OUTBURST OF THE X-RAY TRANSIENT SAX J1818.6-1703 DETECTED BY INTEGRAL IN SEPTEMBER 2003

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During the observation of the Galactic-center field by the INTEGRAL observatory on September 9, 2003, the IBIS/ISGRI gamma-ray telescope detected a short (several-hours-long) intense ($\sim 380$ mCrab at the peak) outburst of hard radiation from the X-ray transient SAX J1818.6-1703. Previously, this source was observed only once in 1998 during a similar short outburst. We present the results of our localization, spectral and timing analyses of the object and briefly discuss the possible causes of the outburst. The release time of the bulk of the energy in such an outburst is appreciably shorter than the accretion (viscous) time that characterizes the flow of matter through a standard accretion disk.

Keywords: X-ray sources, transients, accretion

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INTRODUCTION

The source SAX J1818.6-1703 was discovered by the BeppoSAX observatory on March 11, 1998, during an X-ray outburst that lasted only a few hours (in’t Zand et al. 1998; in’t Zand 2001). The appearance of a new transient near the well-known burster GX 13+1 (at an angular distance of $\sim 1^\circ$) was recorded by the WFC-2 wide-field X-ray camera at 19$^h$10$^m$ (UT). By 20$^h$40$^m$, the photon flux from SAX J1818.6-1703 reached its maximum: $\sim 100$ mCrab in the range 2–9 keV and $\sim 400$ mCrab in the range 9–25 keV. The observation was interrupted 3 h later, but the flux was almost halved by this time, indicative of a fast decay of the transient. The source’s position, $R.A. = 18^h18^m39^s$, $Decl. = -17^\circ03'1'$ (epoch 2000.0), was determined with an accuracy of 3'. Only one catalogued B3 III star, HD 168078, with $V = 10.7$ is within the error circle (in’t Zand et al. 1998), but there is no additional reasons to believe it to be a real candidate for optical identification with SAX J1818.6-1703.

All that has been known about SAX J1818.6-1703 until recently is listed above. Its nature and, primarily, the mechanism that produced such a short outburst with a duration much shorter than the characteristic time scale for the propagation of disturbances in a standard accretion disk ($t_{vis} \gtrsim 1.4$ days) have remained unclear. In this paper, we present the results of our observations of the second outburst of hard radiation from this source that has allowed us to investigate it in more detail. This flare was detected on September 9, 2003, by the INTEGRAL observatory.

OBSERVATIONS

The INTEGRAL international gamma-ray astrophysics observatory (Winkler et al. 2003) was placed in a high apogee orbit by a PROTON launcher on October 17, 2002 (Eismont et al. 2003). There are four telescopes on its board that allow concurrent X-ray, gamma-ray, and optical observations of cosmic sources. This work is based on the data obtained with the IBIS gamma-ray telescope at energies above 18 keV. Unfortunately, no concurrent observations of SAX J1818.6-1703 were performed in the standard X-ray range (by the JEM-X telescope). Since the source is fairly far from the Galactic center toward which the observatory was pointed, it was not within the field of view of the JEM-X telescope, which is narrower than that of the IBIS telescope.
The IBIS telescope (Ubertini et al. 2003) uses the principle of a coded aperture to image the sky in hard X-rays and gamma-rays in a 30°×30° field of view (the fully coded field is 9°×9°) with an angular resolution of 12' (FWHM). It is equipped with two position-sensitive detectors: ISGRI (Lebrun et al. 2003) composed of 128×128 CdTe semiconductor elements with a high sensitivity in the range 18-200 keV and PICsIT located under it (Labanti et al. 2003) and composed of 64×64 scintillators CsI(Tl) with an optimal sensitivity in the range 175 keV – 10 MeV. In this paper, we use only the ISGRI data. The total area of the sensitive elements of this detector is 2620 cm²; the effective area for sources at the center of the field of view is ∼ 1100 cm² (half of the detector is shadowed by opaque aperture elements). The detector provides fairly good energy, ∆E/E ~ 7% (FWHM), and high time, ∆t ~ 61 µs, resolutions.

Although the outburst of SAX J1818.6-1703 was initially detected using a standard software package for analyzing the INTEGRAL data (at that time, OSA-3.1), all of our results presented in this paper were obtained using the data processing codes developed for the IBIS/ISGRI telescope at the Space Research Institute of the Russian Academy of Sciences. A general description of the procedures used can be found in a paper by Revnivtsev et al. (2004). Application of the latest version of these programs to the observations of the Crab Nebula has shown that the systematic measurement error of the absolute photon flux from the source does not exceed 7%, while the measurement error of the relative fluxes in various spectral channels does not exceed 3%. In our spectral analysis, we used the response matrix of the OSA-4.2 standard package (rmf-file of version 12 and the arf-file of version 6), which proved to be good at fitting the spectra of the Crab Nebula, in particular, the spectra measured in August 2003 immediately before the observations under consideration. The spectrum of the Nebula was assumed to be \( dN(E)/dE = 10 E^{-2.1} \) phot cm⁻² s⁻¹ keV⁻¹, where the energy \( E \) is given in keV. For our study within the framework of the same general approach to analyzing the IBIS/ISGRI data, we developed codes for reconstructing the source’s light curves with a good time resolution.

When the outburst of the transient SAX J1818.6-1703 occurred, the INTEGRAL observatory was performing a long (with a total exposure time of 2 Ms) series of observations of the Galactic-center region. During this series, the IBIS telescope detected 60 hard radiation sources of various intensities (Revnivtsev et al. 2004). Curiously enough, another poorly studied source, AX J1749.1-2733, flared up in this region on September 9, 2003, almost simultaneously with SAX J1818.6-1703. The results of its study are presented else-
where (Grebenev and Sunyaev 2005). The INTEGRAL observations in this period were performed by successive pointings at points of the Galactic-center field spaced ~ 2° apart according to the 5 × 5 scheme. Depending on the pointing, the exposure efficiency of SAX J1818.6-1703 changed greatly. The duration of each pointing was ~ 3450 s.

RESULTS

The appearance of the transient source in the field of view was first recorded at a statistically significant level by the IBIS/ISGRI telescope (at a signal-to-noise ratio of $S/N = 9.4$) during the pointing that began on September 9, 2003, at 00$^h$01$^m$ (UT). Analysis of its X-ray image showed that SAX J1818.6-1703 flared up. The measured photon flux from it was 69 ± 7 mCrab in the range 18–45 keV and 43 ± 16 mCrab in the range 45–70 keV (the flux of 1 mCrab in these ranges corresponds to radiation fluxes of $1.1 \times 10^{-11}$ and $4.7 \times 10^{-12}$ erg cm$^{-2}$ s$^{-1}$, respectively). The brightness of the source remained the same during the next pointing; subsequently, it faded for 2–3 h$^1$, but flared up again. During the pointings that began at 10$^h$42$^m$ and 12$^h$41$^m$, two superintense bursts were detected from the source during which it became the brightest among all of the sources in the field of view. During the first (stronger) burst, the measured photon flux in the above ranges reached 230 ± 5 and 172 ± 10 mCrab, respectively. The source remained moderately bright (≈ 50–70 mCrab) until 20$^h$, we failed to detect it in several subsequent pointings, the observations were then interrupted, because the satellite entered the Earth’s radiation belts in the final segment of its orbit. During the next orbital cycle (September 10–13), the source was detected only at the telescope’s sensitivity limit ($S/N \approx 6.0$) with a mean 18–45-keV flux of 6.6 ± 1.1 mCrab.

The described picture is illustrated by Fig. 1, which shows the source’s light curves constructed from the observations of September 7–13 in two energy ranges. Each point of these curves is the measurement of the photon flux from the source in the corresponding sky image obtained during an individual pointing.

The vertical dashed lines in Fig. 1 indicate the interval of the source’s statistically significant detection. We used this interval to accumulate the integrated images of the sky near SAX J1818.6-1703 (signal-to-noise maps) in the energy ranges 18–45 and 45–70 keV. Since the pointings at this time were particularly unfavorable for the source’s observations (it was at the very edge of the field of view), the flux was measured with large errors; nevertheless, the fall in flux appears statistically significant (see Fig. 1).
Fig. 1: IBIS/ISGRI light curve for SAX J1818.6-1703 in the energy ranges 18–45 and 45–70 keV obtained in the period September 7-13, 2003. Each point of this curve corresponds to an individual ∼3450-s-long pointing of the INTEGRAL observatory. The dashed and dotted vertical lines indicate the source’s activity period and the main event of the outburst (two intense bursts of hard radiation).

keV shown in Figs. 2 and 3, respectively. The total exposure time was 75400 s. Apart from SAX J1818.6-1703, four more X-ray sources are seen in Fig. 2: the bursters GX 17+2 and GX 13+1, the “atoll” source GX 9+1, and the X-ray pulsar IGR J18027-2016 (also known as SAX J1802.7-2017). SAX J1818.6-1703 is the brightest of these sources — it was detected at a signal-to-noise ratio of $S/N \simeq 48$, while the next brightest source GX 9+1 has $S/N \simeq 20$. In Fig. 3, SAX J1818.6-1703 is the only source (it is seen at $S/N \simeq 15$). Estimates indicate that this is attributable not just to the natural decrease in the hard X-ray photon flux typical of all sources; the flux from SAX J1818.6-1703 falls in this case more slowly, i.e., the source has a much harder (with the possible exception of the X-ray pulsar IGR J18027-2016) spectrum.

The image shown in Fig. 2 was used to improve the localization of the source. The position found, $R.A. = 18^h 18^m 38^s 2$, $Decl. = -17^\circ 03' 11''$ (epoch 2000.0, 1.5' uncertainty), coincided with its position measured by BeppoSAX in 1998 to within 12''.

Fig. 2: IBIS/ISGRI image of the outburst region in the energy range 120–250 keV obtained in the same period as the light curve. The flux map shows a bright source visible starting on day 9. The position found, $R.A. = 18^h 18^m 38^s 2$, $Decl. = -17^\circ 03' 11''$ (epoch 2000.0, 1.5' uncertainty), coincides with the source detected in all other observations.

Fig. 3: IBIS/ISGRI image of the outburst region in the energy range 70–120 keV obtained in the same period as the light curve. The flux map shows a bright source visible starting on day 9. The position found, $R.A. = 18^h 18^m 38^s 2$, $Decl. = -17^\circ 03' 11''$ (epoch 2000.0, 1.5' uncertainty), coincides with the source detected in all other observations.
The Outburst Time Profile

To elucidate the nature of the source’s outburst, it is crucially important to analyze the structure of the two intense short bursts occurred at about 11 and 13 h. Since the light curve in Fig. 1 does not allow this to be done, we reconstructed more detailed light curves. The top panel in Fig. 4 shows the 18–45-keV light curve with a time resolution (bin size) of 500 s. It spans only the source’s activity period. The actually measured count rate, i.e., the count rate corrected for the dead time and other instrumental effects, but uncorrected for the variations in the effective (source-irradiated) area of the detector due to the change in the INTEGRAL pointing, is along the Y axis. This effect is important, since the source was outside the fully coded field of view of the telescope. We do not make the
corresponding correction in order not to overload the figure. At the time resolution used, statistically insignificant spikes appear in the corrected light curve due to the Poissonian fluctuations of the count rate when the source approaches the edge of the field of view. Instead, the bottom panel in Fig. 4 shows the curve of variations in the effective area of the detector. We clearly see its correlation with the count rate, which, however, does not distort severely the main event. The effective area for the observation of SAX J1818.6-1703 was only 620 cm$^2$ even at maximum, i.e., it was almost a factor of 2 smaller than the area typical of the sources in the fully coded field of view. For such an effective area, 1 count/s corresponded to a flux of $\sim 16.4$ mCrab in the energy range under consideration, so, according to this figure, the maximum flux from the source reached $\sim 380$ mCrab.

The figure suggests that the two bursts of the main outburst event have a fairly
Fig. 4: Detailed IBIS/ISGRI 18–45-keV light curve for SAX J1818.6-1703 obtained on September 9, 2003, in the period of its activity (the top panel). The time in hours from the beginning of the day (UT) is along the X axis. The time resolution is 500 s. The count rate along the Y axis was corrected for the dead time of the detector and other instrumental effects, except the variations in the effective area for this source related to the change in the INTEGRAL pointing (the effect of partial coding). The corresponding change in the effective area is shown in the bottom panel.

complex time profile. A narrow (10–20 min) precursor peak and a broader (1.5–2 h) main peak can be distinguished in each of them. The amplitude of the precursor peak in the first burst is almost twice that of the main peak, while the precursor peak in the second burst is appreciably smaller. In general, the two bursts resemble ordinary type-I X-ray bursts with photospheric expansion, i.e., bursts produced by a thermonuclear explosion on the neutron star surface at which the photospheric luminosity reached the Eddington limit (see Lewin et al. 1993). However, the duration of the bursts from SAX J1818.6-1703 was 2–3 h, which is much longer than the duration of ordinary X-ray bursts. The recently discovered superbursts (Kuulkers et al. 2002; in’t Zand et al. 2004) have comparable durations, but exhibit completely different time profiles — a very fast rise and a long exponential decay. As we will see below, there are also more fundamental differences between these bursts.
Fig. 5: Change with energy of the time profile for the main outburst event of SAX J1818.6-1703 recorded by the IBIS/ISGRI telescope on September 9, 2003. The resolution is 500 s everywhere, except the profile measured in a wide energy range, 18–70 keV (the bin size for it is 300 s). The count rate along the Y axis was corrected for all instrumental effects and reduced to the same area of 620 cm$^2$, which corresponds to the maximum achieved efficiency of the source’s observations (1 count/s is approximately equal to 36, 48, 31, and 12 mCrab in the ranges 18–26, 26–36, 36–70, and 18–70 keV, respectively). The time in hours from the beginning of the day (UT) is along the X axis.
Figure 5 shows the time profiles of the main event in several energy ranges after their reduction to the effective area of $620 \, \text{cm}^2$. In general, they are similar in structure, suggesting that the spectral shape of the source changed little during the outburst. However, note a clear decrease with energy in the relative amplitude of the precursor peak in the first burst and a probable decrease in the amplitude of the precursor peak in the second burst. These changes were confirmed during a detailed spectral analysis.

![Spectrum Graph](image)

**Fig. 6:** Average IBIS/ISGRI spectrum of SAX J1818.6-1703 obtained on September 9, 2003, in the period of its activity (open circles). The spectrum is very hard; the characteristic temperature when fitting the spectrum by the bremsstrahlung law of an optically thin thermal plasma is $kT \simeq 36 \, \text{keV}$. For comparison, the filled circles indicate the X-ray spectrum of the source GX13+1 closest to SAX J1818.6-1703 measured at the same time, which is typical of accreting neutron stars with a weak magnetic field ($kT \simeq 5 \, \text{keV}$). At low energies, an additional soft radiation component is apparently present in the spectrum of SAX J1818.6-1703. The dotted lines indicate the best fits to the spectra (see the text).

**The Radiation Spectrum**

Figure 6 shows the average spectrum of SAX J1818.6-1703, obtained in the period of its activity (during the interval bounded by the vertical dashed lines in Figs. 1 and 4). The source’s radiation is recorded up to $\sim 200 \, \text{keV}$, with an exponential cutoff being observed at
energies above 70 keV. Note that an additional soft ($h\nu < 30$ keV) radiation component is present in the spectrum. The energy characteristics of the source’s radiation in this period, its mean luminosity and energy release calculated by assuming that SAX J1818.6-1703 is actually near the Galactic center, at a distance of $d \simeq 8$ kpc\(^2\), are given in Table 1.

Table 1. Parameters of the outburst of SAX J1818.6-1703 observed with IBIS/ISGRI on September 9, 2003.

| Interval                  | Parameter\(^a\) | Value             |
|---------------------------|------------------|-------------------|
| Entire activity period\(^b\) | $\Delta T$   | 22.5 h            |
|                           | $L_X$            | $7.5 \times 10^{36}$ erg c\(^{-1}\) |
|                           | $F_X$            | $6.1 \times 10^{41}$ erg |
| Main event,               | $\Delta T$       | 2.7 h             |
|                           | $L_X$            | $1.9 \times 10^{37}$ erg s\(^{-1}\) |
|                           | $F_X$            | $1.8 \times 10^{41}$ erg |

\(^a\) Duration $\Delta T$, luminosity $L_X$, and energy release $F_X$

\(^b\) Bounded by the vertical dashed lines in Fig. 1

The sum of intervals A, B, C marked in Fig. 5

Table 2 summarizes the results of fitting the spectrum by simple analytical models: a power law (PL), a power law with an exponential high energy cutoff (PE), the radiation formed through Comptonization of low energy photons in a cloud of high temperature plasma (ST, Sunyaev and Titarchuk 1980), the bremsstrahlung of an optically thin thermal plasma (TB), the bremsstrahlung with an additional soft blackbody component (TB+BB), and the Comptonization radiation with an additional blackbody component (ST+BB). We see that even the single-component PL, PE, and ST models describe satisfactorily the radiation spectrum. Although the introduction of an additional soft radiation component affects only the first two or three points of the spectrum, this leads to further significant improvement of its approximation. Extrapolating the soft component to the X-ray energy range we get a luminosity an order of magnitude higher than that in the hard energy range. Thus, the overall energetics of the source could be maintained at a level approaching the critical Eddington level for accretion onto a neutron star (or, given the uncertainty in the spectral shape of the soft component, even onto a black hole of a small $\sim 3$ $M_\odot$ mass).

Figure 7 shows the spectral evolution of SAX J1818.6-1703 during the outburst under

\(^2\)For the source GX 13+1 closest to SAX J1818.6-1703 $d \simeq 7 \pm 1$ kpc (Bandyopadhyay et al. 1999).
Table 2. Results of the best-fit approximation of the spectrum of SAX J1818.6-1703, averaged over the entire period of its activity.

| Model  | $kT$, keV | $\alpha^b$ | $kT_{bb}$, keV | $L_{bb}$, $10^{38}$ erg s$^{-1}$ | $\chi^2(N)^d$ |
|--------|-----------|-------------|----------------|-------------------------------|--------------|
| PL     | 2.75 ± 0.08 | 1.02 (22)   |                |                               |              |
| PE     | 136 ± 4    | 2.46 ± 0.31 | 1.02 (21)      |                               |              |
| ST     | 27.9 ± 2.1 | 2.51 ± 0.10 | 1.02 (21)      |                               |              |
| TB     | 28.8 ± 1.9 | 1.37 (22)   |                |                               |              |
| TB+BB  | 36.3 ± 3.5 | 1.7 ± 0.7   | 1.6 ± 0.4      | 0.75 (20)                     |              |
| ST+BB  | 16.8 ± 3.7 | 2.08 ± 0.57 | 1.7$^e$        | 1.4 ± 0.5                    | 0.78 (20)    |

$^a$ The notation of the models is given in the text.
$^b$ The photon index.
$^c$ Parameters of the soft radiation component: the blackbody temperature and bolometric luminosity (for $d = 8$ kpc).
$^d$ The $\chi^2$ value of the best fit normalized to $N$ ($N$ is the number of degrees of freedom).
$^e$ A fixed parameter.

Discussion. Spectra A, B, and C were measured by the IBIS/ISGRI telescope at different evolutionary phases of the main event (the time intervals corresponding to these phases are indicated in the upper panel of Fig.5). Spectrum D was measured during the remaining activity period of the source. The solid lines indicate the best fit to spectrum A by the bremsstrahlung law of an optically thin thermal plasma ($kT \simeq 29$ keV). The soft component, which is absent in the main radiation of the bursts (spectra B and C), is clearly seen at energies below $\sim 30$ keV in the spectra of the precursor peak in the first burst (spectrum A) and the period of moderate activity of the source (spectrum D), as well as in the average spectrum of the source. The results of fitting the presented spectra by a power law (PL) and the bremsstrahlung law of an optically thin thermal plasma (TB) are given in Table 3. We see that in the period of moderate activity, the source had a rather soft radiation spectrum (with a photon index of $\alpha \sim 3$); at the onset of the main event, the spectral hardness increased ($\alpha \sim 2.7$) and continued to increase, reaching $\alpha \sim 2.4$ in the second burst.

DISCUSSION

Transients like SAX J1818.6-1703 form a special, fairly representative population among the X-ray sources discovered or recorded during their outbursts by the INTEGRAL obser-
Fig. 7: Spectral evolution of SAX J1818.6-1703 during the hard X-ray outburst observed on September 9, 2003. Spectra A, B, and C were measured by the IBIS/ISGRI telescope at different evolutionary phases of the main event (see Fig. 5); spectrum D was measured during the remaining activity period of the source. The solid lines indicate the best fit to spectrum A by the bremsstrahlung law of an optically thin thermal plasma \( kT \simeq 29 \text{ keV} \); for spectrum D, the normalization of the fit was decreased by a factor of 5. The soft component, which is absent in the main outburst radiation (spectrum B and particularly spectrum C), is clearly seen at energies below \( \sim 30 \text{ keV} \) in the radiation spectra of the precursor peak in the first burst (spectrum A) and the period of moderate activity of the source (spectrum D).
Table 3. Results of the best-fit approximation of the spectrum of SAXJ1818.6-1703 at various evolutionary phases of the outburst

| Spectrum | Model | $kT$, keV | $\alpha^a$ | $L_X^{b}$, $10^{37}$ erg s$^{-1}$ | $\chi^2(N)$ $^c$ |
|----------|-------|-----------|------------|------------------|----------------|
| A        | PL    | 2.74 ± 0.10 | 2.37 ± 0.77 | 2.05 ± 0.18       | 1.03 (23)       |
|          | TB    | 28.6 ± 2.4  |            |                  |                |
| B        | PL    | 2.55 ± 0.10 | 1.98 ± 0.66 | 1.70 ± 0.15       | 1.25 (23)       |
|          | TB    | 34.3 ± 3.4  |            |                  |                |
| C        | PL    | 2.41 ± 0.11 | 2.21 ± 0.79 | 1.88 ± 0.17       | 1.76 (23)       |
|          | TB    | 39.0 ± 4.4  |            |                  |                |
| D        | PL    | 3.05 ± 0.18 | 0.42 ± 0.21 | 0.36 ± 0.06       | 0.83 (23)       |
|          | TB    | 20.0 ± 2.4  |            |                  |                |

$^a$ The photon index
$^b$ The 20–200-keV luminosity for an assumed distance of $d = 8$ kpc
$^c$ The $\chi^2$ value of the best fit normalized to $N$ ($N$ is the number of degrees of freedom)

The activity of these sources could in principle be caused by the following: (1) thermonuclear explosions on the neutron star surface, (2) magnetic energy release in the case of a neutron star with a very strong magnetic field, and (3) unsteady accretion onto a neutron star or a black hole in a binary system. The first two possibilities seem unlikely, since the life time of such transients is much longer than the duration of both soft gamma-ray bursts from gamma-repeaters (magnetars) and ordinary X-ray bursts from neutron stars with a weak magnetic field (bursters). Our results show that the bursts of SAXJ1818.6-1703 also differ greatly from the superbursts discovered recently from bursters (Kuulkers et al. 2002; in’t Zand et al. 2004) primarily by an increase in the hardness during the burst and by the burst profile. Note that the energy released during the main outburst event of SAXJ1818.6-1703 accounted for only 1/3 of the total energy released in the period of its activity (Table 1). This is also difficult to explain in terms of a thermonuclear explosion on the neutron star surface without invoking unsteady accretion processes.
On the other hand, the lifetime of such outbursts is much shorter than the accretion (viscous) time that characterizes the propagation of disturbances in a standard accretion disk,

\[
t_{\text{vis}} \sim \frac{2}{3\alpha} \frac{1}{\Omega_K(R)} \left(\frac{R}{H}\right)^2 \sim 1.4 \left(\frac{R}{10^{10} \text{ cm}}\right)^{3/2} \left(\frac{M}{1.4 \, M_\odot}\right)^{-1/2} \text{ days}
\]

(Shakura and Sunyaev 1973)\(^3\). Here, \(R\) is the outer radius of the disk, \(H\) is the disk half-thickness at this radius, \(\Omega_K = (GM/R^3)^{1/2}\) is the Keplerian frequency, \(M\) is the mass of the compact object, and \(\alpha \sim 1\) is the viscosity parameter. We disregarded the weak \(R\)-dependence of \(H/R\) on the right-hand side of this expression (in the standard disk accretion model, \(H/R \sim R^{1/8}\)) and set \(H/R \simeq 0.02\), which corresponds to the most compact binaries with \(R \sim 10^{10} \text{ cm}\) (for a discussion, see Gilfanov and Arefiev 2005). We can decrease \(t_{\text{vis}}\) by increasing \(H/R\) (advection-dominated regime), but this will cause the accretion efficiency to decrease appreciably. At an accretion efficiency of \(\xi = 1/12\) typical of black holes or compact neutron stars (\(R_{\text{ns}} \sim 3R_g\), where \(R_{\text{ns}}\) is the radius of the neutron star surface, and \(R_g\) is its gravitational radius), a compact object would accrete \(M_{\text{acc}} \sim F_X/(\xi c^2) \approx 8 \times 10^{21} \text{ g}\) of matter for the energy release to be \(F_X \simeq 6 \times 10^{41} \text{ erg}\) (Table 1). The other possibility to decrease \(t_{\text{vis}}\) appears in the case of unsteady accretion from the stellar wind. In this case the radius of the forming disk may be much smaller than the size of the binary.

The mechanisms responsible for the outbursts of such transients can be considered in detail only after their reliable optical identification. At present, this has not yet been done.

This work is based on the observational data obtained by the INTEGRAL observatory, an ESA satellite with instruments provided by ESA member states (especially France, Italy, Germany, Switzerland, Denmark, and Spain), the Czech Republic, and Poland, placed in orbit by Russia and operated by the ESA with the participation of the USA, and provided via the Russian and European INTEGRAL Science Data Centers. We used some of the codes developed by E.M. Churazov to analyze the data. This study was supported by the Russian Foundation for Basic Research (project no. 05-02-17454), the Presidium of the Russian Academy of Sciences (the “Nonstationary Phenomena in Astronomy” Program), and the Program of the Russian President for Support of Leading Scientific Schools (project no. NSh-2083.2003.2).

\(^3\)In fact, for the disk filling the Roche lobe \(t_{\text{vis}}\) depends on \(M\) only weakly because \(R \sim M^{1/3}\) (but \(t_{\text{vis}}\) depends on the orbital period of the binary and the value \(R \sim 10^{10} \text{ cm}\) corresponds to very short periods).
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