Swift/XRT monitoring of the supergiant fast X-ray transient IGR J17354-3255

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Abstract

We report on the first monitoring of the supergiant fast X-ray transient IGR J17354−3255 with the soft X-ray instrument *Swift*/XRT. The *Swift* observations span 1.2 orbital periods ($P = 8.4474$ d) for a total exposure of about 24 ks. The study of the flux variability of the sources in the XRT field of view allowed us to unambiguously identify the soft X-ray counterpart of IGR J17354−3255. The $0.3-10$ keV XRT light curve shows a moderate orbital modulation and a dip. We compared the observed X-ray light curve with those calculated with a model based on the Bondi-Hoyle-Lyttleton accretion theory, for different wind parameters, eccentricities and spectral type of the donor star. We found that the X-ray orbital modulation produced by a neutron star in an eccentric orbit cannot explain the presence of the dip. We showed that an eclipse or the onset of a gated mechanism are the most likely explanations for the dip.

Properties of IGR J17354–3255

- It shows a hard X-ray flaring activity (mean flare $18-60$ keV flux of $\sim 4\times10^{-10}$ erg cm^{-2} s^{-1}) and an average flux of $\sim 1.4\times10^{-11}$ erg cm^{-2} s^{-1} ($20-40$ keV).
- $P_{\rm orb} = 8.4474 \pm 0.0017$ d (D'Aì et al. 2011, A&A 529, 30; Sguera et al. 2011, MNRAS 417, 573).
- Based on the fast flaring activity, Sguera et al. (2011) proposed that IGR J17354–3255 is a supergiant fast X-ray transient (SFXT).
- SFXTs are high mass X-ray binaries (HMXBs) with O or B supergiant stars which display short X-ray outbursts with peak luminosities of $10^{36}-10^{37}$ erg s^{-1} and a dynamic range of 3–5 orders of magnitude. See more details in the poster "The *Swift* SFXTs Project" of P. Romano et al.
- The donor star is a O8.5-9Iab star (Coleiro et al. 2013, arXiv:1310.0451).

Reduction and data analysis

- We analyzed the *Swift*/XRT data collected in 2012 July. The ToO monitoring program lasted 11 days for a total exposure time of $\sim$ 24 ks.
- We also re-analyzed the *Swift* observations of 2008 and 2009.

Results: Spectral analysis

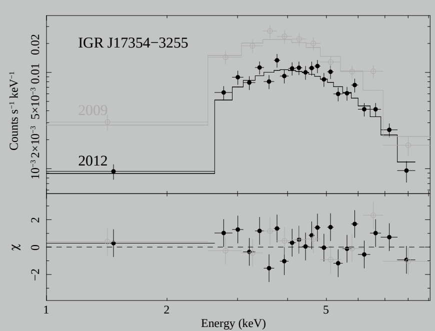

Figure 1: Spectrum of the 2009 observation (grey) and 2012 campaign (black). The data fit with an absorbed power-law model.

	$N_{\rm H}$ (10^{22} cm^{-2})	Γ	Flux^a	L^b	χ^2_ν/dof
2009	$7.8^{+2.9}_{-2.2}$	$1.7^{+0.6}_{-0.5}$	2.0	1.7	1.04/18
2012	11^{+3}_{-2}	$1.7^{+0.5}_{-0.4}$	1.0	0.9	1.17/42

^{a} Unabs. 2–10 keV fluxes (10^{-11} erg cm^{-2} s^{-1}).
^{b} 2–10 keV luminosities in units of 10^{35} erg s^{-1}, at 8.5 kpc.

Results: Identification of the soft X-ray counterpart of IGR J17354–3255

The observed orbital modulation in the folded lightcurves of Swift J173527.7–325555 and IGR J17354–3255 (which has a dip corresponding to the minimum observed in the folded BAT and *INTEGRAL* lightcurves) allows a definitive identification of the soft X-ray counterpart of IGR J17354–3255. This identification was previously mainly based on positional association.

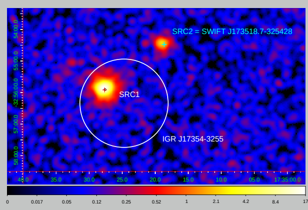

Figure 2: *Swift*/XRT observation (0.3–10 keV). The large circle is the *INTEGRAL* 90% error box. The crosses mark the two XRT sources in the field of IGR J17354–3255 (src1 within the *INTEGRAL* error circle, src2 outside of it).

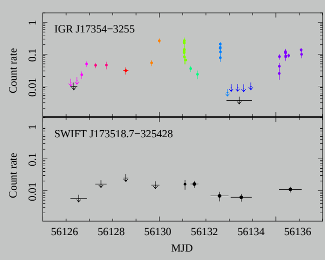

Figure 3: *Swift*/XRT 0.3–10 keV lightcurves of the two X-ray sources detected during the 2012 July monitoring program. Top: Swift J173527.7–325555 (src1, identified with the soft X-ray counterpart of IGR J17354–3255).

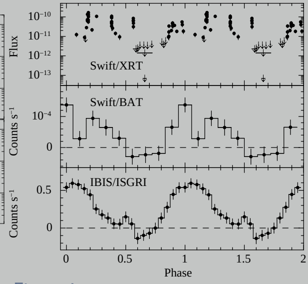

Figure 4: Lightcurves of IGR J17354–3255 folded at $P_{\rm orb} = 8.4474$ d.

Results: The *Swift*/XRT lightcurve

The soft X-ray lightcurve (Figure 5) shows:

- a moderate orbital modulation;
- flaring activity on short time scales (hundreds of seconds);
- a dip centered at $\phi \sim 0.7$ which lasts $\Delta\phi \sim 0.2-0.24$.

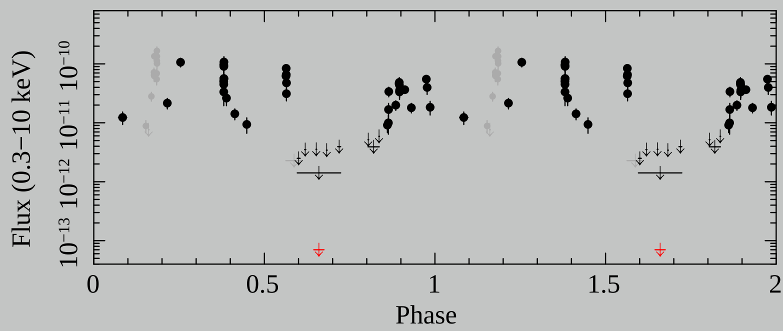

Figure 5: *Swift*/XRT 0.3–10 keV flux light curve of IGR J17354–3255, folded at $P_{\rm orb} = 8.4474$ d, which includes the data collected in 2012 (black) and 2008-2009 (grey). Downward-pointing arrows are 3σ upper limits. The red arrow at $\sim 7\times10^{-14}$ erg cm^{-2} s^{-1} at phase 0.66 is the 3-σ upper limit obtained from a 19 ks exposure on 2011 March 6 with *XMM-Newton* (Bozzo et al. 2012).

Results: An investigation of the nature of the dip

We investigated the nature of the dip by comparing the X-ray lightcurve with the prediction of the Bondi-Hoyle-Lyttleton (BHL) accretion theory, assuming both spherical and nonspherical symmetry of the outflow from the donor star, by varying the mass and radius of the OB supergiant star, and for different values of the mass loss rate, terminal velocity, and orbital eccentricity.

- We found that the dip cannot be explained only with the X-ray orbital modulation (i.e. high eccentricity).
- We propose that an eclipse or the onset of a gated mechanism is the most likely explanation for the observed lightcurve.
- The 2D histogram of Figure 6 shows the BHL solutions that reproduce the observed X-ray luminosities obtained assuming the accretion from a spherically symmetric wind of a supergiant star.
- For each solution we also plotted the mean luminosity (averaged over the orbit) in the histogram of Figure 7. The allowed eccentricities (obtained by comparing the observed X-ray luminosities with those calculated with the BHL model) are $0 \lesssim e \lesssim 0.64$.

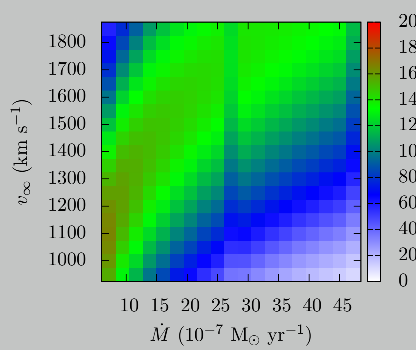

Figure 6: 2D histogram showing the solutions that reproduce the out-of-dip luminosities. Different colors refer to different numbers of occurrences.

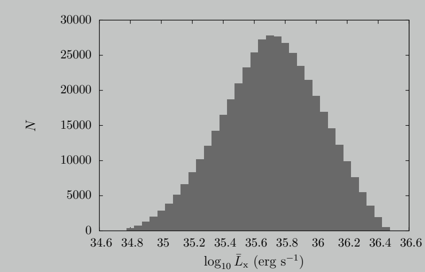

Figure 7: Histograms of the mean luminosity.