IGR J17544-2619 from quiescence to outburst with XMM-Newton and NuSTAR

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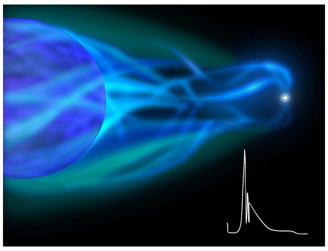
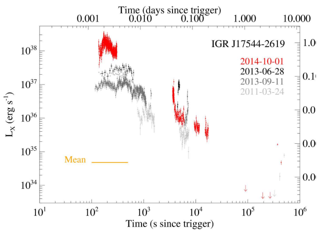
(on behalf of a large collaboration – please see references below)

We report below on the preliminarily results obtained from a 150 ks-long observational campaign on the Supergiant Fast X-ray Transient prototype IGR J17544-2619. The observations have been carried out simultaneously with NuSTAR and XMM-Newton.

Supergiant Fast X-ray Transients

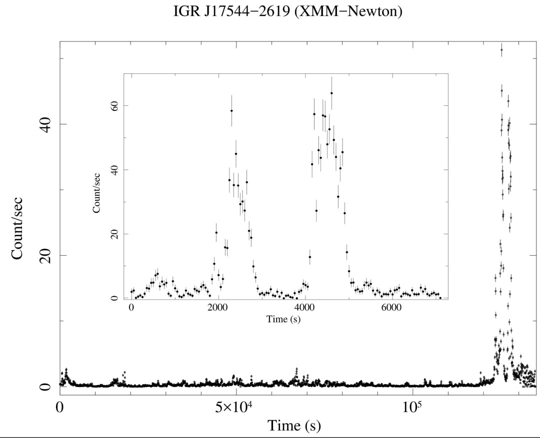




The so-called Supergiant Fast X-ray Transients (SFXTs)are a sub-class of wind accreting supergiant high mass X-ray binaries (SgXBs) showing a peculiar variability in the X-ray domain. Contrary to other SgXBs that display a usual variability by a factor of 10-100 and a rather persistent average luminosity (L_X =10^{34}-10^{36} erg/s), the SFXTs are characterized by long periods of very low quiescence (10^{32}-10^{33} erg/s) and short sporadic outbursts reaching 10^{36}-10^{37} erg/s and lasting a few hours at the most. The mechanism originating this extreme variability is still highly debated, as these systems share many properties with the other SgXB.

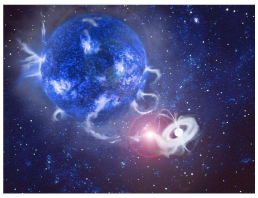
IGR J17544-2619 is the prototype of the SFXTs, showing so far the most extreme variability in X-rays. The system has been observed in quiescence down to few times 10^{32} erg/s and the brightest outburst recorded by Swift reached about 4×10^{38} erg/s, thus summing up to a total dynamical range in X-rays of $>10^6$ (see the figure above for the brightest outbursts recorded by Swift; Romano et al. 2015, A&A, 576, 4).
For its extreme variability, IGR J17544-2619 is also often called "The King".
The system is known to have an orbital period of 4.9 days and a O9Ib supergiant companion. Pulsations were never confirmed.

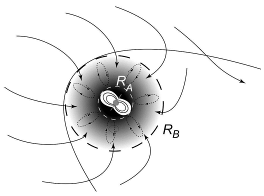
XMM-Newton and NuSTAR LIGHTCURVES

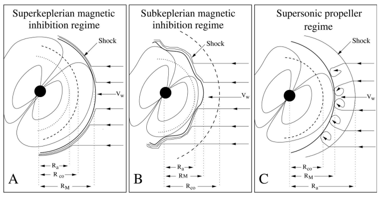


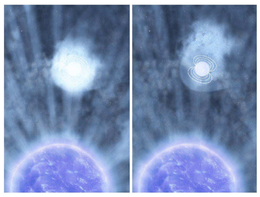
SIMULTANEOUS XMM-Newton and NuSTAR OBSERVATIONS

The SFXT IGR J17544-2619 was observed simultaneously by XMM-Newotn and NuSTAR on 2015-03-21 for about 150 ks (only the XMM-Newotn lightcurve is shown on the left). The source displayed an extended period of quiescence of roughly 120 ks and then underwent a bright outburst for about 7 ks toward the end of the observation.
The outburst comprised three distinct X-ray flares. The average flux during the quiescent period was about 2×10^{-12} erg/cm^2/s. During the peak of the brightest flare we recorded a flux of 4×10^{-9} erg/cm^2/s.
NuSTAR observed the same behavior, but the second of the three flare was not observed due to orbital constraints.
So far, this is the longest ever observational campaign performed on an SFXT with a focusing pointed instrument.





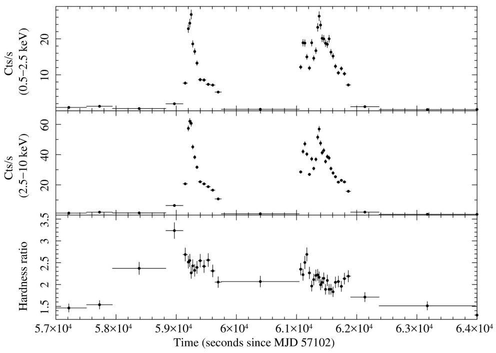


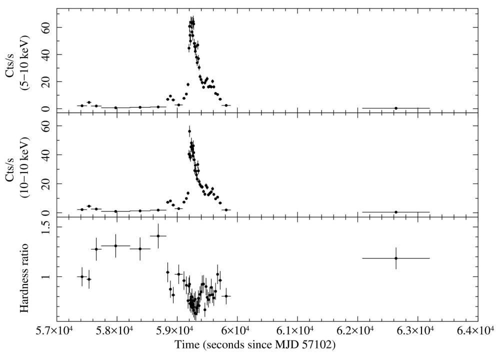


THE SFXT VARIABILITY: THEORETICAL INTERPRETATIONS

As mentioned above, the mechanisms triggering the SFXT X-ray variability are still widely debated and investigated. Different models have been put forward, ranging from the presence of temporary accretion disks around the compact objects in these systems (leftmost figure; Romano et al. 2015, A&A, 576, 4), the presence of a sub-sonic settling accretion regime (second figure from the left; Shakura et al. 2012, MNRAS, 420, 216), the effect of magnetic and centrifugal gatings (Bozzo et al. 2008, ApJ, 683, 1031), or the accretion from an extremely clumpy wind (Bozzo et al. 2011, A&A 531, 130).

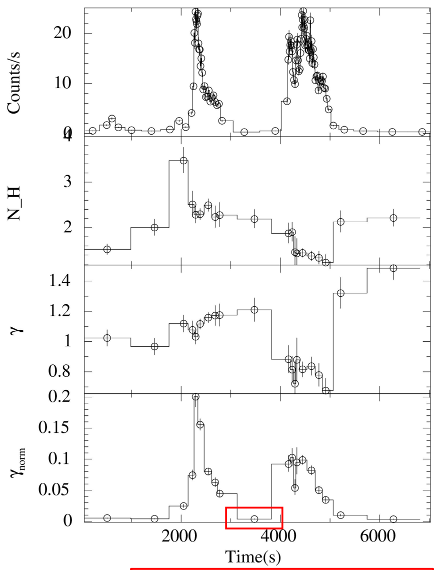
THE X-RAY SPECTRAL VARIABILITY

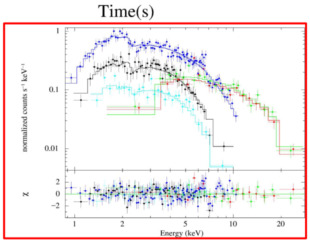




SPECTRAL VARIABILITY DURING THE X-RAY OUTBURST

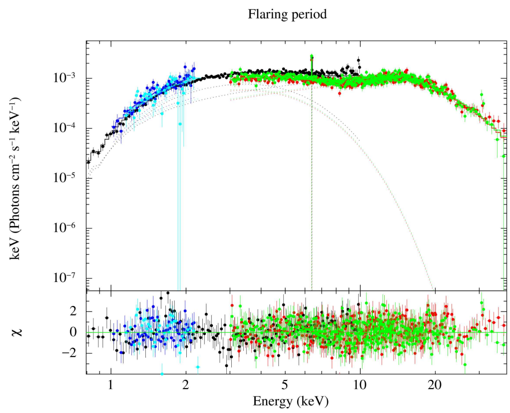
The figures above show the harness ratios built from the NuSTAR and the XMM-Newton lightcurves during the flaring period of the observations. The start time of the lightcurves is the same and the adaptive binning have been chosen to achieve a signal-to-noise ratio of >15 in both cases for each time bin. The plots show a clear hardening of the source spectrum during the rise to the first flare on the outburst (which comprises three distinct flares). The hardening is visible in both the XMM-Newton and the NuSTAR energy bands. Unfortunately, the second bright flare of the outburst could not be observed by NuSTAR due to the periodical orbital constraints.
In XMM-Newton the lowest recorded count-rate is about 10^{-2} cts/s, while the peak count-rate achieves about 100 cts/s. The total dynamic range of the source during this observation is thus at least $>10^4$ (in the 0.5-10 keV energy range).

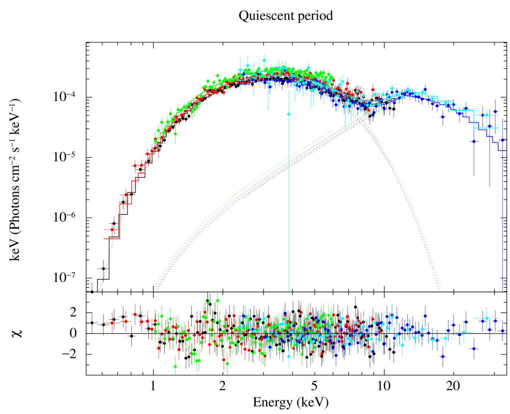




HARDNESS RATIO RESOLVED SPECTRAL ANALYSIS

A refined spectral analysis is being carried out selecting the time intervals of the different flares during which a significant variation of the hardness ratio was measured (see figures on the left). By using XMM-Newton data alone, the rise of the first flare seems to occurring after a significant increase in the absorption column density (see figure above). An intriguing absorption feature at 7 keV is detected during one of the spectral interval (shown above).





COMPARING X-RAY SPECTRA DURING THE OUTBURST AND DURING QUIESCENCE

The figures above show the combined simultaneous XMM-Newton and NuSTAR spectra accumulated during the first 120 ks of the observation when the source was quiescent and then during the 7 ks corresponding to the outburst period. The best fit model is obtained with an absorbed BBODYRAD plus a HIGHECUT*POW model in XSPEC. The two components are clearly visible in the unfolded spectra above.

CONTRIBUTORS

This work is being currently carried out in collaboration with: V. Bhalerao, P. Pradhan, J. Tomsick, P. Romano, C. Ferrigno, M. Falanga, L. Stella, L. Oskinova, S. Camapa, A. Manousakis, R. Walter, et al.