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Letter to the Editor

IGR J11215–5952: a hard X-ray transient displaying recurrent outbursts*

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ABSTRACT

Context. The hard X-ray source IGR J11215–5952 has been discovered with INTEGRAL during a short outburst in 2005 and proposed as a new member of the class of supergiant fast X-ray transients.

Aims. We analysed INTEGRAL public observations of the source field in order to search for previous outbursts from this transient, not reported in literature.

Methods. Our results are based on a systematic re-analysis of INTEGRAL archival observations, using the latest analysis software and instrument calibrations.

Results. We report the discovery of two previously unnoticed outbursts, spaced by intervals of ~330 days, that occurred in July 2003 and May 2004. The 5–100 keV spectrum of IGR J11215–5952 is well described by a cut-off power law, with a photon index of ~0.5, and a cut-off energy ~15–20 keV, typical of High Mass X-ray Binaries hosting a neutron star. A 5–100 keV luminosity of $\sim 3 \times 10^{36}$ erg s^{-1} has been derived (assuming 6.2 kpc, the distance of the likely optical counterpart).

Conclusions. The 5–100 keV spectral properties, the recurrent nature of the outbursts, together with the reduced error region containing the blue supergiant star HD 306414, support the hypothesis that IGR J11215–5952 is a member of the class of the Supergiant Fast X-ray Transients.

Key words. X-rays: stars – X-rays: individuals: IGR J11215–5952

1. Introduction

More than one hundred hard X-ray ($E > 15$ keV) sources have been discovered with the INTEGRAL satellite since its launch in 2002 (see e.g. Bird et al. 2005). About one third of these new sources are associated with High Mass X-ray Binaries (HMXRBs), either thanks to their secure identification at optical/infrared wavelengths with blue supergiants or Be stars, or based on their X-ray properties typical of HMXRBs, like e.g. periodic pulsations or hard X-ray/gamma-ray spectra.

The discovery of several transient sources with Be star companions was not unexpected, since these sources are thought to represent the most abundant class of HMXRBs in the Galaxy. Every new X-ray satellite mission increased the sample of these objects, by detecting outbursts from new sources. More interestingly, INTEGRAL discovered two other kinds of HMXRBs with supergiant companions that escaped detection with previous high-energy satellites: highly absorbed persistent sources, often showing periodic pulsations (e.g., Lutovinov et al. 2005), and recurrent transients characterized by short outbursts lasting only a few hours (e.g. Negueruela et al. 2005a; Sguera et al. 2005).

The transient hard X-ray source IGR J11215–5952 was discovered with the INTEGRAL satellite in April 2005 (Lubinski et al. 2005) and tentatively associated with the supergiant star HD 306414 (Negueruela et al. 2005b). In the course of a systematic re-analysis of all the observations from the INTEGRAL public data archive we discovered two previous outbursts of IGR J11215–5952 which demonstrate the recurrent nature of this transient and hint to a possible periodicity of about 330 days for its outbursts.

2. Observations and results

The ESA INTEGRAL gamma-ray observatory, launched in October 2002, carries three co-aligned coded mask telescopes: the imager IBIS (Ubertini et al. 2003), which allows high angular resolution imaging over a large field of view (29° × 29°) in the energy range 15 keV–10 MeV, the spectrometer SPI (Vedrenne et al. 2003; 20 keV–8 MeV) and the X-ray monitor JEM-X (Lund et al. 2003; 3–35 keV). IBIS is composed of a low-energy CdTe detector (ISGRI; Lebrun et al. 2003), sensitive in the energy range from 15 keV to 1 MeV, and a

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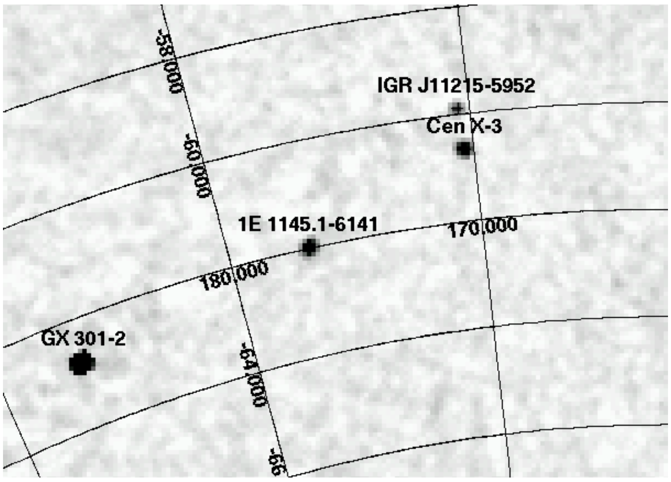

Fig. 1. Section (about 10° × 8°) of the ISGRI mosaic of the two outbursts in the energy range 17–40 keV, with a net exposure time of 42.7 ks. Equatorial coordinates (J2000) are displayed.

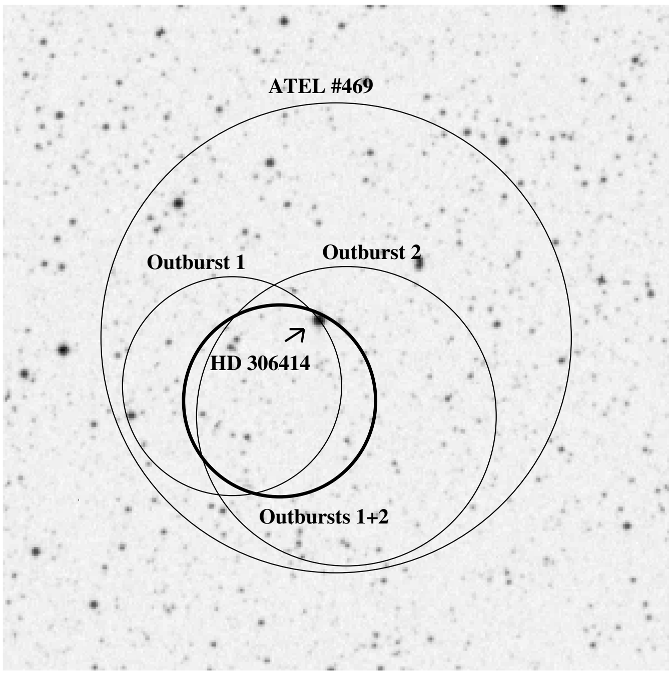

Fig. 2. J-band image of the IGR J11215–5952 field (data taken from UK Schmidt telescope, and provided by the online Digitized Sky Survey, available at `http://heasarc.gsfc.nasa.gov/`). North to the top, East to the left. The large solid circle marks the ISGRI error circle (3′ radius) from the 2005 outburst (Lubinski et al. 2005, ATel 496); the two thin smaller circles indicate the error regions from the analysis of the outbursts occurred in 2003 and 2004. The smaller thick solid circle indicates the error region derived in the mosaic of the two outburst in 2003 and 2004. The arrow indicates HD 306414, the likely optical counterpart (Negueruela et al. 2005).

CsI detector (PICsIT; Labanti et al. 2003), designed for optimal performance at 511 keV, and sensitive in the 175 keV–10 MeV energy range.

The sky region of IGR J11215–5952 was repeatedly observed by INTEGRAL. We analyzed all the public ISGRI observations pointed within 15° of the source, i.e. 850 individual pointings (Science Windows) performed between December 2002 and August 2004, yielding a total exposure time of about 1.8 Ms. We processed all the data using version 5.1 of the OSA INTEGRAL analysis software, with the corresponding response matrices.

IGR J11215–5952 was detected with a significance larger than 5σ in the 17–40 keV range in 17 Science Windows. These detections correspond to two outbursts occurring on 3–4 July 2003 and 26–27 May 2004 (see Table 1). Due to the sparse sampling of the observations, we cannot determine precisely the duration of the outbursts. The lower limits on their duration are ~9 h and about two days for the 2003 and 2004 outbursts, respectively. We can also assess that the duration of both outbursts did not exceed ~7 days.

Combining the Science Windows of the two outbursts in a single mosaic we obtained the image shown in Fig. 1. IGR J11215–5952 is clearly visible at ~45′ from the bright X-ray pulsar Cen X-3. Its coordinates (J2000) are: RA = $11^{\rm h}21^{\rm m}50.8^{\rm s}$, Dec = $-59°52'48.3''$, with a statistical uncertainty of 1.2′. This refined position is consistent with what measured during the April 2005 discovery outburst (Lubinski et al. 2005) and our smaller error region still contains the proposed optical counterpart HD 306414 (Masetti et al. 2006). The different error regions are compared in Fig. 2.

Based on our refined source position, we extracted the ISGRI and JEM-X spectra. The latter were available only for a subset of the Science Windows, due to the smaller field of view of the JEM-X instrument (radius 3.5°).

The source spectra extracted at the peak of the two different outbursts, are plotted in Fig. 3. The 5–100 keV spectrum of July 2003 (Fig. 3, left panel) could not be fitted with a single power law, while a cutoff power law gave an acceptable result (χ^2 = 47.5 for 50 degrees of freedom, d.o.f.), with a photon index of $0.5^{+0.4}_{-0.6}$ and cutoff energy of 15^{+5}_{-4} keV. In Fig. 4 we show the contour plot for the photon index and the cutoff energy in this model. The best fit parameters correspond to fluxes of 6.2×10^{-10} erg cm^{-2} s^{-1} (5–100 keV) and 2.8×10^{-10} erg cm^{-2} s^{-1} (20–60 keV). An equally good fit could be obtained with a thermal bremsstrahlung model with temperature of 26^{+5}_{-4} keV.

The ISGRI spectrum observed during the second outburst (May 2004) is shown in the right hand panel of Fig. 3. The JEM-X spectrum could not be used because the instrument was switched off during one of the Science Windows in which the source was nearly on-axis, while in the other Science Windows the low statistics hampered a meaningful spectral extraction. Due to the lack of JEM-X spectrum, ISGRI spectrum can be fitted with a single power law (χ^2 = 12.9 for 8 d.o.f.) with a photon index of $2.6^{+1.8}_{-0.6}$. The 20–100 keV flux is 2.5×10^{-10} erg cm^{-2} s^{-1} and the 20–60 keV flux is 2.1×10^{-10} erg cm^{-2} s^{-1}.

3. Discussion and conclusions

Using all the available public INTEGRAL data, we have discovered two outbursts and obtained a refined position for the transient hard X-ray source IGR J11215–5952. The new error circle is still consistent with the proposed optical counterpart

Table 1. Summary of the Science Windows with detections of IGR J11215–5952.

Obs ID	IJD (=MJD–51544)	Detection significance[a] σ	ISGRI rate[a] (s^{-1})	Off-axis angle (degrees)
First outburst (3–4 July 2003)				
008800020010	1279.76	6.8	3.6	4.4
008800040010	1279.81	9.3	3.8	4.8
008800060010	1279.87	5.4	3.0	6.5
008800080010	1279.91	6.4	3.3	2.6
008800090010	1279.94	6.0	3.0	3.4
008800120010	1280.01	8.5	4.6	5.1
008800130010	1280.03	9.2	4.9	3.5
008800140010	1280.05	7.3	3.9	2.6
008800150010	1280.07	9.1	4.6	4.5
008800170010	1280.12	8.2	4.7	6.8
008800180010	1280.14	8.2	4.5	4.8
Second outburst (26–27 May 2004)				
019700600010	1608.09	8.7	3.1	1.4
019700610010	1608.13	8.6	3.2	2.4
019700640010	1608.27	5.8	2.9	7.6
019800050010	1609.00	7.0	2.9	6.8
019800070010	1609.08	7.2	3.9	9.5
019800320010	1610.12	5.7	2.2	2.5

[a] In the 17–40 keV energy range.

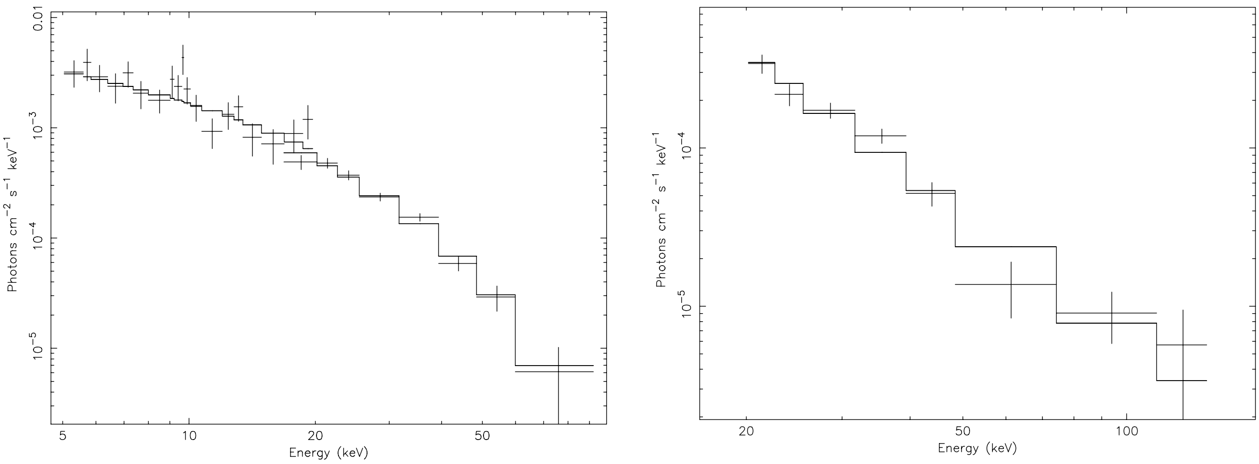

Fig. 3. *Left*: IGR J11215–5952 photon spectrum from the 2003 outburst (JEM-X and ISGRI, 5–100 keV) fit with a cutoff power law. *Right*: IGR J11215–5952 photon spectrum (only ISGRI data, 20–100 keV) from the 2004 outburst, fit with a single power law (see the text for the best fit parameters).

HD 306414, which has been recently studied by Masetti et al. (2006). These authors found evidence for an H_α emission line, confirmed the spectral classification as a B1 Ia-type star and estimated a distance of $d \sim 6.2$ kpc, placing HD 306414 in the Carina spiral arm. Unfortunately, the JEM-X data do not extend to sufficiently low energy to constrain the interstellar absorption and thus give some indication on the distance of the X-ray source.

For the distance of 6.2 kpc, the peak fluxes of the two outbursts reported here correspond to a luminosity of $\sim 3 \times 10^{36}$ erg s^{-1} (5–100 keV). This luminosity, as well as the spectral shape derived with INTEGRAL are typical of High Mass X-ray Binaries containing a neutron star.

The transient nature of the source, the spectral properties observed during the two outbursts, together with the blue supergiant companion, suggest that IGR J11215–5952 is likely a member of the class of Supergiant Fast X-ray Transients (SFXTs; e.g., Smith et al. 2006; Negueruela et al. 2005a). This is a recently recognized class of X-ray binaries with a supergiant companion, similar for what concerns their spectral properties to the persistent X-ray binary pulsars, but characterized by the emission of a significant luminosity only during short X-ray outburst. This behavior is quite surprising since neutron stars accreting from the winds of supergiant companions were, until recently, seen as relatively steady sources. The two newly discovered outbursts from IGR J11215–5952 are

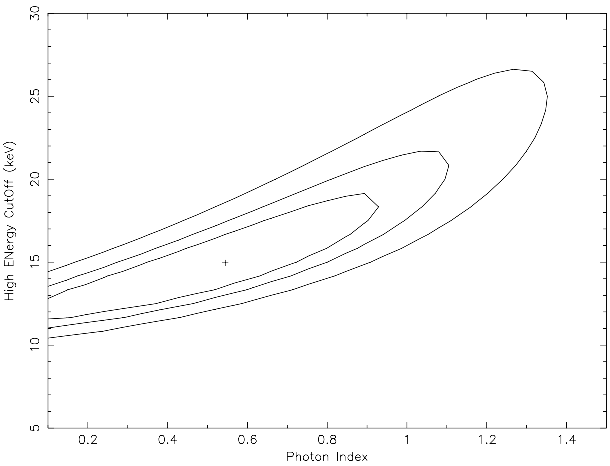

Fig. 4. 68%, 90% and 99% confidence level contours for the photon index and the cutoff energy from the spectral analysis of the emission during the 2003 outburst.

somehow longer than typical outbursts observed to date from other SFXTs (which are shorter than 3 h, Sguera et al. 2005), but are not unusual (see, e.g., the outbursts observed from the SFXT XTE J1739-302, Smith et al. 2006).

The three outbursts observed to date from IGR J11215–5952, the two reported here and the one that led to the source discovery (22 April 2005; data not yet in the public archive), are consistent with a recurrence time of about 330 days[1]. This possible periodicity, if confirmed, is worth noting, since in no other source belonging to the class of SFXTs a periodic behavior has been observed. Indeed, only the recurrent (but not periodic) nature of the outbursts from few members of the class has been observed before (Sguera et al. 2005). The possible ~330 days periodicity could represent the orbital period of the binary system, although such a long period is more typical of Be/X-ray binaries than of Supergiant HMXRB, which, in general, have orbital periods shorter than ~20 days. Negueruela et al. (2005a) suggested that SFXTs have wider orbits than "normal" supergiant persistent HMXRBs (Vela X–1-like systems) and that the compact source accretes from a less dense environment, in order to explain the very low emission level during quiescence in SFXTs (~10^{32}–10^{33} erg s^{-1}). Our possible finding of a long periodic recurrence time of the outbursts could confirm this hypothesis.

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[1] We cannot exclude that the true periodicity is half of this period, because of the lack of INTEGRAL continuous coverage of the source position.