Transient outburst mechanisms in Supergiant Fast X–ray Transients

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Abstract

The recent discovery of a new class of recurrent and fast X–ray transient sources, the Supergiant Fast X–ray Transients, poses interesting questions on the possible mechanisms responsible for their transient X–ray emission. The association with blue supergiants, the spectral properties similar to those of accreting pulsars and the detection, in a few cases, of X-ray pulsations, confirm that these transients are High Mass X-ray Binaries. I review the different mechanisms proposed to explain their transient outbursts and the link to persistent wind accretors. I discuss the different models in light of the new observational results coming from an on-going monitoring campaign of four Supergiant Fast X–ray Transients with Swift.

Key words: X–rays, individuals: IGR J11215–5952, XTE J1739–302, IGR J17544–2619, IGR J16479–4514, AX J1841.0–0536/IGR J18410–0535.

1 Introduction

An unusual X–ray transient in the direction of the Galactic centre region, XTE J1739–302, was discovered in 1997 (Smith et al. 1998). It displayed peculiar properties, particularly related with the duration of the outburst: this source remained active only one day. Since the X–ray spectrum was well fitted with a thermal bremsstrahlung with a temperature of ~20 keV, resembling the spectral properties of accreting pulsars, it was at first classified as a peculiar Be/X-ray transient with an unusually short outburst (Smith et al. 1998).

The INTEGRAL satellite has been performing a monitoring of the Galactic plane since its launch in October 2002 (Bird et al. 2007). Thanks to these observations, several other sources have been discovered, displaying similar prop-
erties to XTE J1739–302: they show sporadic, recurrent, bright and short flares (with a typical duration of a few hours; Sguera et al. 2005, 2006; Negueruela et al. 2006a). The X-ray spectra resemble the typical shape of High Mass X–ray Binaries (HMXBs) hosting X–ray pulsars, with a flat hard power law below 10 keV, and a high energy cut-off at about 15-30 keV, sometimes strongly absorbed at soft energies (Walter et al., 2006; Sidoli et al., 2006).

Follow-up X–ray observations (e.g. Kennea et al. 2005, Tomsick et al. 2006) allowed to refine the source positions at the arcsec level, and to perform IR/optical observations, which permitted to associate these transients with OB supergiant companions (e.g. Halpern et al. 2004, Pellizza et al. 2006, Masetti et al. 2006, Negueruela et al. 2006b, Nespoli et al. 2008). These two main characterizing properties (the unusually short transient X–ray emission together with the association with blue supergiant companions) suggested that these sources define a new class of HMXBs, later named Supergiant Fast X–ray Transients (SFXTs). Indeed, HMXBs with supergiant companions were previously known to show only persistent X–ray emission (e.g. Nagase, 1989). Thanks to the observations of several new SFXTs performed with INTEGRAL (e.g., Sguera et al. 2005, 2006, 2007a; Negueruela et al. 2006a; Walter & Zurita Heras 2007; Blay et al. 2008) and, at softer energies, with Chandra (in’t Zand 2005), XMM-Newton (Gonzalez-Riestra et al. 2004; Walter et al. 2006) and archival observations with ASCA (Sakano et al. 2002), other important properties have been observed: SFXTs display a high dynamic range, spanning 3 to 5 orders of magnitudes, from a quiescent emission at $10^{32}$ erg s$^{-1}$ (characterized by a very soft spectrum, likely thermal; IGR J17544–2619, in’t Zand 2005; IGR J08408–4503, Leyder et al. 2007) up to a peak emission in outburst of $10^{36}$–$10^{37}$ erg s$^{-1}$. At least two SFXTs are X–ray pulsars: IGR J11215–5952 ($P_{\text{spin}} = 186.78 \pm 0.3$ s, Swank et al. 2007) and AX J1841.0–0536 ($P_{\text{spin}} \sim 4.7$ s, Bamba et al. 2001). To date, eight are the confirmed members of the class of SFXTs (IGR J08408–4503, IGR J11215–5952, IGR J16479–4514, XTE J1739–302, IGR J17544–2619, SAX J1818.6–1703, IGR J18410–0535/AX J1841.0–0536, IGR J18483–0311), with other $\sim 15$ candidates (see e.g., the new INTEGRAL sources web page at [http://isdc.unige.ch/~rodrigue/html/igrsources.html](http://isdc.unige.ch/~rodrigue/html/igrsources.html)) which showed short transient flaring activity, but with no confirmed association with an OB supergiant companion. The field is rapidly evolving, with an increasing number of new transients discovered by instruments with a wide field of view (INTEGRAL/IBIS or Swift/BAT), so we expect that the whole class will grow in the near future.

The first SFXT displaying periodic outbursts is IGR J11215–5952 (Sidoli et al. 2006, Smith et al. 2006) which undergoes an outburst about every 165 days (Romano et al. 2007b). This periodically recurrent X–ray activity is probably related to the orbital period of the system. Thanks to the predictability of the outbursts, an observing campaign was planned in February 2007 with Swift.
(Romano et al. 2007a) of the fifth known outburst from IGR J11215–5952. Thanks to the combination of sensitivity and time coverage, Swift observations are a unique data-set and allowed a study of this SFXT from outburst onset to almost quiescence. These observations demonstrated (see the Swift/XRT lightcurve in Fig. 1) that short duration and bright flares are actually part of a longer accretion phase at a lower level, lasting days, not only hours.

2 Transient outburst mechanisms in SFXTs

The main mechanisms proposed to explain the transient outbursts in SFXTs are based on the structure of the supergiant wind, and can be divided into models based on (1)-spherically symmetric clumpy winds, (2)-anisotropic winds, and those which deal with (3)-gated mechanisms able to stop the accretion depending on the properties of both the companion wind and of the compact object (neutron star magnetic field and spin period).

2.1 Outbursts from spherically symmetric clumpy winds

One of the first hypotheses proposed to explain the transient X–ray emission from these sources was the clumpy wind model, where the short flares in SFXTs were supposed to be produced by the sporadic accretion of massive clumps which compose the blue supergiant companion wind (in’t Zand 2005). Indeed, in the last years more attention has been paid to a clumpy wind structure in early type stars (see, e.g., Lepine & Moffat 2008; Oskinova et al. 2007 and references therein).

In the framework of the wind accretion (Bondi & Hoyle 1944) which should be at work in this new class of HMXBs, the X–ray luminosity depends on the wind mass loss rate, $\dot{M}_w$, and on the relative velocity, $v_{\text{rel}}$, of the neutron star and the wind, and is proportional to $\dot{M}_w v_{\text{rel}}^{-4}$ (Waters et al. 1989). This implies that large density and/or velocity wind contrasts produce large variability in the accretion X–ray luminosity, and thus can result in a very large dynamic range. Walter & Zurita Heras (2007) explain INTEGRAL observations of the bright flares from SFXTs as due to the interaction of the compact object orbiting at $\sim 10$ stellar radii from the supergiant companion, accreting wind clumps with a mass of $10^{22}–10^{23}$ g, and with a density ratio between the clumps and the inter-clump medium of 100–10,000.

Recently, Negueruela et al. (2008) proposed a revised version of this hypothesis, based on the clumpy wind model by Oskinova et al. (2007). These authors proposed two possible configurations for the SFXTs: (a)- a circular orbit just
outside the region where the supergiant wind is denser (within about 2 stellar radii) or (b)- a wide eccentric orbit, which allows longer quiescent intervals. In both the proposed geometries, since the neutron star orbits outside the region of the wind where the number density of the clumps is higher, the probability to accrete a clump is very low.

In this framework, the difference between SFXTs and persistent supergiant HMXBs mainly depends on the orbital separation, which is within 2 stellar radii for persistent sources, where the neutron star orbits inside the dense region of the wind, and much more than 2 stellar radii for SFXTs, because of a much lower probability to accrete a single clump.

2.2 Outbursts from anisotropic winds: a preferential plane for the outflowing wind

A second type of explanation involves anisotropic winds, instead of spherically symmetric winds (as assumed in the clumpy wind model), and has been proposed to explain the periodic outbursts observed from the SFXT IGR J11215–5952 (Sidoli et al. 2007). Thanks to the predictable outburst recurrence from this source, a monitoring campaign could be planned with Swift/XRT around the expected time of the new outburst, on 2007 February 9 (Romano et al. 2007a), after 329 days from the previously observed outburst (Fig. 1). The first periodicity discovered in the outburst recurrence from this source was indeed 329 days (Sidoli et al. 2006; Smith et al. 2006). For the first time a complete outburst from a SFXT was observed from quasi-quiescence, up to the peak (lasting less than a day, with several bright and short flares and a high intensity variability), and then back to almost quiescence in a few days.

The main important result of this campaign is that the outburst duration is much longer than a few hours, as was thought before on the basis of INTEGRAL or RXTE observations. The hour duration flares seen by these instruments are indeed part of a much longer accretion phase, lasting a few days. The periodic recurrence of the outburst suggests in a natural way the interpretation of the recurrence timescale as the orbital period of the binary system, with the outbursts triggered at, or near, the periastron passage. Moreover, the shape of the X–ray lightcurve from the entire outburst can be hardly explained with Bondi-Hoyle accretion (Bondi & Hoyle, 1944) from a spherically symmetric wind in a binary system with an orbital period of 329 days (Sidoli et al., 2007): the observed X–ray lightcurve is too narrow and steep compared with the expected smoothly variable X–ray luminosity produced by accretion onto the surface of an approaching neutron star along an eccentric orbit (even assuming very high eccentricities). We interpreted these observations as a clear evidence of the fact that the clumpy supergiant wind is not spherically
symmetric. The short outburst can be explained with accretion from another wind component, for example an equatorially enhanced wind component (or any other preferential plane for the outflowing wind), denser and slower than the symmetric polar wind from the blue supergiant, inclined with respect to the orbital plane of the system, to explain the shortness of the outburst and the shape of the source lightcurve. This geometry can also easily explain the periodic occurrence of the outbursts.

Based on the 329 days periodicity, we planned a second monitoring campaign with Swift during the expected apastron passage (around 165 days after the last outburst). This new campaign led to the observation of a new unexpected outburst from this source after a half of the previous period, suggesting that \(~165\text{ days}\) is probably the new orbital period (Sidoli et al., 2007). These new observations could be explained by two different geometries for the SFXT IGR J11215–5952, depending on the correct orbital period, \(P_{\text{orb}}\): (a) if \(P_{\text{orb}} \sim 165\text{ days}\), the orbit should be eccentric to produce only one outburst per orbit, when the neutron star crosses the equatorial wind; (b) if \(P_{\text{orb}} \sim 329\text{ days}\), then the outbursts are two per orbit and the orbit should be circular, since the two consecutive outbursts reach similar peak luminosities (Sidoli et al., 2007).

This interpretation could explain also the other SFXTs outbursts, although the geometry of this equatorially enhanced wind component could be different from that explaining IGR J11215–5952: for example, the equatorial wind could intersect the orbit of the compact object not near the periastron, but at different phases, thus producing two regions on the orbit with enhanced wind density (where the outbursts are triggered), and thus two different periodicities, \(P_1\) and \(P_2\), in the outburst occurrence, if the orbit is eccentric, such that \(P_1 + P_2 = P_{\text{orb}}\). IGR J11215–5952 could be probably the only system where the

![Lightcurves of the SFXT IGR J11215–5952 during the outburst in February 2007 (MJD 54140=2007 February 9) observed with XRT in the energy range 0.2–10 keV.](image_url)
intersection of the equatorial outflow with the neutron star orbit happens at (or very near to) the periastron. This could explain why it is more difficult to discover a periodicity or (a double periodicity) in the outburst recurrence in the other SFXTs. Moreover, the thickness of this wind component could be different, and the inclination with respect to the orbital plane could vary a lot among SFXTs, thus producing very different phenomenologies, for example in the outburst duration and recurrence, and covering a different and variable fraction of the neutron star orbit.

There are indications that preferential planes in the outflowing supergiant winds are probably present, especially from X–ray observations of other types of HMXBs. In particular, apastron outbursts have been observed in supergiant HMXBs with known orbital periods (e.g. Pravdo & Ghosh 2001; Corbet et al. 2007) where the presence of equatorially enhanced winds inclined with respect to the neutron star orbit have been suggested in order to properly explain the observational X–ray data.

In conclusion, the observational evidence at the basis of our suggestion for the presence of a preferential plane for the outflowing wind in blue supergiant is provided by the periodicity in the IGR J11215–5952 outburst recurrence and by the shape of the X–ray lightcurve, which cannot be produced by any temporary or transient feature in the stellar wind (such as wind streams or gas shells or shocks, or macro-structures of clumps), but must be due to some permanent and orbital phase-fixed structure in the supergiant wind. This is naturally provided by a second wind component crossing the neutron star orbit. We note that periodicities in the outburst recurrence begin to be found also in other SFXTs: IGR J18483–0311 displays a recurrence periodicity of ~18.5 days (Sguera et al., 2007b); this source was at first classified as a Be X–ray transient, but very recently Rahoui & Chaty (2008) optically identified the companion as a blue supergiant, thus the source is actually a SFXT; IGR J08408–4503 displays an X–ray activity (multiple flare duration and X–ray outburst recurrence) which is compatible with an orbital period of 35 days (see Romano et al. 2009 for details).

2.3 Gated mechanisms

Other possibilities which have been suggested to explain the SFXTs outbursts, and especially their high dynamic ranges, are based on gated mechanisms where the accretion is halted because of the presence of a magnetic or a centrifugal barrier, which depends on the properties of the compact object (the neutron star), in particular its spin period and its surface magnetic field. Bozso et al. (2008) applied this idea to SFXTs hosting a highly magnetized neutron star [see also Grebenev & Sunyaev (2007) and references therein; Goetz et
al. (2007)]. Wind accretion in a HMXB containing a magnetized neutron star depends on three different radii: accretion radius \( R_{\text{acc}} \) [Bondi & Hoyle (1944)], corotation radius \( R_{\text{cor}} \) and magnetospheric radius \( R_{\text{m}} \). While the corotation radius depends only on the neutron star mass and its spin period, the other two radii \( R_{\text{acc}} \) and \( R_{\text{m}} \) depend on the properties of the supergiant wind, while \( R_{\text{m}} \) also depend on the neutron star magnetic field, \( B \) (Illarionov & Sunyaev 1975; Stella et al. 1986 and references therein). Different types of interactions (accretion or inhibition of the accretion) between the companion wind and the magnetized neutron star are possible depending on the relative positions of these three radii which, on the other hand, are related to the neutron star magnetic field and spin period, and to the properties of the supergiant wind (its velocity and density). Direct accretion is possible only if \( R_{\text{acc}} > R_{\text{m}} \) and \( R_{\text{cor}} > R_{\text{m}} \). In all the other cases, the accretion is prevented, by a magnetic barrier or by a centrifugal barrier. Large luminosity swings (~10,000 or more) can result from transitions across these different regimes, which are produced if the relative positions of the three radii \( R_{\text{acc}} \), \( R_{\text{cor}} \), \( R_{\text{m}} \) change with time, depending on a change in the wind parameters. Thus, modest variations in the wind properties (as, for example, in a clumpy wind environment) can modify \( R_{\text{acc}} \) and \( R_{\text{m}} \) in such a way to produce an outburst. This only applies if the three radii driving the accretion display very similar values.

Bozzo et al. (2008) show that an abrupt X–ray luminosity jump from the quiescence (at about \( 10^{32} \) erg s\(^{-1}\)) to the peak of an outburst in a SFXT \( (10^{36}–10^{37} \) erg s\(^{-1}\)) can be explained only if the the neutron star spins slowly (~1000 s or larger) and if it displays a magnetar-like magnetic field (\( B \sim 10^{14} \) G), in presence of a relatively mild change in the wind density (one or two orders of magnitude, instead of the at least 4 orders of magnitude requested by the clumpy wind model discussed above). Note that this model requires in any case a variability (although mild) in the wind parameters (such as clumps, or any other structure in the wind with higher density than the smooth wind). However density contrasts of \( 10^4 \) between the clumps and the inter-clump matter seem to be not unusual in supergiant winds [see, e.g., Oskinova et al. (2007) and reference therein or the simulations of the line driven instability performed by Runacres & Owocki (2005), which result in clumps with density contrasts as large as \( 10^3–10^5 \) with respect to the inter-clump matter, with a wind which remains clumpy far away from the hot star, out to 1,300 stellar radii]. Bozzo et al. (2008) applied this interpretation to the outburst observed in 2004 with Chandra from the SFXT IGR J17544–2619 (in’t Zand 2005) and show that the transition to the outburst peak can be explained in terms of the magnetic barrier model, with a magnetar-like neutron star with a spin period of 1300 s (with a wind terminal velocity of 1400 km s\(^{-1}\), and an assumed orbital period of 10 days), if the wind mass loss rate changes from \( 10^{-5} \) M\(_{\odot}\) yr\(^{-1}\) to \( 10^{-4} \) M\(_{\odot}\) yr\(^{-1}\).
In order to test the different proposed mechanisms for the transient outbursts, to measure the outburst duration, to perform a truly simultaneous spectroscopy from soft to hard X-rays during outbursts, and to see in which status the SFXTs spend most of their lifetime, we have been performing a monitoring campaign of a sample of four SFXTs with Swift since October 2007 (Sidoli et al. 2008, Paper I): the two prototypes XTE J1739–302 and IGR J17544–2619, IGR J16479–4514 and the X-ray pulsar AX J1841.0–0536/IGR J18410–0535. The campaign consists of 2–3 observations/week/source (each observation lasts 1–2 ks).

The results of this Swift campaign are shown in Fig. 2, where the X-ray lightcurves of the 4 SFXTs are displayed. The big gap in the observations between about December 2007 and February 2008 is due to the fact that the sources were Sun-costrained. The source fluxes are highly variable even outside the bright outbursts (which have been caught in three of the four sources we are monitoring). Variability on timescales of days, weeks and months, is evident in the lightcurves, with a dynamic range (outside bright outbursts) of more than one order of magnitude in all four SFXTs. The long term average behaviour of the source is a frequent low level flaring activity with an average 2–10 keV luminosity of about $10^{33}–10^{34}$ erg s$^{-1}$ (Paper I), assuming the source distances reported in Rahoui et al. (2008). The average spectra of the out-of-outburst emission is typically hard, well fitted with an absorbed power-law with a photon index in the range 1–2. The out-of-outburst emission in IGR J16479–4514 and in AX J1841.0–0536 appears to be modulated with a timescale in the range 22–25 days, although we postpone a full timing analysis to the end of the campaign. These properties (flux variability of more than one order of magnitude outside the bright outbursts together with the hard spectrum) demonstrate that SFXTs accrete matter even outside their bright outbursts, and that the quiescence (characterized by a very soft spectrum and by a low level of emission at about $10^{32}$ erg s$^{-1}$) is a much rarer state in these sources.

During the monitoring we caught bright outbursts from these sources, except from AX J1841.0–0536, which remarkably has not undergone an outburst for several months (maybe for years). The first one was observed from IGR J16479–4514 on 2008 March 19 (Romano et al. 2008, Paper II), which could be observed over a wide energy band simultaneously with XRT and BAT, and exceeded at peak the flux of $10^{-9}$ erg cm$^{-2}$ s$^{-1}$. The 0.5–100 keV spectrum can be adequately fit with models usually typical for accreting pulsars, an absorbed powerlaw with a high energy cut-off, or a cutoff powerlaw, or a Comptonized emission (see Paper II for details). A time resolved spectroscopy of the flare resulted in similar fitting parameters for the X-ray emission, with
Fig. 2. Lightcurves of the 4 SFXTs monitored with Swift/XRT (0.2–10 keV), from October 2007 to the end of June 2008. The downward-pointing arrows are 3-σ upper limits. The upward pointing arrow in the IGR J17544−2619 lightcurve marks an outburst which triggered the BAT Monitor on MJD 54412 (Paper I) but could not be observed with XRT because of Sun-constraints.
absorbing column density of $\sim 6 \times 10^{22}$ cm$^{-2}$, a powerlaw photon index $\Gamma \sim 1$, a high energy cutoff $E_c \sim 7$ keV, and an e-folding energy $E_l \sim 7$–$20$ keV. Assuming a distance of 4.9 kpc, the 0.5–100 keV luminosity exceeds $5 \times 10^{37}$ erg s$^{-1}$. The source lightcurve spanned at least 4 orders of magnitude in a few days monitored before and after the bright flare.

A new outburst was observed also from IGR J17544–2619 on 2008 March 31 (Sidoli et al. 2009, Paper III). Simultaneous observations with XRT and BAT allowed to perform, in this case as well, for the first time a broad band spectroscopy of the emission in outburst from this SFXT. The deconvolution of the 0.3–50 keV emission results in a hard powerlaw-like spectrum below 10 keV, with high energy cut-off clearly emerging when fitting the BAT spectrum together with the XRT data, typical of accreting pulsars (White et al. 1983). A good fit is provided by a powerlaw with a high energy cut-off with the following fit parameters: $N_H = (1.1 \pm 0.2) \times 10^{22}$ cm$^{-2}$, $\Gamma = 0.75 \pm 0.11$, $E_c = 18 \pm 2$ keV and $E_l = 4 \pm 2$ keV, reaching a luminosity of $5 \times 10^{37}$ erg s$^{-1}$ (0.5–100 keV at 3.6 kpc). The out-of-outburst emission observed with XRT below 10 keV appears to be softer and more absorbed than the emission during the flare.

The third outburst was caught from XTE J1739–302 on 2008 April 8 (Paper III). In this occasion, two bright flares have been observed, separated by about 6000 s. The soft X–ray emission is much more absorbed than IGR J17544–2619, showing a high absorbing column density, $N_H$, of $\sim 1.3 \times 10^{23}$ cm$^{-2}$, while the fit to the broad band X–ray emission with a high energy cut-off powerlaw resulted in the following parameters: $\Gamma = 1.4_{-1.0}^{+0.5}$, $E_c = 6_{-6}^{+7}$ keV and $E_l = 16_{-8}^{+12}$ keV, reaching a luminosity of $3 \times 10^{37}$ erg s$^{-1}$ during the flare (0.5–100 keV, assuming a distance of 2.7 kpc). The out-of-outburst emission observed with XRT below 10 keV is less absorbed than the emission during the flare, and displays similar spectral shape, within the uncertainties.

4 Discussion and conclusions

The monitoring campaign we are performing with Swift allow us to perform an interesting comparison between the properties of the different SFXTs.

In Fig. 3 we show the lightcurves of 4 SFXTs. The duration and the shape of the X–ray lightcurves appear to be similar, and so does the dynamical range spanned during the outbursts (about three orders of magnitude). In the case of the April outburst from XTE J1739–302 we could not follow entirely the flare behaviour, but in the case of IGR J16479–4514 and of IGR J17544–2619 the outburst durations appear very similar to that of the periodic SFXT IGR J11215–5952, as the source dynamic ranges. This demonstrates that it is no longer justified to exclude this source from the class of SFXTs only because
it displays periodic outbursts. This also demonstrates that the outburst duration in SFXTs is much longer than a few hours, as usually assumed based only on INTEGRAL or RXTE observations, which of course could catch only the brightest part of the single flares. Actually, these SFXT X–ray flares belong to a much longer accretion phase (outburst event) which last a few days.

The broad band X–ray emission displays a spectral shape very similar to that of accreting X–ray pulsars, with a flat powerlaw hard X–ray emission below 10 keV with a high energy cutoff. Although no cyclotron lines have been observed yet in this new class of sources, the broad band spectral shape (e.g. the cutoff energies) are consistent with a pulsar magnetic field around a few $10^{12}$ G, assuming the empirical correlation (although never theoretically confirmed) between the high energy cutoff in X–ray pulsars and the observed cyclotron energies (Coburn et al. 2002). This property seems to be in contrast with the hypothesis suggested by Bozzo et al. (2008) that SFXTs are magnetars. Moreover, Bozzo et al. (2008) suggest that, to get the large dynamic ranges observed in SFXTs, these transients should host neutron stars with long spin
periods (of the order of 1000 s or larger), which is not observed in SFXTs, to date: indeed, four SFXTs are X-ray pulsars with much shorter spin periods: IGR J11215–5952 (187 s, Swank et al. 2007), AX J1841.0–0536 (4.7 s, Bamba et al. 2001), IGR J18483–0311 (21 s, Sguera et al. 2007b), IGR J16465−4507 (228 s, Lutovinov et al. 2005). The large dynamic range between the quiescence and the maximum luminosity at the peak of the flares can, in any case, be explained already if the supergiant winds are clumpy with density contrasts as large as $10^5$ (e.g. Runacres & Owocki 2005), thus making the hypothesis of magnetars in SFXTs not actually needed.

The low-level flaring activity we observe in SFXTs during the out-of-outburst emission can be explained both in the anisotropic wind hypothesis, where it is easily accounted for by the accretion from the faster and less dense polar wind component from the supergiant star, and in the spherically symmetric clumpy wind, for example assuming a distribution of clump sizes or masses (although the mass spectrum of the wind clumps is unknown). In any case, the flares from SFXTs cannot be explained by the accretion of a single clump, since the duration of the outburst is much longer than only a few hours, but extends for several days. A spherically symmetric wind (although clumpy) cannot explain the periodicity of the outburst recurrence in IGR J11215–5952. Based on the anisotropic wind hypothesis, the outbursts should occur at preferential orbital phases, and display some sort of periodicity (or double periodicity or quasi-periodicity) in the outburst recurrence. Although several observations have already been performed, not only with Swift but also with INTEGRAL, we emphasize the fact that, if all the other SFXTs are indeed similar to IGR J11215–5952 (which displays periodic outbursts every ~165 days), the likely periodicity (or double periodicity) in the outburst recurrence should be of order of months. This implies that probably they have not been discovered yet because of a lack of observations.

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