New hard X-ray sources discovered in the ongoing INTEGRAL Galactic Plane survey after 14 years of observations

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ABSTRACT

The International Gamma-Ray Astrophysics Laboratory (INTEGRAL) continues to successfully work in orbit after its launch in 2002. The mission provides the deepest ever survey of hard X-ray sources throughout the Galaxy at energies above 20 keV. We report on a catalogue of new hard X-ray source candidates based on the latest sky maps comprising 14 years of data acquired with the IBIS telescope onboard INTEGRAL in the Galactic Plane (|b| < 17.5°). The current catalogue includes in total 72 hard X-ray sources detected at S/N > 4.7σ and not known to previous INTEGRAL surveys. Among them, 31 objects have also been detected in the on-going all-sky survey by the BAT telescope of the Swift observatory. For 26 sources on the list, we suggest possible identifications: 21 active galactic nuclei, two cataclysmic variables, two isolated pulsars or pulsar wind nebulae, and one supernova remnant; 46 sources from the catalogue remain unclassified.

Key words: X-rays: new sources

1 INTRODUCTION

X-ray surveys play a key role in our understanding of energetic phenomena in the Universe. Detailed investigations of the physics and evolution of X-ray selected sources are usually based on systematic studies of their properties. Observations in recent decades have revealed a variety of X-ray point sources beyond the solar system in the Milky Way and Magellanic Clouds. Although the bright X-ray sources in the Milky Way can be effectively studied, many of them are not observable due to the heavy obscuration by the Galactic disk. Studies of nearby galaxies with modern sensitive soft X-ray telescopes are relatively free from the obscuration problem and can provide us uniform samples of X-ray binaries in different environments (see Fabbiano & White 2006; Fabbiano 2006, for a review). As a result, we may know better the properties of X-ray source populations and structure of the nearby galaxies, than of our own Milky Way.

X-ray observations of our Galaxy at energies above 10 keV are free from the obscuration bias. However, due to the large extent of the Milky Way across the sky, a systematic survey of the Galactic X-ray source population and discovery of new X-ray emitters require wide-angle instruments. This makes the IBIS coded-mask telescope (Ubertini et al. 2003) onboard the INTEGRAL observatory (Winkler et al. 2003) unique and most suitable for surveying the Galaxy in the hard X-ray domain.

The INTEGRAL observatory has been successfully operating in orbit since its launch in October 2002. Over the past years, INTEGRAL acquired a huge data set, which allowed us to construct high quality X-ray catalogs in the Galactic Plane (GP), starting from our early papers by Revnivtsev et al. (2004, 2006); Molkov et al. (2004), to more recent surveys (see Krivonos et al. 2012, 2015; Bird et al. 2016, and references therein). These works were subsequently used for many relevant studies, including systematic discoveries of strongly absorbed high-mass X-ray binaries (HMXBs) and the study of their luminosity function and distribution in the Galaxy (Lutovinov et al. 2005, 2013b; Bodaghee et al. 2007, 2012; Chaty et al. 2008; Coleiro et al. 2013), the statistics of low mass X-ray binaries (Revnivtsev et al. 2008b) and cataclysmic variables (CVs) (Revnivtsev et al. 2008a; Scaringi et al. 2010).

In the previous paper (Krivonos et al. 2012), we pre-
Figure 1. Sensitivity of the Galactic plane surveys over the Galactic longitude averaged within $|b| < 5^\circ$ in the 17–60 keV energy band ($4.7\sigma$, 1 mCrab = $1.43 \times 10^{-11}$ erg s$^{-1}$ cm$^{-2}$). Black solid line corresponds to the 9-year survey Krivonos et al. (2012), magenta line shows the sensitivity curve from the current work. Upper panel: open and filled red circles show the positions and fluxes of 26 non-identified persistent sources (Krivonos et al. 2012; Lutovinov et al. 2013b). Filled circles denote objects identified up to now. Long dashed line represents the flux limit used by Lutovinov et al. (2013b) to achieve full completeness of the survey in the inner part of the Galaxy (there are no unidentified sources above the line). Bottom panel: blue open squares denote 46 non-identified sources detected in the current survey. Filled squares show 26 sources with tentatively identified nature.

The sample of 26 persistent unidentified sources is shown by red circles (see Lutovinov et al. 2013b). Filled circles denote objects identified up to now. Long dashed line represents the flux limit used by Lutovinov et al. (2013b) to achieve full completeness of the survey in the inner part of the Galaxy (there are no unidentified sources above the line). Bottom panel: blue open squares denote 46 non-identified sources detected in the current survey. Filled squares show 26 sources with tentatively identified nature.

Figure 2. Face-on view of the Galaxy shown along with the distance range at which an X-ray source of a given luminosity $L_{\text{MX}}$ (or more) can be detected according to the 17–60 keV sensitivity of the current 14-year INTEGRAL survey (solid lines), compared to the 9-year GP survey (Krivonos et al. 2012; dotted lines). Red, orange and yellow contours correspond to $L_{\text{MX}} = 2 \times 10^{35}$, $10^{35}$ and $5 \times 10^{34}$ erg s$^{-1}$, respectively. The background image is a sketch of the Galaxy adopted from Churchwell et al. (2009).

2 DATA ANALYSIS

For this work, we selected all publicly available INTEGRAL data from December 2002 to March 2017 (spacecraft revolutions 26-1790). Prior to actual data analysis we applied the latest energy calibration (Caballero et al. 2013) for the registered IBIS/ISGRI detector events with the INTEGRAL Off-line Scientific Analysis version 10.2 provided by ISDC Data Centre for Astrophysics up to the COR level. Then events were processed with a proprietary analysis package devel-
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op ed at IKI\(^1\) (details available in Krivonos et al. 2010a, 2012; Churazov et al. 2014) to produce a 17 – 60 keV sky image of every individual INTEGRAL observation with a typical exposure time of 2 ks (usually referred as Science Window, or ScW). The flux scale in each ScW sky image was renormalized using the flux of the Crab nebula measured in the nearest observation. This procedure was used to account for the loss of sensitivity at low energies caused by ongoing detector degradation.

In total, we obtained 124727 ScW images covering the whole sky, comprising ~220 Ms of the effective (dead time-corrected) exposure. For the purposes of this work we selected 79234 ScW’s (~130 Ms) within the GP (|b| < 17.5\(^\circ\)). Following Krivonos et al. (2012) we constructed six overlapping 70’×35’ cartesian projections centered at the GP (|b| = 0\(^\circ\)) and Galactic longitudes l = 0\(^\circ\), ±50\(^\circ\), ±115\(^\circ\), and l = 180\(^\circ\).

The peak sensitivity of the survey is 2.2 × 10^{-12} erg s^{-1} cm^{-2} (~0.15 mCrab\(^2\)) in the 17-60 keV energy band) at a 4.7\(\sigma\) detection level. The survey covers 90\% of the geometrical area (12680 degrees) down to the flux limit of 1.3 × 10^{-11} erg s^{-1} cm^{-2} (~0.93 mCrab) and 10\% of the total area down to the flux limit of 3.8 × 10^{-12} erg s^{-1} cm^{-2} (~0.26 mCrab). Given the added exposure in the GP, the achieved sensitivity in sensitivity with respect to the 9-year survey is in the range of 10 – 30\%. The updated sensitivity of the current survey over the Galactic longitude is shown in the bottom panel of Fig. 1. Note that the overall improvement in sensitivity makes it possible to probe deeper into the Galaxy. Fig. 2 shows a face-on schematic view of the Galaxy and the distances at which we can detect a hard X-ray source of a given luminosity \(L_{\text{INTEGRAL}}\) in the 17-60 keV band. One can see that (i) we can now detect all sources with the luminosity \(L_{\text{X}} > 2 \times 10^{36}\) erg s^{-1} at the far end of the Galaxy in the direction towards the Galactic Centre (GC), (ii) the distance range for the luminosity \(L_{\text{X}} > 2 \times 10^{35}\) erg s^{-1} covers most of the Galactic stellar mass, and (iii) the Galactic central bar is fully reachable at luminosities \(L_{\text{X}} > 5 \times 10^{36}\) erg s^{-1}.

Following Krivonos et al. (2012), we adopted a conservative detection threshold of \(S/N_{\text{lim}} > 4.7\sigma\) to ensure that the final catalogue contains no more than one spurious source assuming Poisson statistics. The regions around bright sources, such as Crab, Sco X-1, Cyg X-1, Cyg X-3, Vela X-1, GX 301-2, and GRS 1915+105 were excluded from the automated excess selection to prevent false detections triggered by high systematic noise. However, manual inspection of these regions was performed to select possible source candidates (properly marked as being detected in noisy environment).

A special care was taken for the source detection in the region of ~17 degrees around the GC due to enhanced systematics (see e.g. Krivonos et al. 2010a). False detections were revealed by a distorted excess shape that differs significantly from the instrumental point-spread function, which is a symmetric two-dimensional Gaussian (\(\sigma = 5\)). One can reduce IBIS/ISGRI false detections by using additional information from the BAT coded-mask telescope (Barthelmy et al. 2005) onboard the Swift observatory (Gehrels et al. 2004) working at hard X-ray energies. Since BAT has a different coded-mask design compared to IBIS, it suffers different systematics, which allows one to suppress the non-statistical uncertainties known to IBIS (the idea on which the combined Swift-INTEGRAL survey by Bottacini et al. 2012, is based). We assume that finding a hard X-ray counterpart in the ongoing Swift/BAT surveys (Cusumano et al. 2010; Baumgartner et al. 2013) of a suspected IBIS/ISGRI systematic excess adds more evidence that the excess is a real source.

3 RESULTS

Our analysis of 14-year averaged sky images of the GP (|b| < 17.5\(^\circ\)) led to the detection of 522 hard X-ray sources at significance \(S/N > 4.7\sigma\), which is ~30\% more compared to 402 sources detected in the 9-year survey (Krivonos et al. 2012) with the same detection threshold. Note that 14 weak sources\(^3\) listed in the 9-year survey with fluxes of 0.2 – 0.5 mCrab are not detected in the current study, probably due to an intrinsic variability. Among 134 newly added sources (522–402+14), we identified 62 previously known X-ray emitters, including 17 known sources that experienced transient events after 2010 (Table 1). A detailed analysis of the survey’s catalogue will be presented elsewhere. For the current report we selected those 72 (out of 134) newly detected hard X-ray sources that have not been listed in the INTEGRAL surveys based on the data acquired before 2010 (Krivonos et al. 2007, 2010b, 2012; Bird et al. 2004, 2006, 2007, 2010, 2016), i.e. those sources whose detection is mainly determined by the ~6-year increased INTEGRAL survey sensitivity.

Table 2\(^4\) lists new INTEGRAL sources detected in the current work with significances between 4.7\(\sigma\) and 15\(\sigma\) and fluxes between 0.17 and 1.7 mCrab (2.5 × 10^{-12} – 2.4 × 10^{-11} erg s^{-1} cm^{-2}). We searched for source counterparts within a 3.6\(\sigma\) error circle (90\% confidence), as typical for the INTEGRAL sources detected at \(S/N = 5 – 6\sigma\) (Krivonos et al. 2007). As seen from Table 2, 31 source candidates are also detected in the ongoing Swift/BAT all-sky hard X-ray survey (Cusumano et al. 2010; Baumgartner et al. 2013). No any hard X-ray counterpart were found for 41 sources, thus they have been detected in hard X-rays for the first time.

We utilized also the SIMBAD\(^5\) and NED\(^6\) data bases to perform a preliminary identification of the detected source candidates within 3.6\(\sigma\) of the INTEGRAL position. However, usually unique optical/IR counterparts and hence firm astronomical classification can only be obtained based on arc-

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2 1 mCrab corresponds to 1.43 × 10^{-11} erg s^{-1} cm^{-2} assuming a spectral shape \(10(E/1\text{ keV})^{-2.1}\) photons cm^{-2} s^{-1} keV^{-1}.
3 IGR J17315–3221, IGR J17331–2406, Swift J2113.5+5422, IGR J18175–1530, IGR J17448–3241, XTE J1543–569, IGR J16293–4603, IGR J17197–3010, IGR J16358–4726, IGR J18497–0248, XTE J1751–305, AX J1753.5–2745, IGR J09189–4418 and IGR J20107+4534.
4 Table 2 is only available in the online version of the paper.
5 http://simbad.u-strasbg.fr/simbad
6 http://ned.ipac.caltech.edu

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second positions provided by soft X-ray focusing telescopes. Therefore, we paid a special attention for finding soft X-ray counterparts in the HEASARC\(^7\) data base, Swift/XRT point source catalogue (1SXPS; Evans et al. 2014) and the third XMM-Newton serendipitous source catalogue (3XMM-DR5; Rosen et al. 2016). As a result, we suggest classification for 26 sources from the list, with two (IGR J00555+4610 and IGR J18184–2352) being most likely CVs and 21 probably being active galactic nuclei (Table 2 and filled squares in the bottom panel of Fig. 1). The remaining 46 unclassified sources are shown by open squares in the bottom panel of Fig. 1. Note, that most of them are detected close to the limiting flux of the survey below \(0.5\) mCrab (except for IGR J16459–2325 with a measured flux of \(1.0 \pm 0.1\) mCrab). Twenty out of the 46 nonidentified sources are located in the Galactic bulge at \(|l| < 15^\circ\).  

4 CONCLUDING REMARK

Regular observations of the GP with INTEGRAL are consistently improving the sensitivity of the hard X-ray survey and allowing us to extend our knowledge of the Galactic X-ray source population, both for weak and nearby sources (mostly CVs, see e.g. Lutovinov et al. 2010; Clavel et al. 2016; Tomsick et al. 2016a), and more distant objects located at far end of the Galaxy (Lutovinov et al. 2016; Rahoui et al. 2017). The presented catalogue opens the path to a large program of follow-up observations, dedicated both to unveil new classes of objects and to increase the overall completeness of the source sample, needed for many Galactic population studies.

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**Table 1.** The list of known X-ray transients detected in 14-year time averaged map at \(S/N > 4.7\sigma\) mainly due to outburst event(s) occurred between 2010 and 2016.

| No. | Name   | RA (J2000) (deg) | Dec (J2000) (deg) | Flux\(17–60\) keV \(10^{-11}\) erg s\(^{-1}\) cm\(^{-2}\) | \(S/N\) | Type\(^a\) | Outburst year |
|-----|--------|------------------|------------------|-----------------------------------------------|--------|-----------|--------------|
| 1   | GS 0834-430 | 128.979          | -43.185          | 0.99 \(\pm\) 0.08                         | 12.6   | HMXB     | 2012         |
| 2   | GS 1354-64  | 209.562          | -64.733          | 3.94 \(\pm\) 0.09                         | 45.2   | LMXB     | 2015         |
| 3   | IGR J17177–3565 | 259.424       | -36.860          | 0.32 \(\pm\) 0.06                         | 4.9    | LMXB     | 2011         |
| 4   | GRS 1716–249 | 259.903          | -25.020          | 4.03 \(\pm\) 0.06                         | 65.2   | LMXB     | 2016         |
| 5   | Swift J1734.5–3027 | 263.652       | -30.399          | 0.87 \(\pm\) 0.05                         | 17.2   | LMXB     | 2013         |
| 6   | GRS 1739–278 | 365.661          | -27.748          | 2.11 \(\pm\) 0.05                         | 42.5   | LMXB     | 2014, 2016   |
| 7   | GRO J1744–28  | 266.138          | -28.741          | 4.51 \(\pm\) 0.05                         | 91.8   | LMXB     | 2014, 2017   |
| 8   | Swift J174510.8–262411 | 266.297      | -26.401          | 30.74 \(\pm\) 0.05                        | 607.7  | LMXB     | 2012         |
| 9   | IGR J17498–2921 | 267.482        | -29.323          | 0.72 \(\pm\) 0.05                         | 14.6   | LMXB     | 2011         |
| 10  | 1RXS J180408.9–342058 | 271.036       | -34.356          | 5.80 \(\pm\) 0.06                         | 99.5   | LMXB     | 2012         |
| 11  | SAX J1806.5–2215 | 271.654        | -22.233          | 3.31 \(\pm\) 0.06                         | 54.7   | LMXB     | 2011         |
| 12  | IGR J18179–1621 | 274.477        | -16.481          | 0.38 \(\pm\) 0.08                         | 4.7    | HMXB     | 2012         |
| 13  | IGR J18245–2452 | 276.106        | -24.879          | 1.29 \(\pm\) 0.07                         | 19.3   | LMXB     | 2013         |
| 14  | MAXI J1828–249 | 277.238          | -25.041          | 1.23 \(\pm\) 0.07                         | 17.3   | BHC      | 2013         |
| 15  | MAXI J1836–194 | 278.937          | -19.314          | 2.17 \(\pm\) 0.09                         | 24.5   | XRB      | 2011         |
| 16  | XTE J1859+083 | 284.753          | 8.239            | 0.60 \(\pm\) 0.07                         | 8.3    | HMXB     | 2015         |
| 17  | V404 Cyg | 306.019          | 33.867           | 9.70 \(\pm\) 0.08                         | 119.8  | LMXB     | 2015         |

\(^a\) General astrophysical type of the object: LMXB (HMXB) – low- (high-) mass X-ray binary; BHC – black hole candidate; XRB – X-ray binary.

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REFERENCES

Barthelmy S. D., et al., 2005, Space Sci. Rev., 120, 143
Baumgartner W. H., Tueller J., Markwardt C. B., Skinner G. K., Barthelmy S., Mushotzky R. F., Evans P. A., Gehrels N., 2013, ApJS, 207, 19

\(^7\) https://heasarc.gsfc.nasa.gov

\(^8\) http://isdc.unige.ch

\(^9\) http://hea.iki.rssi.ru/rsdc
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Bikmaev I. F., Revnivtsev M. G., Burenin R. A., Sunyaev R. A., 2006, Astronomy Letters, 32, 588
Bird A. J., et al., 2004, ApJLett, 607, L33
Bird A. J., et al., 2006, ApJ, 636, 765
Bird A. J., et al., 2007, ApJS, 170, 175
Bird A. J., et al., 2010, ApJS, 186, 1
Bird A. J., et al., 2016, ApJS, 223, 15
Bodaghee A., et al., 2007, A&A, 467, S85
Bodaghee A., Tomtick J. A., Rodriguez J., James J. B., 2012, ApJ, 744, 108
Bottacini E., Ajello M., Greiner J., 2012, ApJS, 201, 34
Burenin R. A., et al., 2016, Astronomy Letters, 42, 295
Caballero I., et al., 2013, preprint, (arXiv:1304.1349)
Chaty S., Rahoui F., Poelhui C., Tomtick J. A., Rodriguez J., Walter R., 2008, A&A, 484, 783
Churazov E., et al., 2014, Nature, 512, 406
Churchwell E., et al., 2009, PASP, 121, 213
Cliesinski D., Diaz M. P., Drake A. J., Cook K. H., 2004, PASP, 116, 610
Clavel M., et al., 2016, MNARS, 461, 304
Coleiro A., Chatty S., Zurita Heras J. A., Rahoui F., Tomtick J. A., 2013, A&A, 560, A108
Cusumano G., et al., 2010, A&A, 524, A64
Edelson R., Malkan M., 2012, ApJ, 751, 52
Evans P. A., et al., 2014, ApJS, 210, 8
Fabbiano G., 2006, ARA&A, 44, 323
Fabbiano G., White N. E., 2006, Compact stellar X-ray sources in normal galaxies, pp 475–506
Gehrels N., et al., 2004, ApJ, 611, 1005
Huchra J. P., et al., 2012, ApJS, 199, 26
Karasev D. I., Revnivtsev M. A., Revnivtsev M. G., Krivonos R. A., 2012, Astronomy Letters, 38, 629
Krimm H. A., et al., 2013, ApJS, 209, 14
Krivonos R., Revnivtsev M., Lutovinov A., Sazonov S., Churazov E., Sunyaev R., 2007, A&A, 475, 775
Krivonos R., Revnivtsev M., Tsygankov S., Sazonov S., Vikhlinin A., Pavlinsky M., Churazov E., Sunyaev R., 2010a, A&A, 519, A107
Krivonos R., Tsygankov S., Revnivtsev M., Grebenev S., Churazov E., Sunyaev R., 2010b, A&A, 523, A61
Krivonos R., Tsygankov S., Lutovinov A., Revnivtsev M., Churazov E., Sunyaev R., 2012, A&A, 545, A27
Krivonos R., Tsygankov S., Lutovinov A., Revnivtsev M., Churazov E., Sunyaev R., 2015, MNARS, 448, 3766
Lutovinov A., Revnivtsev M., Gilfanov M., Shytkovskiy P., Molok S., Sunyaev R., 2005, A&A, 444, 821
Lutovinov A., Burenin R. A., Revnivtsev M. G., Saleimanov V. F., Tkachenko A. Y., 2010, Astronomy Letters, 36, 904
Lutovinov A. M., Mironov A. I., Burenin R. A., Revnivtsev M. G., Tsygankov S. S., Pavlinsky M. N., Korotkevich I. V., Esselevich M. V., 2013a, Astronomy Letters, 39, 513
Lutovinov A. A., Revnivtsev M. G., Tsygankov S. S., Krivonos R. A., 2013b, MNARS, 431, 327
Lutovinov A. A., et al., 2015, Astronomy Letters, 41, 179
Lutovinov A. A., Buckley D. A. H., Townsend L. J., Tsygankov S. S., Kennea J., 2016, MNARS, 462, 3823
Masseti N., et al., 2010, A&A, 519, A96
Masseti N., et al., 2013, A&A, 556, A120
Massaro F., Paggi A., Errando M., D’Abrusco R., Masetti N., Tosti G., Fink S., 2013, ApJS, 207, 16
Mereminskiy I. A., Krivonos R. A., Lutovinov A. A., Sazonov S. Y., Revnivtsev M. G., Sunyaev R. A., 2007, ApJ, 664, 45
Molkov S. V., Chepeshchuk A. M., Lutovinov A. A., Revnivtsev M. G., Postnov K. A., Sunyaev R. A., 2004, Astronomy Letters, 30, 534
Paturel G., Petit C., Prugniel P., Theureau G., Rousseau J., Brouty M., Dubois P., Cambresy L., 2003, A&A, 412, 45
Rahoui F., Tomlick J. A., Krivonos R., 2017, MNARS, 465, 1563
Revnivtsev M. G., et al., 2004, Astronomy Letters, 30, 382
Revnivtsev M. G., Sazonov S. Y., Molok S. V., Lutovinov A. A., Churazov E. M., Sunyaev R. A., 2006, Astronomy Letters, 32, 145
Revnivtsev M., Sazonov S., Krivonos R., Ritter H., Sunyaev R., 2008a, A&A, 489, 1121
Revnivtsev M., Lutovinov A., Churazov E., Sazonov S., Gilfanov M., Grebenev S., Sunyaev R., 2008b, A&A, 491, 209
Revnivtsev M. G., Kniazev A., Karasev D. I., Berdnikov L., Barway S., 2013, Astronomy Letters, 39, 523
Reynolds M. T., et al., 2013, The Astronomer’s Telegram, 5200
Rosen S. R., et al., 2016, A&A, 590, A1
Scaringi S., et al., 2010, MNARS, 401, 2207
Sguera V., Bazzano A., Sidoli L., 2015, The Astronomer’s Telegram, 8250
Skrutskie M. F., et al., 2006, AJ, 131, 1163
Sugizaki M., Mitsuda K., Kaneda H., Matsu kazi K., Yamauchi S., Koyama K., 2001, ApJS, 134, 77
Tomsick J. A., Krivonos R., Rahoui F., Ajello M., Rodriguez J., Barri`ere N., Bodaghee A., Chatty S., 2015, MNARS, 449, 597
Tomsick J. A., Rahoui F., Krivonos R., Clavel M., Strader J., Chomiuk L., 2016a, MNARS, 460, 513
Tomsick J. A., Krivonos R., Wang Q., Bodaghee A., Chatty S., Rahoui F., Rodriguez J., Fornasini F. M., 2016b, ApJ, 816, 38
Ubertini P., et al., 2003, A&A, 411, L131
Winkler C., et al., 2003, A&A, 411, L1
Zolotukhin I. Y., Revnivtsev M. G., 2015, MNARS, 446, 2418
Table 2. The list of newly detected INTEGRAL hard X-ray sources based on 14 years of observations. This catalogue is only available in the online version of the paper.

| No. | Name¹ | RA² | Dec² | Flux³ (17–60 keV) | S/N | Type⁴ | Ref⁵ | Hard X-ray/y counterpart | Soft X-ray counterpart | Optical/IR counterpart |
|-----|-------|-----|------|------------------|-----|-------|------|--------------------------|-----------------------|------------------------|
| 1   | J0055+4610 | 13.876 | 46.173 | 1.42 ± 0.28 | 5.1 | CV    | 1,2 | Swift J0055.4+4612 | XSS J0056.4+4548 |  |
| 2   | J0107+6519 | 15.440 | 65.330 | 0.61 ± 0.08 | 8.0 | AGN   | 1 | Swift J0123.7+5147 | | |
| 3   | J0214+5142 | 33.625 | 51.710 | 1.10 ± 0.19 | 5.7 | AGN   | | | | |
| 4   | J0317+5028 | 47.934 | 50.472 | 0.70 ± 0.15 | 4.7 | AGN   | | | | |
| 5   | J0502+2552 | 100.050 | -25.868 | 2.24 ± 0.32 | 7.0 | AGN   | | | | |
| 6   | J0714+0146 | 108.547 | 0.744 | 1.44 ± 0.24 | 6.0 | AGN   | | | | |
| 7   | J0725+0054 | 111.471 | -0.907 | 1.39 ± 0.22 | 6.3 | AGN   | 1 | Swift J0725.7−0055 | | |
| 8   | J0739−3143 | 114.908 | -31.732 | 1.73 ± 0.21 | 8.1 | AGN?  | | | | |
| 9   | J0743−2544 | 115.844 | -25.736 | 1.22 ± 0.15 | 7.9 | AGN?  | | | | |
| 10  | J0800−4309 | 120.121 | -43.160 | 0.58 ± 0.10 | 5.7 | AGN?  | | | | |
| 11  | J0821−1320 | 125.387 | -13.339 | 0.98 ± 0.14 | 6.9 | AGN?  | 3 | | | |
| 12  | J0832−1808 | 128.022 | -18.141 | 1.11 ± 0.15 | 7.3 | AGN?  | 4,5 | | | |
| 13  | J0839−1214 | 129.961 | -12.243 | 1.80 ± 0.15 | 11.7 | AGN   | 5,1 | Swift J0839.6−1213 | | |
| 14  | J0845−3529 | 131.329 | -35.493 | 0.72 ± 0.12 | 6.0 | AGN?  | 1,7 | Swift J0845.0−3531 | | |
| 15  | J0928−3935 | 141.965 | -39.590 | 0.66 ± 0.12 | 5.7 | AGN?  | | | | |
| 16  | J0931−4725 | 143.302 | -47.441 | 0.57 ± 0.09 | 6.2 | AGN?  | | | | |
| 17  | J1127−5319 | 171.898 | -53.369 | 0.71 ± 0.11 | 6.5 | AGN?  | 8 | PBC J1127.7−5320 | | |
| 18  | J1129−6557 | 172.490 | -65.960 | 0.58 ± 0.10 | 5.8 | AGN?  | 5 | | | |
| 19  | J1208−6327 | 182.157 | -63.452 | 0.54 ± 0.09 | 6.0 | AGN?  | | | | |
| 20  | J1249−5930 | 192.161 | -59.507 | 0.49 ± 0.09 | 5.5 | AGN?  | | | | |
| 21  | J1252−6351 | 193.241 | -63.868 | 0.49 ± 0.09 | 5.5 | AGN?  | | | | |
| 22  | J1404−6164 | 211.029 | -61.700 | 0.69 ± 0.08 | 8.1 | AGN?  | 1 | Swift J1403.6−6146 | | |
| 23  | J1442−5533 | 220.427 | -55.550 | 0.69 ± 0.09 | 7.4 | AGN?  | 5 | | | |
| 24  | J1492−6048 | 214.819 | -60.810 | 0.43 ± 0.09 | 5.1 | PSR/PWN | 1 | Swift J1418.8−6055 | AX J1418.7−6058 |  |
| 25  | J1555−4306 | 238.769 | -43.090 | 0.50 ± 0.09 | 5.7 | AGN?  | | | | |
| 26  | J1645−2325 | 251.477 | -23.428 | 1.39 ± 0.13 | 11.0 | AGN?  | | | | |
| 27  | J1649−1740 | 252.355 | -17.676 | 0.80 ± 0.14 | 5.6 | AGN?  | 4,9 | 4PBC J1649.3−1738 | | |
| 28  | J1704−4305 | 256.010 | -43.080 | 0.44 ± 0.07 | 6.2 | AGN?  | 5,6 | 4PBC J1709.7−2348 | | |
| 29  | J1709−2344 | 257.455 | -23.747 | 0.63 ± 0.08 | 8.4 | AGN?  | | | | |
| 30  | J1715−2124 | 258.959 | -21.411 | 0.59 ± 0.08 | 7.5 | AGN?  | 8,9 | 4PBC J1725.8−4510 | | |
| 31  | J1725−4509 | 261.380 | -45.170 | 0.58 ± 0.08 | 7.1 | AGN?  | | | | |
| 32  | J1732−3445 | 263.169 | -34.754 | 0.29 ± 0.06 | 5.2 | AGN?  | | | | |
| 33  | J1732−4405 | 263.183 | -44.103 | 0.62 ± 0.09 | 6.9 | AGN?  | | | | |
| 34  | J1742−2108 | 265.560 | -21.106 | 0.25 ± 0.05 | 5.0 | AGN?  | 6 | | | |
| 35  | J1752−2022 | 268.217 | -20.367 | 0.43 ± 0.06 | 6.7 | AGN?  | 8 | 4PBC J1752.6−2020 | | |
| 36  | J1758−2544 | 268.463 | -25.749 | 0.54 ± 0.05 | 10.5 | AGN?  | 10 | Swift J1753.7−2544 | | |
| 37  | J1757−2500 | 269.266 | -25.015 | 0.34 ± 0.08 | 6.4 | AGN?  | | | | |
| 38  | J1759−2315 | 269.907 | -23.266 | 0.39 ± 0.06 | 6.9 | AGN?  | | | | |
| 39  | J1801−3045 | 270.271 | -30.764 | 0.37 ± 0.05 | 7.2 | AGN?  | | | | |
| 40  | J1803−3222 | 270.326 | -32.371 | 0.34 ± 0.05 | 6.4 | AGN?  | | | | |
| 41  | J1807−3507 | 271.750 | -35.132 | 0.30 ± 0.06 | 4.9 | AGN?  | | | | |
| 42  | J1810−1751 | 272.555 | -17.853 | 0.55 ± 0.07 | 7.4 | AGN?  | | | | |

Continued on next page.
| No. | Name | RA° (deg) | Dec° (deg) | Flux (17–60 keV) | S/N | Type | Ref. | Hard X-ray/γ counterpart | Soft X-ray counterpart | Optical/IR counterpart |
|-----|------|-----------|------------|-----------------|-----|------|------|--------------------------|----------------------|------------------------|
| 45  | J18112−2641 | 272.854 | -26.707 | 0.48 ± 0.06 | 8.7 |       |      |                          |                      |                        |
| 46  | J18141−0606 | 273.525 | -6.114   | 0.45 ± 0.09 | 5.1 |       |      |                          |                      |                        |
| 47  | J18141−1823 | 273.538 | -18.395  | 0.68 ± 0.07 | 9.0 | 8     | 4PBC J1814.1−1822 | MACHO 311.37389.3983 |                      |                        |
| 48  | J18147−3400 | 273.690 | -34.010  | 0.54 ± 0.06 | 8.6 |       |      |                          |                      |                        |
| 49  | J18165−3912 | 274.136 | -39.202  | 0.61 ± 0.09 | 7.0 |       |      |                          |                      |                        |
| 50  | J18172−1944 | 274.307 | -19.740  | 0.55 ± 0.07 | 7.6 |       |      |                          |                      |                        |
| 51  | J18184−2352 | 274.610 | -23.880  | 0.96 ± 0.06 | 15.2 | CV?   | 11   | HESS J1825−137          |                      |                        |
| 52  | J18265−1345 | 276.576 | -13.753  | 0.55 ± 0.08 | 6.6 | PWN?  |      |                          |                      |                        |
| 53  | J18345−5958 | 208.621 | -59.982  | 0.54 ± 0.09 | 6.4 |       |      |                          |                      |                        |
| 54  | J18443−0508 | 280.855 | -5.138   | 0.52 ± 0.08 | 6.2 |       |      |                          | 8.12 4PBC J1842.8−0506 | Swift J184311.0−050539 |
| 55  | J18544+0839† | 283.605 | 8.661    | 0.50 ± 0.08 | 6.7 |       |      |                          |                      |                        |
| 56  | J19039+3348 | 285.948 | 33.825   | 1.05 ± 0.17 | 6.2 | AGN   | 1     | Swift J1903.9+3349      |                      |                        |
| 57  | J19071+0716 | 285.783 | 7.274    | 0.40 ± 0.07 | 5.7 | 5.13  | [1] 1SXPS J19070.6+072004 | [1] XMM J19070.6+072003† |                      |                        |
| 58  | J19260+4136 | 291.517 | 41.608   | 0.66 ± 0.14 | 4.7 | AGN   | 1     | Swift J1926.9+4140      | 1RXS J192630.6+413314 | 2MASX J19263018+4133053 |
| 59  | J19305+1851 | 292.632 | 18.857   | 0.78 ± 0.10 | 7.7 | SNR?  |      |                          | 1RXS J193029.9+185205 |                      |
| 60  | J19421+3613 | 295.530 | 36.219   | 0.61 ± 0.09 | 6.6 |       |      |                          |                      |                        |
| 61  | J19498+2534 | 297.470 | 25.557   | 0.52 ± 0.10 | 5.0 |       | 8.14 4PBC J1950.0+2532 | AX J1949.8+2534      |                      |
| 62  | J19577+3339 | 299.429 | 33.658   | 0.46 ± 0.08 | 5.6 |       |      |                          |                      |                        |
| 63  | J19504+3318† | 291.675 | 33.311   | 0.63 ± 0.09 | 7.4 | 9.61  | 1RXS J195020.5+331419 |                      |                        |
| 64  | J20063+3641 | 301.601 | 36.684   | 0.72 ± 0.08 | 8.9 | 1     | Swift J2006.4+3645      |                      |                        |
| 65  | J20084+3221 | 302.124 | 32.350   | 0.68 ± 0.08 | 8.4 | 5.8   | 4PBC J2008.7+3221       | 1SXPS J200843.8+321824 |                      |                        |
| 66  | J20096+4303 | 314.914 | 43.054   | 0.57 ± 0.08 | 6.8 | 1     | Swift J2009.6+4301A/B   |                      |                        |
| 67  | J21099+3533 | 317.400 | 35.560   | 0.71 ± 0.11 | 6.6 |       |      |                          |                      |                        |
| 68  | J21133+3154 | 318.328 | 31.923   | 0.75 ± 0.15 | 4.8 |       | 1RXS J211319.3+315211 |                      |                        |
| 69  | J21382+3204 | 324.563 | 32.072   | 1.27 ± 0.24 | 5.4 | AGN   | 1     | Swift J2138.8−3207      | 1RXS J213833.0+320507 | WISE J213833.43+320505.8 |
| 70  | J21397+5949 | 324.945 | 59.832   | 0.78 ± 0.11 | 7.1 | AGN   | 1     | Swift J2139.7+5951      | 1RXS J213944.3+595016 | WISE J213944.96+595015.1 |
| 71  | J22018+5049 | 330.474 | 50.830   | 0.68 ± 0.10 | 6.7 | 1     | Swift J2201.9+5057      | 87GB 215950.2+503417 |                      |
| 72  | J22455+3940 | 341.383 | 39.683   | 2.43 ± 0.45 | 5.4 | AGN   | 1     | Swift J2246.0+3941      | 3C452                 |                      |

1 **INTEGRAL** (IGR) name of the source. A dagger symbol † marks that the source is located in the region of high systematic noise, and that its measured flux should be taken with the caution.

2 Equatorial coordinates (right ascension and declination) are in standard J2000.0 epoch.

3 The measured 17–60 keV flux of the source x10^{-14} erg cm^{-2} s^{-1}.

4 General astrophysical type of the object: AGN – active galactic nucleus, SNR – supernova remnant; CV – cataclysmic variable; PSR – isolated pulsar or pulsar wind nebula (PWN).

A question mark indicates that the specified type should be confirmed.

5 References. – (1) Baumgartner et al. (2013); (2) Bilkmaev et al. (2006); (3) Fatourechi et al. (2003); (4) Massaro et al. (2013); (5) Edelson & Malkan (2012); (6) Evans et al. (2014); (7) Masetti et al. (2010); (8) Casulano et al. (2010); (9) Skrutskie et al. (2006); Huchra et al. (2012); (10) Krimm et al. (2013); (11) Cieslinski et al. (2004); (12) Reynolds et al. (2013); (13) Rosen et al. (2016); (14) Sguera et al. (2015); Sugizaki et al. (2001);