The *Swift* Supergiant Fast X-ray Transients outburst factory

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ABSTRACT: We present the *Swift* Supergiant Fast X-ray Transients project, which has been exploiting *Swift*'s capabilities in a systematic study of SFXTs and classical supergiant X-ray binaries (SGXBs) since 2007. We performed an efficient long-term monitoring of 16 sources including both SFXTs and classical SGXBs and followed source activity across more than 4 orders of magnitude in X-ray luminosity, sampling the light curves on timescales spanning from few hundred seconds to years. We use our measurements of dynamic ranges, duty cycles as a function of luminosity, and luminosity distributions to highlight systematic differences that help discriminate between different theoretical models proposed to explain the differences between the wind accretion processes in SFXTs and classical SGXBs. Our follow-ups of the SFXT outbursts provide a steady advancement in the comprehension of the mechanisms triggering the high X-ray level emission of these sources. In particular, the recent observations of the outburst of the SFXT prototype IGR J17544-2619 on 2014 October 10, when the source reached a peak luminosity of 3×10^{38} erg s^{-1}, challenged for the first time the maximum theoretical luminosity achievable by a wind-fed neutron star high mass X-ray binary. We propose that this giant outburst was due to the formation of a transient accretion disc around the compact object.

Long term monitoring

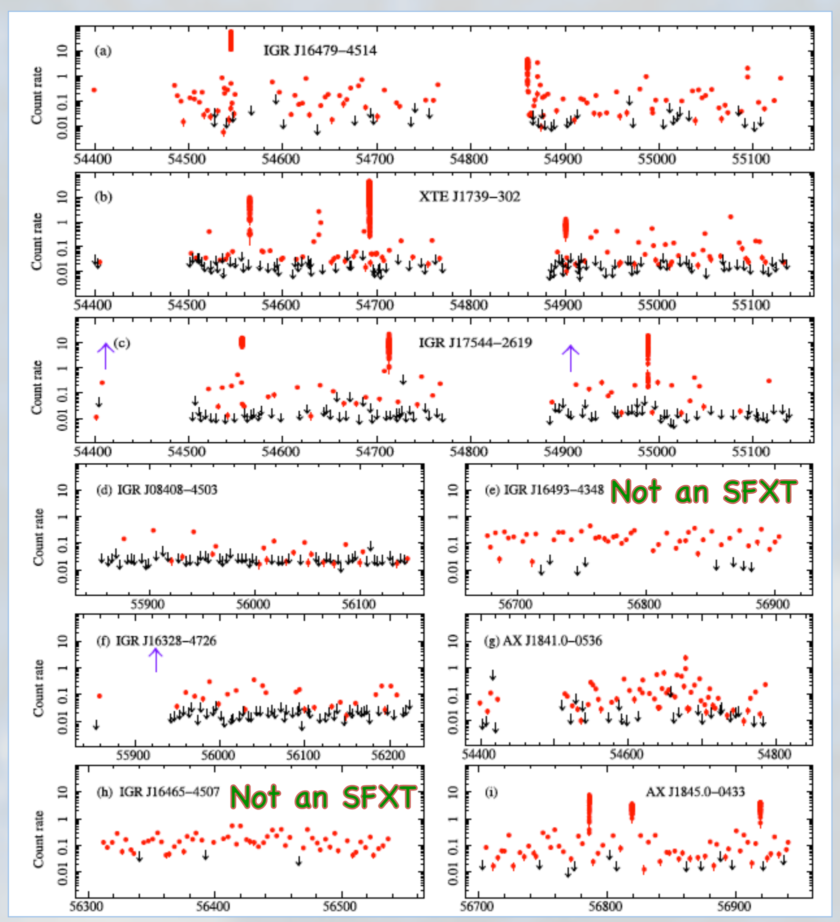


Fig. 1: *Swift*/XRT (0.2–10 keV) long term light curves for the *yearly monitoring sample*. The x-axis is in MJD. The points refer to the average count rate measured for each observation except for outbursts, where the data were binned to include at least 20 counts bin^{-1} (to best represent the dynamic range). Red points are detections, black downward-pointing arrows are 3-σ upper limits. Violet upward-pointing arrows mark bright outbursts detected by BAT (and not simultaneously followed by XRT), or by MAXI (for AX J1841.0–0536).

XRT dynamic range:
4 orders of magnitude

Variability observed on all timescales and all intensity levels

Short timescales (1 ks, down to 0.1 counts s^{-1}): clumpy winds with clumps of 10^{18-19} g

3-5% of time spent in bright outbursts

Most probable observed flux:
1-3x10^{-11} erg cm^{-2} s^{-1}
(2-10 keV, unabsorbed)

Long term behavior is intermediate state of accretion
L~10^{33} – 10^{34} erg s^{-1}

Sources accreting matter most of the time

Outburst follow-ups

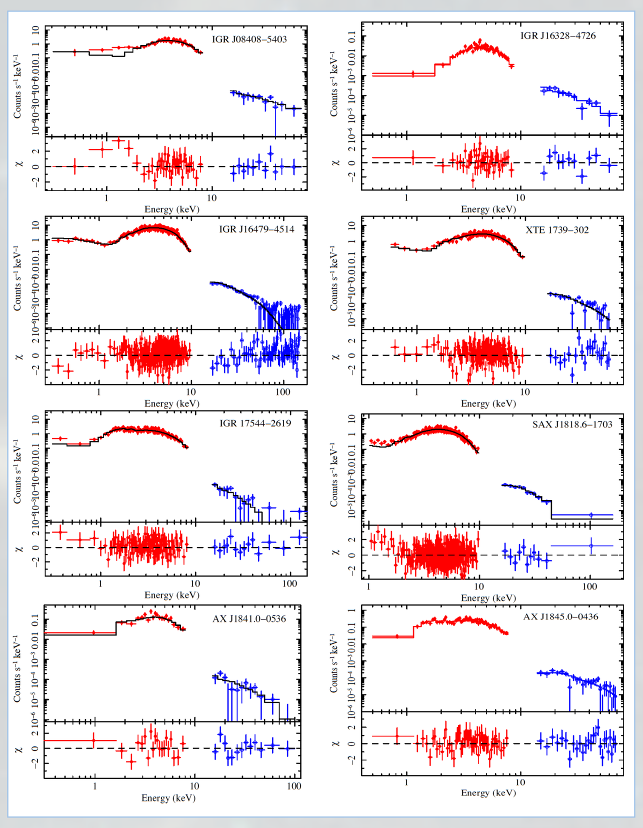


Fig. 2: *Swift* broad-band spectroscopy of outbursts of SFXTs. Top: simultaneous XRT (0.3-10 keV, filled red circles) and BAT (15-150 keV, empty blue circles) data fit with the best phenomenological models. Bottom: the residuals of the fit (in units of standard deviations).

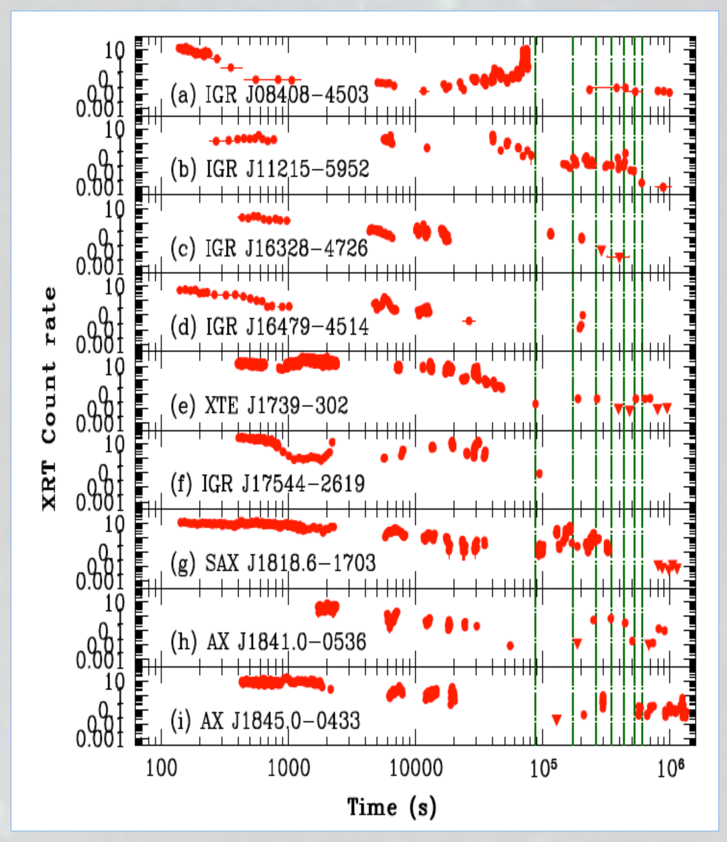


Fig. 3: Light curves of the most outstanding outbursts of SFXTs followed by *Swift*/XRT with starting times referred to their respective BAT triggers (IGR J11215–5952 and IGR J16418–4532 did not trigger the BAT, so data are referred to the start of the observation). Points denote detections, triangles 3σ upper limits. Vertical dashed lines mark 1 day time intervals up to a week.

Common outburst features:

Absorption + spectral cut-off, models for accreting NS
High energy cutoff consistent with B~10^{12} G (no cyclotron lines observed until 2014)

Outburst length > hours
Multiple peaked structure with lots of flares
Dynamic range: 3 orders of magnitude

IGR J17544-2619 giant outburst

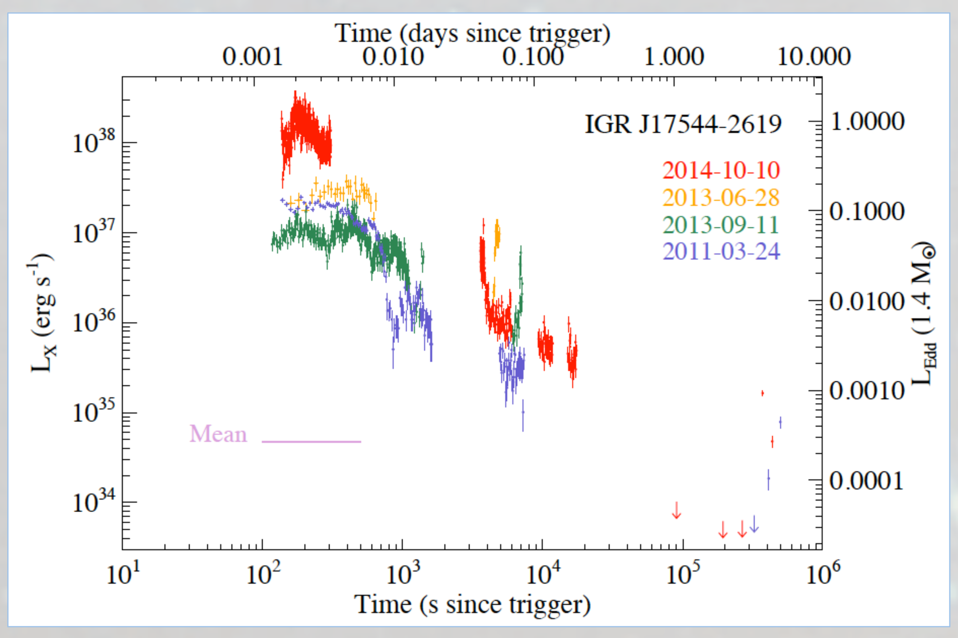
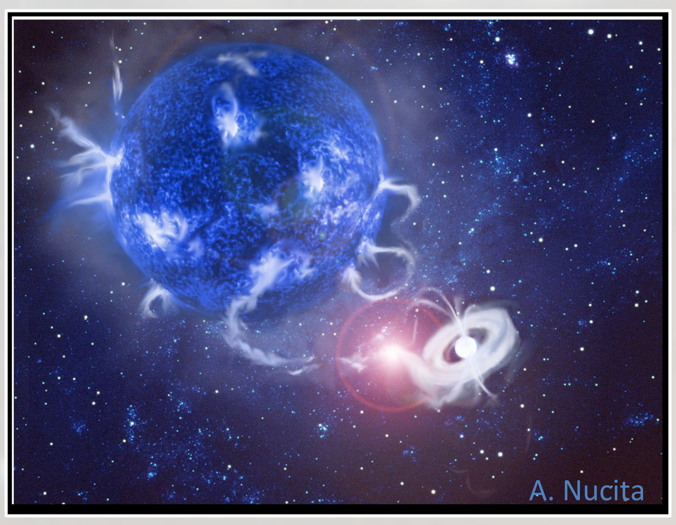


Fig. 4: Bolometric X-ray luminosity light curves of the brightest outbursts recorded by *Swift* for IGR J17544–2619. The giant burst of 2014 October 10 is shown in red, and compared with previous bright outbursts from this source. The horizontal (pink) line marks the average level for this source, obtained from the two year monitoring campaign (Fig. 1), while the right-hand y-axis is the standard Eddington luminosity for spherical accretion of fully ionized hydrogen for a 1.4 $M_\odot$

A transient disk?



High L reached L_{Edd}

- higher than wind accreting SGXBs

L_X~3x10^{38} erg s^{-1} can be achieved with

- ingestion of massive clump (see Bozzo+2011, but no spectral support)
- very high mass loss rate >> 10-6 $M_\odot$/yr (unrealistically high)
- **very low wind velocity** <~ 2x10^6 cm s^{-1} due to ionization of the wind material, favored by short orbital period (P=4.926d) and eccentric orbits

Difficult to avoid formation of temporary accretion disk whose dissipation would produce 10x mass accretion rates (flares!!!)

Romano 2015, JHEAp, 7, 26
Romano et al. 2015, A&A, 576, L4

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