SWIFT, INTEGRAL, RXTE, AND SPITZER REVEAL IGR J16283–4838

V. Beckmann

NASA Goddard Space Flight Center, Exploration of the Universe Division, Code 661, Greenbelt, MD 20771; beckmann@milkyway.gsfc.nasa.gov

AND

J. A. Kennea, C. Markwardt, A. Paizis, S. Soldi, J. Rodriguez, D. N. Burrows, M. Chester, N. Gehrels, M. Mowlavi, and J. Nousek

Received 2005 April 28; accepted 2005 June 8

ABSTRACT

We present the first combined study of the recently discovered source IGR J16283–4838 with Swift, INTEGRAL, and RXTE. The source, discovered by INTEGRAL on 2005 April 7, shows a highly absorbed [variable $N_H = (0.4–1.7) \times 10^{23}$ cm$^{-2}$] and flat ($\Gamma \sim 1$) spectrum in the Swift XRT and RXTE PCA data. No optical counterpart is detectable ($V > 20$ mag), but a possible infrared counterpart within the Swift XRT error radius is detected in the 2MASS and Spitzer GLIMPSE. The observations suggest that IGR J16283–4838 is a high-mass X-ray binary (HMXB) containing a neutron star embedded in Compton thick material. This makes IGR J16283–4838 a member of the class of highly absorbed HMXBs, discovered by INTEGRAL.

Subject headings: gamma rays: observations — stars: neutron — X-rays: binaries — X-rays: individual (IGR J16283–4838)

Online material: color figures

1. INTRODUCTION

Star formation in our Galaxy takes place mainly in the dense regions of the spiral arms. These regions host massive molecular clouds and also the majority of the single and binary neutron stars ($\sim 10^9$) and black holes ($\sim 10^6$) in the Milky Way. The dense molecular clouds lead to strong star formation activity, which also results in the formation of binary systems and subsequently to X-ray binary systems. These objects show X-ray flares and outbursts because of accretion processes onto the compact object. At the same time, the gas and dust of the spiral arms absorb most of the emission in the optical to soft X-ray regime below 10 keV. In addition, dense absorbing atmospheres around the object make the detection of these sources even more difficult. The hard X-ray and soft gamma-ray mission INTEGRAL (International Gamma-Ray Astrophysics Laboratory) (Winkler et al. 2003) operates at energies above 20 keV. With the large field of view of the main instruments, the imager IBIS (Imager on Board the INTEGRAL Satellite) (Ubertini et al. 2003; $15' \times 15'$, partially coud field of view) and the spectrograph SPI (Spectrometer on INTEGRAL) (Vedrenne et al. 2003; $35' \times 35'$, partially coud field of view), and its observing program focused on the Galactic plane and center, INTEGRAL is a powerful tool for discovering highly absorbed sources ($N_H > 10^{23}$ cm$^{-2}$) in the Galactic plane. So far a handful of those enigmatic objects have been found since the launch of INTEGRAL in 2002 October. Six of those sources have been published so far: IGR J16318–4848 (Walter et al. 2003), with an absorption of $N_H \simeq 19 \times 10^{23}$ cm$^{-2}$ (Matt & Guainazzi 2003), IGR J19140+0951 ($N_H = (0.3–1.0) \times 10^{23}$ cm$^{-2}$; Rodriguez et al. 2005), IGR J16320–4751 ($N_H \simeq 2 \times 10^{23}$ cm$^{-2}$; Rodriguez et al. 2003), IGR J16393–4643 ($N_H \simeq 10^{23}$ cm$^{-2}$; Combi et al. 2004), IGR J16358–4726 ($N_H \simeq 4 \times 10^{23}$ cm$^{-2}$; Patel et al. 2004), and IGR J16479–4514 ($N_H > 5 \times 10^{23}$ cm$^{-2}$; Walter et al. 2004). While the nature of the latter source is still unknown, the other sources appear to be high-mass X-ray binaries (HMXBs), probably hosting a neutron star as the compact object. Most, if not all, of these sources show variable absorption. In this paper we report the discovery and analysis of another highly absorbed source, IGR J16283–4838 (Soldi et al. 2005). This work makes the first use of the combined data of INTEGRAL, Swift, the Rossi X-Ray Timing Explorer (RXTE), and the Spitzer Space Telescope.

2. OBSERVATIONS OF IGR J16283–4838

All observations discussed in this section are summarized in Table 1.

2.1. Discovery by INTEGRAL

IGR J16283–4838 was discovered (Soldi et al. 2005) during the observation of the Norma arm region by the IBIS INTEGRAL Soft Gamma-Ray Imager (ISGRI) (Lebrun et al. 2003) on board INTEGRAL. The observation lasted from 2005 April 7, 13:57 UT until April 9, 4:44 UT, with an effective ISGRI exposure time of 126 ks. The source position is R.A. = $16^h28^m3$, decl. = $-48^\circ38^\prime$ (J2000.0) with 3$\sigma$ uncertainty. The source showed...
a flux of $f_X = (4.8 \pm 0.8) \times 10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$ in the 20–60 keV band. No emission was detectable above 60 keV. From the
analysis of another ISGRI observation with similar exposure time, we estimate the 3 $\sigma$ upper limit in the 60–200 keV band $f_X < 1.2 \times 10^{-10} \text{ ergs cm}^{-2} \text{ s}^{-1}$. The analysis of the data prior to
the discovery, lasting from April 4, 01:55 UT until April 6, 11:24 UT with an exposure time of 192 ks, resulted in a 3 $\sigma$ upper
limit of $f_{20–60 \text{ keV}} = 1.7 \times 10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$. The source showed significant brightening during an INTEGRAL
observation starting on April 10, 1:26 UT. Although IGR J16283–4838 was in the partially coded field of view of IBIS, the analysis gave
an 11.6 $\sigma$ detection within 96 ks with a flux of $f_{20–60 \text{ keV}} = (11.3 \pm 1.0) \times 10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$ (Paizis et al. 2005). The low
flux level of the source did not allow the extraction of a spectrum from the ISGRI data, and no simultaneous soft X-ray and optical
observations are available, as IGR J16283–4838 was always outside the field of view of INTEGRAL’s Joint European X-Ray Monitor
(JEM-X) and that of the Optical Monitoring Camera (OMC). No further INTEGRAL observations of the source were obtained.

### 2.2. X-Ray Follow-up Observations

After the discovery of IGR J16283–4838, a Swift follow-up
observation was requested in order to obtain an X-ray spectrum and
an optical measurement. The Swift mission (Gehrels et al.
2004) is a multiwavelength observatory for gamma-ray burst
astronomy. The payload combines a gamma-ray instrument (the
Burst Alert Telescope [BAT], 15–150 keV; Barthelmy et al.
2005), the X-Ray Telescope (XRT; Burrows et al. 2005), and the
Optical Telescope (UVOT; Roming et al. 2005). The XRT is a
focusing X-ray telescope with a 110 cm$^2$ effective area, 23$''$
field of view, 18$''$ resolution, and 0.2–10 keV energy range. The UVOT
design is based on the Optical Monitor (OM) on board ESA’s
XMM-Newton mission, with a field of view of 17$''$ x 17$''$ and
an angular resolution of 2$''$.

Two Swift observations took place 3 and 5 days after the last
INTEGRAL observation. The first started on April 13, 14:02 UT
with an exposure time of 2.5 ks, which resulted in an effective
Swift XRT exposure of 550 s. A preliminary analysis of the XRT
data refined the position of IGR J16283–4838 to R.A. =
16$^h$28$^m$10$^s$, decl. = $-48^\circ$38$'$55$''$ (J2000.0), with an estimated
uncertainty of 5$''$ radius (Kennea et al. 2005). A second obser-
vation was performed on April 15, 00:16 UT with a 2600 s e-
fective XRT exposure time.

For our analysis of the Swift data we used the calibration files
that had been released on 2005 April 5 and the software pro-
vided by the Swift Science Center. These tools are included in
the release of HEAsoft version 6.0 as of 2005 April 12. Ap-
plying a centroid algorithm to the data of April 15 gives a
refined position for the source of R.A. = 16$^h$28$^m$10.56$^s$, decl. =
$-48^\circ$38$'$56.4$''$, with an uncertainty of 6$''$ radius, consistent with both
the preliminary analysis and the INTEGRAL measurement.
The spectra extracted from the XRT data of April 15 are shown
in Figure 1. The spectral fitting was done using version 11.3.2
of XSPEC (Arnaud 1996). Both XRT spectra are well repre-
sented by an absorbed power law with the same photon index
($\Gamma = 1.12 \pm 0.35$) but different absorption column density.
The observation of April 13 shows a less absorbed ($N_{HI} = 5.6_{-0.2}^{+0.4} \times 10^{23} \text{ cm}^{-2}$) spectrum with a lower flux [$f_{2–10 \text{ keV}} = (3.9 \pm 0.3) \times
10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$] than the April 15 one. The latter data
show $N_{HI} = 1.7_{-0.1}^{+0.3} \times 10^{23} \text{ cm}^{-2}$ and a flux in the 2–10 keV band
of $f_{2–10 \text{ keV}} = (2.7 \pm 0.3) \times 10^{-11} \text{ ergs cm}^{-2} \text{ s}^{-1}$. The data are
equally well fit by an absorbed blackbody with $N_{HI} = 0.3 \times
10^{23} \text{ cm}^{-2}$ (April 13) and $N_{HI} = 1.4 \times 10^{23} \text{ cm}^{-2}$ (April 15), with
a temperature of $kT = 2.0 \pm 0.3$ keV. Adding a Gaussian line to
the fit does not improve the results significantly. The 3 $\sigma$
upper limit for the Fe K$\alpha$ line at 6.4 keV is 3 $\times 10^{-14} \text{ photons cm}^{-2} \text{ s}^{-1}$,
with an equivalent width of EW < 600 eV. Because of the short
exposure time, the source was not detected by the BAT instrument.

IGR J16283–4838 was then also observed twice by RXTE
using the Proportional Counter Array (PCA). The first obser-
vation, starting on April 14, 04:46 UT lasted 3.6 ks; the second
on April 15, 16:07 UT lasted 2.9 ks (Markwardt et al. 2005).

### Table 1

| Instrument                  | Date       | Energy Range (keV) | Flux (10$^{-11}$ ergs cm$^{-2}$ s$^{-1}$) | $N_{HI}$ (10$^{22}$ cm$^{-2}$) | $\Gamma$ |
|-----------------------------|------------|-------------------|------------------------------------------|--------------------------------|---------|
| Spitzer                     | 2004       | 3.6 $\mu$m        | 3.5 $\pm$ 0.2 mJy                       | ...                            | ...     |
| 2MASS                       | 1999 Jun 18| $K$ band          | 13.95 $\pm$ 0.06 mag                    | ...                            | ...     |
| Magellan-Baade              | 2005 Apr 21| $K$ band          | 14.1 mag                                 | ...                            | ...     |
| Swift UVOT                  | 2005 Apr 13| $V$ band          | >20 mag                                  | ...                            | ...     |
| Swift XRT                   | 2005 Apr 13| 2–10              | 3.9 $\pm$ 0.3                           | 6 $\pm$ 2                      | 1.1 $\pm$ 0.4 |
| Swift XRT                   | 2005 Apr 15| 2–10              | 2.7 $\pm$ 0.3                           | 17 $\pm$ 4                     | 1.1 $\pm$ 0.4 |
| XRT PCA                     | 2005 Apr 14| 2–10              | 5.8 $\pm$ 0.3                           | 13 $\pm$ 6                     | 0.9 $\pm$ 0.1 |
| INTEGRAL ISGRI             | 2005 Apr 13| 10–20             | 13.2 $\pm$ 0.7                          | ...                            | ...     |
| INTEGRAL ISGRI             | 2005 Apr 14| 20–40             | 30.7 $\pm$ 1.5                          | ...                            | ...     |
| INTEGRAL ISGRI             | 2005 Apr 15| 10–20             | 4.9 $\pm$ 0.7                           | 4 $\pm$ 4                      | 0.8 $\pm$ 0.3 |
| INTEGRAL ISGRI             | 2005 Apr 15| 20–40             | 8.8 $\pm$ 1.3                           | ...                            | ...     |
| INTEGRAL ISGRI             | 2005 Apr 15| 20–40             | 20.6 $\pm$ 3.1                          | ...                            | ...     |
| INTEGRAL ISGRI             | 2005 Apr 4–6| 20–60             | <1.7                                     | ...                            | ...     |
| INTEGRAL ISGRI             | 2005 Apr 7–9| 20–60             | 4.8 $\pm$ 0.8                           | ...                            | ...     |
| INTEGRAL ISGRI             | 2005 Apr 10| 20–60             | 11.3 $\pm$ 1.0                          | ...                            | ...     |

$^a$ Energy range in units of keV if not indicated differently.

$^b$ Measured flux in units of 10$^{-11}$ ergs cm$^{-2}$ s$^{-1}$ if not indicated differently.
During both observations the PCA pointing was offset by 45′ to avoid the nearby bright low-mass X-ray binary (LMXB) 4U 1624–490. The RXTE PCA has a large field of view (2° FWZM). For targets near the Galactic plane, a significant amount of Galactic diffuse emission enters the PCA aperture, which is considered background. This background was modeled by taking a nearby observation of the Galactic plane (observation 91409-01-02-00, l = 341°4, b = 0°6). This observation is at a similar latitude as IGR J16283–4838, so the diffuse emission should have nearly the same spectrum. The background observation was modeled as a thermal bremsstrahlung with a temperature of $kT = 7.4$ keV, plus line emission at $\sim 6.5$ keV with an equivalent width of 600 eV. The shape of the background template was fixed and added to the spectral model of the two PCA observations of IGR J16283–4838; only the total normalization of the template was allowed to vary. The fluxes are collimator-corrected after background subtraction. The best-fit models for the source are shown in Table 1. No pulsations are detectable in the PCA data.

2.3. Infrared and Optical Data

Within the 6″ error radius around the refined position determined from the Swift XRT data, the infrared source 2MASS J16281083–4838560 is located at a distance of 2″7 (Rodriguez & Paizis 2005). This source has $K$, $J$, and $H$-band magnitudes of $K = 13.95 \pm 0.06$ mag, $H > 15.8$ mag, and $J > 16.8$ mag (95% lower limits).

The Galactic Legacy Infrared Midplane Survey Extraordinaire (GLIMPSE;10 Benjamin et al. 2003) data show the source SSTGLMC G335.3268+00.1016 at a distance of 2°9 from the XRT position, consistent with the 2MASS detection. GLIMPSE is a four-band near- to mid-infrared survey by Spitzer (Werner et al. 2004) of the inner two-thirds of the Galactic disk with a spatial resolution of $\sim 2″$. The Infrared Array Camera (Fazio et al. 2004) imaged 220 deg$^2$ at wavelengths centered on 3.6, 4.5, 5.8, and 8.0 μm in the Galactic longitude range 10°–65° on both sides of the Galactic center and in Galactic latitude $\pm 1°$. The Spitzer GLIMPSE data show a clear detection in all four energy bands (Table 1). Another observation in the $K$ band was performed with the 6.5 m Magellan-Baade telescope on 2005 April 21. This observation indicates that the source seen in the 2MASS is a blend of point sources, with the brightest showing $K = 14.1$ mag (Steeghs et al. 2005). Therefore, the identification with the Spitzer source is tentative. In case the infrared source is not the counterpart to the hard X-ray source, the data presented here would be upper limits for the near and mid-infrared emission.

Within the error radius of IGR J16283–4838, no optical counterpart is detectable on the POSS II plates of the Digitized Sky Survey. During the observations by Swift on April 13 and 15 the UVOT took an image in the $V$ band. No source is detected within the error radius down to a magnitude of $V > 20$ mag. The image extracted from the Swift UVOT data on April 15 is shown in Figure 2. The contours indicate the XRT count map, and the cross gives the position of the mid-infrared counterpart.

3. SPECTRAL ENERGY DISTRIBUTION

The spectral energy distribution (SED) of IGR J16283–4838 is shown in Figure 3. In the chosen diagram a single power law with photon index $\Gamma = 2$ would appear as an even, horizontal line. No error bars have been included for the Swift XRT data, and only the XRT data of April 15 are shown for better visibility. From the comparison of the XRT data points with the measurements by RXTE PCA it is apparent that both were taken during a similar high state of the source, while the two INTEGRAL ISGRI measurements describe a lower flux state. Unfortunately, the 60–200 keV upper limit does not constrain the SED significantly.

Note that we display in the SED the absorbed X-ray fluxes as they are measured at the observer, as most of the absorption appears to be intrinsic to the source. The situation is different in the optical, where the flux is already significantly absorbed by material in the line of sight. The hydrogen column density in the direction of the source is $N_H = 2.2 \times 10^{22}$ cm$^{-2}$. This leads to an extinction of $A_V = N_H/(1.79 \times 10^{21}$ cm$^{-2}) = 12.3$ mag (Predehl & Schmitt 1995). Therefore, the unabsorbed optical limit is $V > 7.7$ mag and outside the displayed range of Figure 3. The absorption has a lower effect on the near-infrared fluxes. With $A_K = 0.112 A_V$, $A_H = 0.176 A_V$, and $A_J = 0.276 A_V$ (Schlegel et al. 1998), the unabsorbed flux values are $K = 12.7$ mag.
The hard X-ray spectrum with strong absorption indicates the presence of an HMXB in which no pulsations have been detected so far (Markwardt et al. 2005). In addition, the bright infrared emission, if connected to the X-ray source, would indicate a massive star as the companion of the compact object.

For an HMXB it is likely that IGR J16283–4838 is located close to a star-forming region in a Galactic spiral arm. Several arms are located along the line of sight toward the source (Russel 2003): the Sagittarius-Carina arm (0.7 kpc), the Scutum-Crux arm (3.2 kpc), the Norma-Cygnus arm (4.8 kpc), a star-forming region (7 kpc), and the Perseus arm (10.8 kpc). The luminosity of the object during the flare can be estimated by taking the brightest stage during the RXTE observation and assuming a distance to the object between 1 and 10 kpc. The unabsorbed flux is in this case only 20% larger than the absorbed one, because a significant part of the luminosity is emitted in the hard X-rays. The bolometric luminosity is then in the range $L_{\text{bol}} = 34.0 \rightarrow 36.5$ (where $L$ is in units of ergs s$^{-1}$). The quiescent luminosity of the system is at least a factor of $\sim 20$ lower with $L_{\text{q}} < 33 \rightarrow 35.2$. This range of values is consistent with measurements from known Be/X-ray binaries with a neutron star as the compact object (Negueruela 1998). In any case, the luminosity is far below the Eddington luminosity of a neutron star of $1.4 M_\odot$ ($L = 1.8 \times 10^{38}$ ergs s$^{-1}$).

The properties of IGR J16283–4838 are similar to those of a number of highly absorbed sources $[N_H = (1\rightarrow 20) \times 10^{23}$ cm$^{-2}$] found in the Galactic plane, especially in the Norma arm region (Walter et al. 2004). The HMXB IGR J19140+0951 also shows strong variable absorption (Rodriguez et al. 2005), indicating intrinsic absorption in the source. The observed properties of IGR J16283–4838 are consistent with those of IGR J19140+0951 in the bright state, in which the iron line flux decreased to $4 \times 10^{-4}$ photons cm$^{-2}$ s$^{-1}$, which is at the upper limit for the Swift XRT measurement in our case. The (non)variability of the absorption in IGR J16318–4848 is still under discussion, as Walter et al. (2003) claim constant absorption, whereas Revnivtsev (2003) discovered variable absorption that could be connected with the orbital phase of the binary system. Only one of the newly detected highly absorbed sources has been claimed so far not to be an HMXB. Patel et al. (2004) observed IGR J16358–4726 with the Chandra X-Ray Observatory. From the X-ray data they favor the source to be a millisecond pulsar LMXB, although the HMXB interpretation cannot be ruled out completely, but some unknown kind of spin-down torque would be required to prevent the neutron star from spinning up in this particular case.

X-ray binaries with strong intrinsic absorption had already been detected before INTEGRAL, for example, in 4U 1700–377, GX 301–2, Vela X-1, and CI Cam. Except for the latter, for which the nature of the source is unclear to date, these sources are also HMXBs, likely hosting a neutron star as the compact object. Vela X-1 shows variable absorption from a negligible value up to $7 \times 10^{22}$ cm$^{-2}$ (Pan et al. 1994), GX 301–2 shows strong absorption variation (up to $12 \times 10^{23}$ cm$^{-2}$; White & Swank 1984), and so does CI Cam ($0.025 \rightarrow 10^{23}$ cm$^{-2}$; Boirin et al. 2002). In 4U 1700–377 the absorption is linked to the state of the HMXB system and varies by a factor of 2 between $0.9 \times 10^{23}$ and $2.0 \times 10^{23}$ cm$^{-2}$ (Boroson et al. 2003). It appears that variable absorption is a common feature in highly absorbed HMXBs. This could mean that the absorbing material is linked to the existence of a high-mass donor in the binary system. In this case a strong and dense stellar wind ($10^{-7} \rightarrow 10^{-5}$ $M_\odot$ yr$^{-1}$) from the early-type companion would probably cause the absorption
in the system. The fact that all the absorbed sources so far have been shown to be HMXBs (Kuulkers 2005; Walter et al. 2004) containing neutron stars does not rule out significant contribution of HMXBs with a black hole as the compact object. But these systems are expected to be less numerous than the neutron star HMXBs by a factor of 10–100, making the detection of a black hole binary within a sample of only about 10 detected highly absorbed HMXBs unlikely. These absorbed binary systems might provide a significant contribution to the Galactic hard X-ray background at energies above 10 keV (Lebrun et al. 2004; Valinia et al. 2000).

5. CONCLUSIONS

The newly discovered hard X-ray source IGR J16283–4838, located in the Norma arm region, is likely to be an HMXB containing a neutron star as the compact object. It is located in the Galactic plane in the direction of star-forming regions in the spiral arms and shows a large flare, which makes an extragalactic origin unlikely. The spectrum is hard ($\Gamma \sim 1$) and strongly absorbed during the flare, which indicates that it is an HMXB rather than an LMXB. The luminosity is comparably low ($L < 10^{37}$ erg s$^{-1}$), which is typical for a neutron star HMXB. The strong and variable absorption [$N_H = (0.4–1.7) \times 10^{23}$ cm$^{-2}$] indicates that IGR J16283–4838 belongs to the class of highly absorbed HMXBs discovered by INTEGRAL along the Galactic plane. Bright and absorbed sources like IGR J16283–4838 could contribute significantly to the Galactic hard X-ray background in the 10–200 keV band.

It must be pointed out that the discovery and classification of IGR J16283–4838 would not be possible without combining the observations of the recent observatories in space, like INTEGRAL, Swift, RXTE, and Spitzer. Combined efforts from these missions should lead to deeper insights into the nature of the hard X-ray source population in our Galaxy in the near future.

We would like to thank John Greaves for pointing out the GLIMPSE data. This work is based in part on observations made with the Swift Space Telescope, which is operated by the Jet Propulsion Laboratory, California Institute of Technology under NASA contract 1407. This research has made use of the SIMBAD Astronomical Database, which is operated by the Centre de Données astronomiques de Strasbourg. This work was supported in part by NASA contract NAS5-00136.

REFERENCES

Arnaud, K. A. 1996, in ASP Conf. Ser. 101, Astronomical Data Analysis Software and Systems V, ed. G. Jacoby & J. Barnes (San Francisco: ASP), 17
Barthelmy, S. D., et al. 2005, Space Sci. Rev., in press (astro-ph/0507410)
Benjamin, R. A., et al. 2003, PASP, 115, 953
Boirin, L., Parmar, A. N., Oosterbroek, T., Lumb, D., Orlandi, M., & Schartel, N. 2002, A&A, 394, 205
Boroson, B., Vrtilek, S. D., Kallman, T., & Corcoran, M. 2003, ApJ, 592, 516
Burrows, D. N., et al. 2005, Space Sci. Rev., in press (astro-ph/0508071)
Combi, J. A., Ribo, M., Mirabel, I. F., & Sugizaki, M. 2004, A&A, 422, 1031
Dewangan, G. C., Boller, T., Singh, K. P., & Leighly, K. M. 2002, A&A, 390, 65
Fazio, G., et al. 2004, ApJS, 154, 10
Gehrels, N., et al. 2004, ApJ, 611, 1005
Kennea, J. A., et al. 2005, ATel, 459
Kuulkers, E. 2005, in AIP Conf. Proc., Interacting Binaries: Accretion, Evolution and Outcomes, ed. L. A. Antonelli et al. (New York: AIP), in press (astro-ph/0504625)
Lebrun, F., et al. 2003, A&A, 411, L141
———. 2004, Nature, 428, 293
Markwardt, C. B., Swank, J. H., & Smith, E. 2005, ATel, 465
Martí, J., Mirabel, I. F., Chatty, S., & Rodriguez, L. F. 1998, A&A, 330, 72
Matt, G., & Guainazzi, M. 2003, MNras, 341, L13
N wageruela, I. 1998, A&A, 338, 505
Paizis, A., Miller, J. M., Soldi, S., & Mowlavi, N. 2005, ATel, 458
Pan, H. C., Kretschmar, P., Skinner, G. K., Kendziorra, E., Sunyaev, R. A., & Borozdin, K. N. 1994, ApJS, 92, 448
Patel, S. K., et al. 2004, ApJ, 602, L45
Predehl, P., & Schmitt, J. H. M. M. 1995, A&A, 293, 889
Revnivtsev, M. 2003, Astron. Lett., 29, 644
Rodriguez, J., Cabanac, C., Hannikainen, D. C., Beckmann, V., Shaw, S. E., & Schultz, J. 2005, A&A, 432, 235
Rodriguez, J., & Paizis, A. 2005, ATel, 460
Rodriguez, J., Tomsick, J. A., Foschini, L., Walter, R., Goldwurm, A., Corbel, S., & Kaaret, P. 2003, A&A, 407, L41
Roming, P. W. A., et al. 2005, Space Sci. Rev., in press (astro-ph/0507413)
Russell, D. 2003, A&A, 397, 133
Sazonov, S. Y., Revnivtsev, M. G., Lutovinov, A. A., Sunyaev, R. A., & Grebenev, S. A. 2004, A&A, 421, L21
Schlegel, D. J., Finkbeiner, D. P., & Davis, M. 1998, ApJ, 500, 525
Soldi, S., Brandt, S., Domingo Garau, A., Grebenev, S. A., Kuulkers, E., Palumbo, G. C. C., & Tarana, A. 2005, ATel, 456
Steeghs, D., Torres, M. A. P., Jonker, P. G., Miller, J., Green, P., & Rakowski, C. 2005, ATel, 478
Ubertini, P., et al. 2003, A&A, 411, L131
Valinia, A., Kinzer, R. L., & Marshall, R. E. 2000, ApJ, 530, 777
Vedrenne, G., et al. 2003, A&A, 411, L63
Walter, R., et al. 2003, A&A, 411, L427
———. 2004, in Proc. 5th INTEGRAL Workshop (ESA SP-552; Noordwijk: ESA), 417
Werner, M., et al. 2004, ApJS, 154, 1
White, N. E., & Swank, J. H. 1984, ApJ, 287, 856
Winkler, C., et al. 2003, A&A, 411, L1