera et al. (2020) found only one infrared source. This source is not listed in the 2MASS catalogue but is in the catalogue of *Gaia* (*Gaia* DR3 5940285090075838848) and is likely to be the optical counterpart of IGR J16374-5043.

XTE J1716-389: Ratti et al. (2010) used *Chandra* for localisation of Galactic X-ray sources and did follow-up observations in the optical and NIR bands. One of the observed sources was XTE J1716-389. The refined *Chandra* position allowed Ratti et al. (2010) to identify the only possible optical counterpart, an

infrared source 2MASS J17155645-3851537, that is thus consid- Newton position. Based on this observation, IGR J18482+0049 ered to be XTE J1716-389's counterpart.

IGR J17375-3022: IGR J17375-3022 was a poorly studied source until Sguera et al. (2020) investigated it in the hard and soft X-ray bands, and in the infrared band. With an enhanced source position from Swift/XRT, the study found only one NIR object within the Swift/XRT error circle in the VVV survey. Therefore, Sguera et al. (2020) proposed that VVV J173733.74-302314.5 is the best counterpart candidate for IGR J17375-3022.

RX J1739.4-2942: RX J1739.4-2942, originally identified as an LMXB, could potentially be a Be/HMXB Bahramian et al. (2016). Therefore, we included RX J1739.4-2942 in the catalogue as an HMXB candidate (Number 67 in Liu et al. 2006).

IGR J18029-2016: Walter et al. (2006) proposed two possible NIR counterparts for IGR J18029-2016; they were 2MASS J18024194-2017172 and 2MASS J180242.0-201720.2, which were found in the 2MASS catalogue and the Second Guide Star Catalogue, respectively. The first candidate, 2MASS J18024194-2017172, was later confirmed to be the counterpart of the HMXB by Masetti et al. (2008).

IGR J18179-1621: With the refined position of IGR J18179-1621 reported by Li et al. (2012), Nowak et al. (2012) were able to observe the object with *Chandra* and identify a possible optical counterpart. 2MASS J18175218-1621316 was identified as a possible companion, due to it being the only NIR source in the 2MASS catalogue within a 1" radius of the Chandra position.

IGR J18219-1347: Quite recently O'Connor et al. (2022) identified a bright IR counterpart for IGR J18219-1347 close to the Chandra localisation, at RA(J2000)=18h 21m 54.821s DEC(J2000)=-13°47' 26.703", which appeared to be the combination of two point sources (Star A and Star B). They concluded that Star A is the Counterpart of IGR J18219-1347, because it is consistent with the SED of a Be star, and therefore the system was classified as a BeXRB.

AX J1841.0-0536: Fortin et al. (2022a) queried the confirmed HMXBs of their previous work (Fortin et al. 2022b) in Gaia DR3. For AX J1841.0-0536 the source Gaia DR3 4256500538116700160 was therefore identified as an optical counterpart.

Ginga 1839-04: For Ginga 1839-04 no optical counterpart has yet been identified. Liu et al. (2006) included this source in their catalogue due to a tentative pulsation detection of ~ 81s (Koyama et al. 1990) by Ginga during an outburst in 1989. Since then no further X-ray detections have been reported (Sguera et al. 2009). Therefore, Ginga 1839-04 is classified as a candidate HMXB in this catalogue.

IGR J18482+0049: Bodaghee et al. (2012) observed five IN-TEGRAL sources towards the Scutum Arm, one of which was IGR J18482+0049. With the refined position, they found only one object in the 2MASS catalogue that was consistent with the XMM- has a possible association with 2MASS J18481540+0047332.

Ginga 1855-02: Within Ginga 1855-02, the positional error is 10' (Koyama et al. 1990). Like *Ginga* 1839-04, *Ginga* 1855-02 is a poorly studied source that does not have an identified optical counterpart, and therefore it is also classified as a candidate HMXB based on its transient behaviour.

XTE J1859+083: After an outburst of XTE J1859+083 detected by MAXI (Negoro et al. 2015), follow-up Swift/XRT observations by Li & Kong (2015) allowed the improvement of the position of the HMXB. No UVOT counterpart was detected, but with the enhanced position Li & Kong (2015) were able to find a possible counterpart in the USNO-B1.0 (USNO-B1.0 0982-0467424) and 2MASS catalogues (2MASS J18590163+0814444).

1912.5+1031: Bozzo et al. (2011) identified 2MASS J19145680+1036387 as the most likely counterpart of 1E 1912.5+1031, based on the position inside the error circle of their estimated Swift/XRT position for 1E 1912.5+1031.

AX J1949.8+2534: For AX J1949.8+2534 the source 2MASS J19495543+2533599 was proposed to be the optical counterpart (Sguera et al. 2017). This was later confirmed to be the case by Hare et al. (2019).

W63 X-1: W63 X-1 is an X-ray binary within the supernova remnant W63, with a pulsation period of 36 sec (Rho et al. 2004). Based on the pulsation period and spectrum, Rho et al. (2004) concluded that the companion is likely an isolated neutron star, HMXB, or LMXB. They found an optical counterpart with $H\alpha$ -excess emission typical for a Be companion, and thus classified the source as an HMXB.

Several objects present in Liu et al. (2006) were removed from the current catalogue as they are no longer classified as HMXBs:

1WGA J0648.0-4419: 1WGA J0648.0-4419, previously listed as source 18 in Liu et al. (2006), was removed because the optical star in the system has since been classified as a hot sub-dwarf (Jaschek & Jaschek 1963).

IGR J12349-6434: IGR J12349-6434 (source 35 in Liu et al. (2006)] was initially classified as a new source. However, it is thought to be associated with RT Cru (Tueller et al. 2005), a symbiotic star containing a WD (Luna & Sokoloski 2007). It was therefore excluded from the catalogue.

1A 1246-588: 1A 1246-588, which was source 38 in Liu et al. (2006), is an LMXB Bassa et al. (2006).

SAX J1452.8-5949: With the de-reddened magnitudes of their observations in the JHK-bands and the assumption of a blackbody model, Kaur et al. (2009) made estimations of the distance of SAX J1452.8-5949 (source 46 in Liu et al. 2006). This ruled out the possibility of the object being an HMXB, due to the fact that the system would be an extragalactic source. They concluded

that the binary system must have a low mass companion, and therefore is either an LMXB or an intermediate polar (IP, accreting magnetised white dwarf).

IGR J16358-4726: Chaty et al. (2008) classified IGR J16358-4726 (source 55 in Liu et al. 2006) as an HMXB; however, this classification was revoked by Nespoli et al. (2010) and the source is now considered to be a symbiotic X-ray binary.

AX J1700.1-4157: Based on NIR observations, Kaur et al. (2010) estimated that the companions of AX J1700.1-4157²⁶ (source 63 in Liu et al. 2006) should be a low mass star. In combination with a detected Fe emission line, Kaur et al. (2010) concluded that AX J1700.1-4157 is most likely an IP, and therefore AX J1700.1-4157 was removed from this catalogue.

IGR J17091-3624: IGR J17091-3624 (source 64 in Liu et al. 2006) is also now classified as an LMXB (Grinberg et al. 2016).

AX J1740.1-2847: AX J1740.1-2847 (source 68 in Liu et al. 2006) is a similar case to AX J1700.1-4157. Kaur et al. (2010) also estimated that the companion should be a low mass star, and due to a detected Fe emission line they concluded that AX J1740.1-2847 is most likely an IP as well, and hence it was removed from the catalogue.

4U 1807-10: 4U 1807-10 (source 75 in Liu et al. 2006) was detected by *UHURU* (Forman et al. 1978) within a large error of 1.3°. To date, it is not certain if 4U 1807-10 is an HMXB or an LMXB. However, it is more likely that 4U 1807-10 is an LMXB as the system shows type I X-ray bursts (Chelovekov et al. 2017). Therefore, we excluded it from this catalogue.

SAX J1819.3-2525: MacDonald et al. (2014) determined a mass of 2.9 M_{\odot} for the optical companion of SAX J1819.3-2525²⁶ (source 77 in Liu et al. 2006), which classifies this system as an IMXB, and therefore it was excluded from the catalogue.

AX J1838.0-0655: AX J1838.0-0655²⁶ (source 82 in Liu et al. 2006) is currently classified as a supernova remnant. Malizia et al. (2005) does not exclude the possibility of AX J1838.0-0655 being an X-ray binary, but mentions that this scenario is unlikely due to the lack of strong X-ray and γ -ray variability, as well as the extension of the source to up to TeV energies. Therefore, AX J1838.0-0655 was removed from the catalogue.

XTE J1901+014: Karasev et al. (2008) proposed that XTE J1901+014 (source 94 in Liu et al. 2006) could be the first low mass fast X-ray transient. To date, the nature of this system is not completely clear (Sato et al. 2019); we therefore decided to exclude this source from the current version of this catalogue.

XTE J1906+09: XTE J1906+09 (source 96 in Liu et al. 2006) was not excluded, but the name was changed to XTE J1906+090 to match that commonly used in the literature.

A handful of sources that are included in the recently published catalogue of high mass X-ray binaries by Fortin et al. (2023) have been omitted from our catalogue. These sources have already been mentioned and are AX J1700.1-4157, SAX J1819.3-2525, AX J1838.0-0655, and GRS 1758-258. In the case of GRS 1758-258, there is a possibility that the system is an intermediate-mass X-ray binary, as proposed by Martí et al. (2016), and hence this source can be found in Avakyan et al. (2023) instead of this catalogue.

4. Conclusion

The Major changes with respect to Liu et al. (2006), in addition to the problematic cases, are described here.

- We homogenised the energy ranges of the reported X-ray fluxes. Liu et al. (2006) used an energy range of 2 10 keV for most sources, but in some cases the nominal energy range was different, and identifying these cases was not trivial. We now quote the soft and hard X-ray fluxes in well-defined energy ranges separately.
- Liu et al. (2006) only reported the maximum value of X-ray flux in units of Jy in most cases. In this work we report flux ranges in the two energy bands in the more commonly used cgs units, which are more accessible for X-ray sources.
- We increased the number of flags used to characterise source properties from 6 in Liu et al. (2006) to a total of 15 to better reflect the various features reported in the literature.
- While Liu et al. (2006) flags sources where a cyclotron line was detected, no information regarding the energy is available in most cases. We report both the observed energies and corresponding references. The number of objects where a line was detected also increased substantially due to the availability of new observations and publications.
- Effective stellar temperature and estimated optical luminosity, as well as the hydrogen column density are three completely new fields introduced in this version of the catalogue.
- Finally, we include up to six finding charts as part of the catalogue (from NIR images to hard X-ray bands) instead of referencing the existing finding charts.

Differences with respect to Fortin et al. (2023) are as follows:

- Fortin et al. (2023) utilised a flag to indicate the type of the optical companion. We used similar flags for the optical companion, but introduced additional flags for the compact object (e.g. CRSF to indicate if a neutron star has a detected cyclotron line).
- For sources with known cyclotron line energies we included both fundamental and harmonic energies.
- In addition to the cyclotron line energy, we also reported X-ray fluxes in different energy ranges for the compact object.
 This can be used to gauge the variability of the source and to make an estimation of the expected flux, although this cannot replace an in-depth analysis of individual sources.
- For the optical companions, we reported magnitudes in the optical and in the NIR bands. Some additional information regarding the properties of optical counterparts can be found in Fortin et al. (2023).

²⁶ It can be found in the recently published catalogue of high mass X-ray binaries in the Galaxy by Fortin et al. (2023).

Together with the catalogues of Fortin et al. (2023) and Avakyan et al. (2023), this catalogue provides a useful tool for further studies of XRBs. With ongoing surveys like eROSITA, the number of known XRBs is expected to increase substantially (Doroshenko et al. 2014); therefore, we plan to keep the web version of our catalogue²⁷ up-to-date to the best of our ability.

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References

Anders, F., Khalatyan, A., Queiroz, A. B. A., et al. 2022, A&A, 658, A91 Avakyan, A., Neumann, M., Zainab, A., et al. 2023, A&A, 675, A199

Bahramian, A., Heinke, C. O., Sivakoff, G. R., et al. 2016, The Astronomer's Telegram, 8704, 1

Bailer-Jones, C. A. L., Rybizki, J., Fouesneau, M., Demleitner, M., & Andrae, R. 2021, AJ, 161, 147

Balona, L. A. & Ozuyar, D. 2020, MNRAS, 493, 2528

Barthelmy, S. D., Barbier, L. M., Cummings, J. R., et al. 2005, Space Sci. Rev., 120, 143

Bassa, C. G., Jonker, P. G., in't Zand, J. J. M., & Verbunt, F. 2006, A&A, 446, L17

Bodaghee, A., Tomsick, J. A., & Rodriguez, J. 2012, ApJ, 753, 3

Boller, T., Freyberg, M. J., Trümper, J., et al. 2016, A&A, 588, A103

Bozzo, E., Ferrigno, C., Pavan, L., Walter, R., & Stella, L. 2011, The Astronomer's Telegram, 3326, 1

Burenin, R., Makarov, D., Uklein, R., Revnivtsev, M., & Lutovinov, A. 2009, The Astronomer's Telegram, 2193, 1

Burrows, D. N., Hill, J. E., Nousek, J. A., et al. 2005, Space Sci. Rev., 120, 165 Chaty, S. 2022, Accreting Binaries; Nature, formation, and evolution (IOP Publishing)

Chaty, S., Rahoui, F., Foellmi, C., et al. 2008, A&A, 484, 783

Chelovekov, I. V., Grebenev, S. A., Mereminskiy, I. A., & Prosvetov, A. V. 2017, Astronomy Letters, 43, 781

Corbet, R. H. D. 1986, MNRAS, 220, 1047

Corbet, R. H. D., Chomiuk, L., Coe, M. J., et al. 2019, ApJ, 884, 93

Cutri, R. M., Skrutskie, M. F., van Dyk, S., et al. 2003, 2MASS All Sky Catalog of point sources.

Dib, R., Kaspi, V. M., & Gavriil, F. P. 2009, ApJ, 702, 614

Doroshenko, V., Ducci, L., Santangelo, A., & Sasaki, M. 2014, A&A, 567, A7 Doroshenko, V., Zhang, S. N., Santangelo, A., et al. 2020, MNRAS, 491, 1857 Dower, R. G., Apparao, K. M. V., Bradt, H. V., et al. 1978, Nature, 273, 364

Evans, I. N., Primini, F. A., Glotfelty, K. J., et al. 2010, ApJS, 189, 37

Evans, P. A., Page, K. L., Osborne, J. P., et al. 2020, ApJS, 247, 54

Fernique, P., Allen, M. G., Boch, T., et al. 2015, A&A, 578, A114 Forman, W., Jones, C., Cominsky, L., et al. 1978, ApJS, 38, 357 Fortin, F., García, F., & Chaty, S. 2022a, A&A, 665, A69

Fortin, F., García, F., Chaty, S., Chassande-Mottin, E., & Simaz Bunzel, A. 2022b, A&A, 665, A31

Fortin, F., García, F., Simaz Bunzel, A., & Chaty, S. 2023, A&A, 671, A149 Gaia Collaboration, Prusti, T., de Bruijne, J. H. J., et al. 2016, A&A, 595, A1 Gaia Collaboration, Vallenari, A., Brown, A. G. A., et al. 2023, A&A, 674, A1 Gavriil, F. P. & Kaspi, V. M. 2002, ApJ, 567, 1067

Gehrels, N., Chincarini, G., Giommi, P., et al. 2004, ApJ, 611, 1005

Grimm, H. J., Gilfanov, M., & Sunyaev, R. 2002, Mem. Soc. Astron. Italiana, 73,

Grimm, H. J., Gilfanov, M., & Sunyaev, R. 2003, MNRAS, 339, 793

Grinberg, V., Fuerst, F., Ballhausen, R., et al. 2016, The Astronomer's Telegram,

Hare, J., Halpern, J. P., Clavel, M., et al. 2019, ApJ, 878, 15

Heinz, S., Sell, P., Fender, R. P., et al. 2013, ApJ, 779, 171

Jansen, F., Lumb, D., Altieri, B., et al. 2001, A&A, 365, L1

Jaschek, M. & Jaschek, C. 1963, PASP, 75, 365

Johnston, H. M., Soria, R., & Gibson, J. 2016, MNRAS, 456, 347

Jonker, P. G., Nelemans, G., & Bassa, C. G. 2007, MNRAS, 374, 999 Karasev, D. I., Lutovinov, A. A., & Burenin, R. A. 2008, Astronomy Letters, 34, 753

Kaur, R., Wijnands, R., Patruno, A., et al. 2009, MNRAS, 394, 1597

Kaur, R., Wijnands, R., Paul, B., Patruno, A., & Degenaar, N. 2010, MNRAS, 402, 2388

Kennea, J. A., Krimm, H., Romano, P., et al. 2010, The Astronomer's Telegram, 2962, 1

Koyama, K., Kawada, M., Kunieda, H., Tawara, Y., & Takeuchi, Y. 1990, Nature, 343, 148

Kretschmar, P., El Mellah, I., Martínez-Núñez, S., et al. 2021, A&A, 652, A95 Kretschmar, P., Fürst, F., Sidoli, L., et al. 2019, New A Rev., 86, 101546

Krimm, H. A., Barthelmy, S. D., Baumgartner, W., et al. 2012, The Astronomer's Telegram, 4008, 1

Krivonos, R., Tsygankov, S., Lutovinov, A., et al. 2012, A&A, 545, A27 Kudritzki, R.-P. & Puls, J. 2000, ARA&A, 38, 613

Li, J., Zhang, S., Torres, D. F., et al. 2012, MNRAS, 426, L16

Li, K. L. & Kong, A. K. H. 2015, The Astronomer's Telegram, 7067, 1

Liu, Q. Z., van Paradijs, J., & van den Heuvel, E. P. J. 2006, A&A, 455, 1165 Luna, G. J. M. & Sokoloski, J. L. 2007, ApJ, 671, 741

Lutovinov, A. A., Buckley, D. A. H., Townsend, L. J., Tsygankov, S. S., & Kennea, J. 2016, MNRAS, 462, 3823

Lutovinov, A. A., Burenin, R. A., Revnivtsev, M. G., & Bikmaev, I. F. 2012, Astronomy Letters, 38, 1

MacDonald, R. K. D., Bailyn, C. D., Buxton, M., et al. 2014, ApJ, 784, 2

Malizia, A., Bassani, L., Stephen, J. B., et al. 2005, ApJ, 630, L157

Marocco, F., Eisenhardt, P. R. M., Fowler, J. W., et al. 2021, ApJS, 253, 8 Martí, J., Luque-Escamilla, P. L., & Muñoz-Arjonilla, Á. J. 2016, A&A, 596, A46

Masetti, N., Mason, E., Morelli, L., et al. 2008, A&A, 482, 113

Masetti, N., Parisi, P., Palazzi, E., et al. 2009, A&A, 495, 121

Minniti, D., Lucas, P. W., Emerson, J. P., et al. 2010, New A, 15, 433

Negoro, H., Suzuki, K., Namba, T., et al. 2015, The Astronomer's Telegram, 7034,

Negueruela, I., Smith, D. M., Reig, P., Chaty, S., & Torrejón, J. M. 2006, in ESA Special Publication, Vol. 604, The X-ray Universe 2005, ed. A. Wilson, 165

Nespoli, E., Fabregat, J., & Mennickent, R. E. 2010, A&A, 516, A94 Nowak, M. A., Paizis, A., Rodriguez, J., et al. 2012, ApJ, 757, 143

O'Connor, B., Göğüş, E., Huppenkothen, D., et al. 2022, ApJ, 927, 139

Oh, K., Koss, M., Markwardt, C. B., et al. 2018, ApJS, 235, 4 Olausen, S. A. & Kaspi, V. M. 2014, ApJS, 212, 6

Pfahl, E., Rappaport, S., & Podsiadlowski, P. 2003, ApJ, 597, 1036

Ratti, E. M., Bassa, C. G., Torres, M. A. P., et al. 2010, MNRAS, 408, 1866 Reig, P. 2011, Ap&SS, 332, 1

Revnivtsev, M., Sunyaev, R., Lutovinov, A., & Sazonov, S. 2007, The Astronomer's Telegram, 1253, 1

Rho, J., Moon, D. S., Gotthelf, E., Pannuti, T., & Corbet, R. 2004, in AAS/High Energy Astrophysics Division, Vol. 8, AAS/High Energy Astrophysics Division #8, 17.30

Sato, T., Negoro, H., Iwakiri, W., et al. 2019, The Astronomer's Telegram, 13328,

Savonije, G. J. 1978, A&A, 62, 317

Schlafly, E. F., Meisner, A. M., & Green, G. M. 2019, ApJS, 240, 30

Sguera, V., Romero, G. E., Bazzano, A., et al. 2009, ApJ, 697, 1194

Sguera, V., Sidoli, L., Bird, A. J., Paizis, A., & Bazzano, A. 2020, MNRAS, 491,

Sguera, V., Sidoli, L., Paizis, A., et al. 2017, MNRAS, 469, 3901

Sidoli, L., Esposito, P., & Sguera, V. 2020, The Astronomer's Telegram, 14039, 1 Staubert, R., Trümper, J., Kendziorra, E., et al. 2019, A&A, 622, A61

Tananbaum, H., Gursky, H., Kellogg, E. M., et al. 1972, ApJ, 174, L143

Tennant, A. F., Fabian, A. C., & Shafer, R. A. 1986, MNRAS, 221, 27P

Torrejón, J. M. & Orr, A. 2001, A&A, 377, 148

Truemper, J. 1982, Advances in Space Research, 2, 241

Tueller, J., Gehrels, N., Mushotzky, R. F., et al. 2005, The Astronomer's Telegram, 591, 1

van den Eijnden, J., Degenaar, N., Russell, T. D., et al. 2022, MNRAS, 516, 4844 van den Eijnden, J., Degenaar, N., Russell, T. D., et al. 2021, MNRAS, 507, 3899 Voges, W., Aschenbach, B., Boller, T., et al. 1999, A&A, 349, 389

Walter, R., Zurita Heras, J., Bassani, L., et al. 2006, A&A, 453, 133

Wang, W., Tong, H., & Guo, Y.-J. 2014, Research in Astronomy and Astrophysics, 14,673

Webb, N. A., Coriat, M., Traulsen, I., et al. 2020, A&A, 641, A136

Weisskopf, M. C., Tananbaum, H. D., Van Speybroeck, L. P., & O'Dell, S. L. 2000, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 4012, X-Ray Optics, Instruments, and Missions III, ed. J. E. Truemper & B. Aschenbach, 2–16

Winkler, C., Courvoisier, T. J. L., Di Cocco, G., et al. 2003, A&A, 411, L1 Wright, E. L., Eisenhardt, P. R. M., Mainzer, A. K., et al. 2010, AJ, 140, 1868

²⁷ http://astro.uni-tuebingen.de/~xrbcat/

Appendix A: Catalogue format

Table A.1. Definition of columns in the HMXB catalogue. In total the catalogue contains **66** columns

<u>N₀</u>	Column name	Unit	Description
		UIIII	
1	'Name'	dag	Object name, which is the most common name in the literature
2	'RAdeg'	deg	Right Ascension in degrees (ICRS).
3	'DEdeg'	deg	Declination in degrees (ICRS).
4	'PosErr'	arcsec	Positional error in arcseconds.
5	'Coord_Ref'		Reference of catalogue or literature, which was used to extract the coordinates and uncertainties
6	'ID_Flag'		Robust identification of the optical counterpart:
	_ &		0 — solidly identified optical counterpart in the literature
			1 — tentative optical counterpart identification in the literature
			2 — no identified optical counterpart
7	'GLON'	deg	Galactic longitude in degrees.
8	'GLAT'	deg	Galactic latitude in degrees.
9	'Xray_Type'	008	List of the X-ray types assigned to the object. For more information see section
	may_1ype		above § 2.1.
10	'Porb'	day	Orbital period of the binary system in days if determined.
11	'Ppulse'	S	Pulsation period (spin) of the binary (with NS) in seconds if determined.
12		keV	Cyclotron line energies in keV
13	'Alt_Name'	KC V	Second most used name in the literature.
14	'SpType'		Spectral type of the optical counterpart.
15	'Gaia_DR3_ID'		Source Name in the Gaia DR3 catalogue.
16	'Gmag'	maa	Optical magnitude in G-band according to a Gaia's catalogue.
17	'e_Gmag'	mag	Corresponding magnitude's error in G-band according to Gaia's catalogue.
18	'Vmag'	mag	Optical magnitude in V-band according to SIMBAD database.
		mag	
19 20	'e_Vmag'	mag	Corresponding magnitude's error in V-band according to SIMBAD database. IR magnitude in J-band according to 2MASS (Cutri et al. 2003).
	'Jmag'	mag	
21	'e_Jmag'	mag	Corresponding magnitude's error in J-band according to 2MASS (Cutri et al. 2003).
22	'Hmag'	mag	IR magnitude in H-band according to 2MASS (Cutri et al. 2003).
23	'e_Hmag'	mag	Corresponding magnitude's error in H-band according to 2MASS (Cutri et al. 2003).
24	'Kmag'	mag	IR magnitude in K-band according to 2MASS (Cutri et al. 2003).
25	'e_Kmag'	mag	Corresponding magnitude's error in K-band according to 2MASS (Cutri et al. 2003).
26	'W1mag'	mag	IR magnitude in W1 <i>CatWISE</i> 2020 band (Marocco et al. 2021).
27	'e_W1mag'	mag	Corresponding magnitude's error in W1 <i>CatWISE</i> 2020 band (Marocco et al. 2021).
28	'W2mag'	mag	IR magnitude in W2 <i>CatWISE</i> 2020 band (Marocco et al. 2021).
29	'e_W2mag'	mag mag	Corresponding magnitude's error in W2 <i>CatWISE</i> 2020 band (Marocco et al. 2021).
	0_112mag	mug	2021).
30	'N_H'	10^{21} cm^{-2}	Neutral hydrogen column density, assuming a power-law spectrum (Evans et al. 2020).
31	'XMM_min_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Minimum X-ray flux for XMM-Newton (0.2-12.0 keV).
32	'XMM_max_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Maximum X-ray flux for XMM-Newton (0.2-12.0 keV).
33	'Chandra_min_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Minimum X-ray flux for Chandra ACIS (0.5-7.0 keV) or HRC (0.1-10.0 keV).
34	'Chandra_max_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Maximum X-ray flux for Chandra ACIS (0.5-7.0 keV) of HRC (0.1-10.0 keV).
35	'Chandra_Instrument'	to eigeni s	Chandra Instrument used for Chandra flux values.
		$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	
36	'XRT_min_flux'		Minimum X-ray flux for Swift/XRT (0.3-10.0 keV).
37	'XRT_max_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Maximum X-ray flux for Swift/XRT (0.3-10.0 keV).
38	'BAT_min_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Minimum X-ray flux for Swift/BAT (14-195 keV).
39	'BAT_max_flux'	10 ⁻¹² erg cm ⁻² s ⁻¹	Maximum X-ray flux for Swift/BAT (14-195 keV).
40	'INTEGRAL_min_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Minimum X-ray flux for INTEGRAL (17-60 keV).
41	'INTEGRAL_max_flux'	$10^{-12} \text{ erg cm}^{-2} \text{ s}^{-1}$	Maximum X-ray flux for INTEGRAL (17-60 keV).
42	'Mean_Mass'	${ m M}_{\odot}$	Mean mass of the compact object.
43	'Low_Mass'	${ m M}_{\odot}$	Lower limit of the compact object mass.
44	'High_Mass'	${ m M}_{\odot}$	Upper limit of the compact object mass.
45	'Mean_Dist'	pc	Mean (between the two, minimum and maximum) estimate of the distance to
			the binary system

Table A.1 – continued

	1able A.1 – continued					
№	Column name	Unit	Description			
			according to Gaia Collaboration et al. (2023); Bailer-Jones et al. (2021); Anders			
			et al. (2022) or taken from literature. In every literature case only one source of			
			information was taken.			
46	'Low_Dist'	pc	The lowest (minimum) estimate of the distance to the binary system according to			
			Gaia Collaboration et al. (2023); Bailer-Jones et al. (2021); Anders et al. (2022)			
			or taken from literature. In every literature case only one source of information			
			was taken.			
47	'High_Dist'	pc	The highest (maximum) estimate of the distance to the binary system according			
			to Gaia Collaboration et al. (2023); Bailer-Jones et al. (2021); Anders et al.			
			(2022) or taken from literature. In every literature case only one source of			
			information was taken.			
48	'Teff'	K	Effective stellar temperature provided by Gaia Collaboration et al. (2023);			
			Anders et al. (2022).			
49	'Lopt'	${ m L}_{\odot}$	Luminosity estimate of the optical companion provided by Gaia Collaboration			
			et al. (2023).			
50	'IDS'		List of all identifiers, that we found in SIMBAD and in the catalogues and			
			articles.			
51	'CRSF_Ref'		References to the articles, which providing the corresponding values for cy-			
			clotron line energies.			
52	'Spin_Ref'		References to the articles, which providing the corresponding value for Pulsation			
5 0	(O.1. D. C)		Periods.			
53	'Orb_Ref'		References to the articles, which providing the corresponding value for Orbital			
~ .	(C . 1 D C)		parameters.			
54	'Spectral_Ref'		References to the articles, which providing the spectral type of the optical star.			
55	'Dist_Ref'		Reference to the article, which provides the distance estimation, if literature			
5.0	(M D . C)		values were used.			
56	'Mass_Ref'		Reference to the article, which provides the mass estimation of the compact			
57	·: D -£'		object.			
57	'misc_Ref'		miscellaneous references regarding the object.			
58 59	'comments'		Comments regarding the object.			
60	'_2MASS_ID' 'CatWISE_ID'		Source name in the 2MASS All-Sky Catalogue of Point Sources Source name in the CatWISE2020 catalogue			
61						
62	'ROSAT_ID' 'XMM_ID		Source name in the Second ROSAT all-sky survey (2RXS) source catalogue Source name in the XMM-Newton Serendipitous Source Catalogue			
63	'Chandra_ID'		Source name in the Chandra Source Catalogue (CSC) Release 2.0			
64	'XRT_ID'		Source name in the 2SXPS Swift X-ray telescope point source catalogue			
65	'BAT_ID'		Source name in the Swift-BAT 105-Month All-Sky Hard X-Ray Survey cata-			
03	מו_ווע		logue			
66	'INTEGRAL_ID		Source name in the INTEGRAL/IBIS 9-year Galactic Hard X-Ray Survey			
00	HATEORAL_ID		catalogue			
			catalogue			