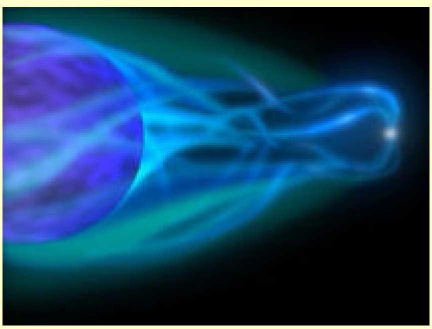
Supergiant Fast X-ray Transients observed by INTEGRAL



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In collaboration with:

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Outline

- Introduction to Supergiant High Mass X-ray Binaries (SGXBs)

- SGXBs in the INTEGRAL era

  New class of SGXBs:

  Supergiant Fast X-ray Transients (SFXTs)

- INTEGRAL results on SFXTs

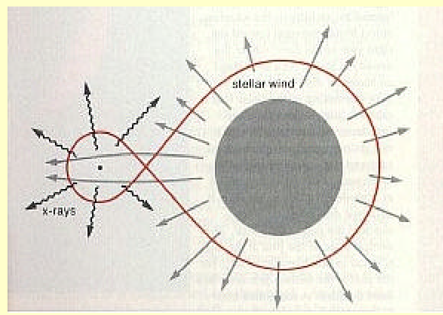
- Summary

SGXBs: main characteristics

• systems composed by an accreting compact object and a **massive supergiant early type (OB)** companion donor star

• X-ray emission powered by accretion:

Stellar wind or Roche lobe overflow



because of the evolutionary timescale involved, up to recently SGXBs were believed to be rare objects, a dozen SGXBs have been discovered in our Galaxy in almost 40 years of X-ray astronomy! (Liu et al. 2000)

SGXBs: main characteristics

- bright **persistent** X-ray sources not strongly absorbed and rather stable in the long run

  X-ray luminosities in the range **10^{36}-10^{38} erg s^{-1}**

- orbital period in the range **1.4-14 days**
- nearly **circular** orbit

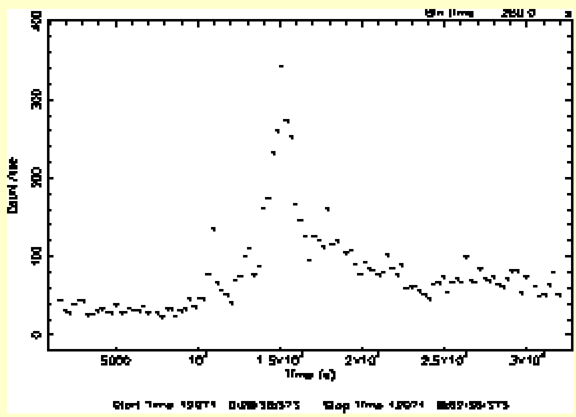
three persistent SGXBs known to undergo fast X-ray flares on few hours timescale
Cygnus X-1 (Golenetskii et al. 2003), **1E 1145.1-6141** (Bodaghee et al. 2004)

Vela X-1 (Krivonos et al. 2003, Staubert et al. 2004, Laurent et al. 1995)

Wind fed persistent **L_x~ $4x10^{36}$ erg s^{-1}**

fast X-ray flares peak **L_x~ $4x10^{37}$ erg s^{-1}**

Fast X-ray flares related to highly structured and inhomogeneous stellar wind



ISGRI light curve 20-30 keV (Nov 2003)

SGXBs in the INTEGRAL era

Since its launch in 2002, in just a few years INTEGRAL doubled the population of SGXBs in our Galaxy! **About 17 newly discovered SGXBs**

About 13 SGXBs are persistent hard X-ray sources which escaped previous detections because of their **strongly obscured nature**, **$N_H = 10^{23}$ cm^{-2}**

population of persistent strongly absorbed SGXBs

(i.e. Walter et al. 2006, Chaty et al. 2006)

The remaining newly discovered SGXBs are not strongly absorbed. They escaped previous detections because of their **fast X-ray transient nature**, a characteristic never seen before from "classical persistent SGXBs"

new class of SGXBs:

Supergiant Fast X-ray Transients, SFXTs

(i.e. Sguera et al. 2005,2006,2007, Negueruela et al. 2005,2006)

......Once upon a time XTE J1739-302

Unusual new X-ray transient discovered by RXTE on Aug 1997 (Smith et al. 1998).

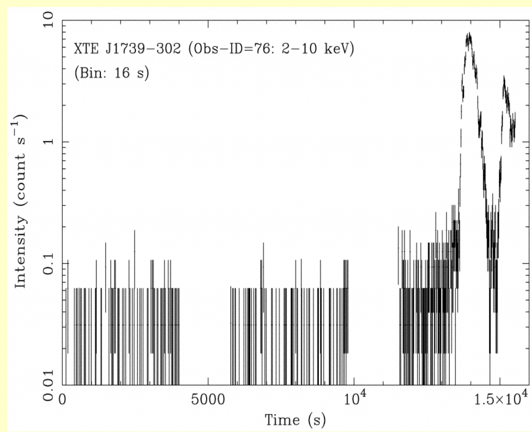
Active only one day, the brightest source in the GC region while active
$\mathbf{F_X \sim 10^{-9}}$ **erg cm^{-2} s^{-1}** , bremsstrahlung kT ~ 21 keV (2-25 keV)

Detected again by ASCA on March 1999

(Sakano et al. 2002)

upper limit $\mathbf{F_X = 9x10^{-13}}$ **erg cm^{-2}** s^{-1} (2-10 keV)
in less than 4 minutes flared up to $\mathbf{F_X \sim 10^{-9}}$ **erg cm^{-2}**

spectrum during the flare is absorbed and hard
G~0.8 $N_H \sim 10^{22}$ cm^{-2}



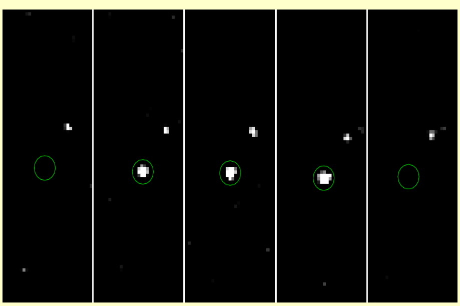
from Sakano et al. 2002

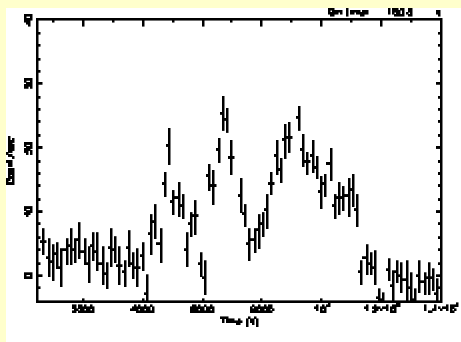
INTEGRAL detections of XTE J1739-302

Table 4.1: Summary of ISGRI observations of outbursts of XTE J1739−302.

No.	Date	duration (hours)	energy band (keV)	flux at the peak (mCrab)	luminosity peak (10^{36} erg s^{-1})	ref
1	22 March 2003	~ 2	20–60	~ 210	~ 1.6	[1]
2	26 August 2003	~ 14	18–60	~ 120		[2]
3	6 September 2003	~ 7	18–60	~ 60		[2]
4	9 March 2004		20–30	~ 280	~ 0.8	[1]
5	10 March 2004	~ 1.5	20–30	~ 250	~ 0.7	[1]
6	21 August 2004		20–60	~ 480	~ 3.5	[1]
7	31 August 2004	~ 6	20–60	~ 210	~ 1.5	[1]

[1] Sguera et al. 2005,2006,2007, [2] Sunyaev et al. 2003, Lutovinov et al. 2005





Sguera et al. 2005

Duration ~ 2 hours **peak flux** 2.5×10^{-9} erg cm^{-2} s^{-1} (20-60 keV)

Broad band 3-80 keV spectrum (JEM-X+ISGRI) G~ 1.2 E_C ~ 18 keV

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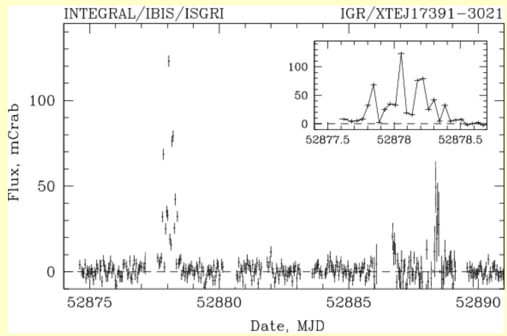
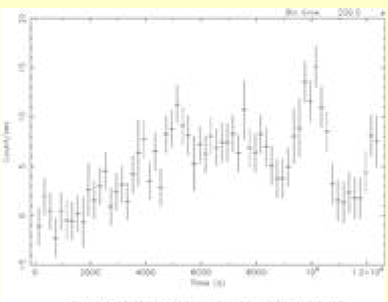


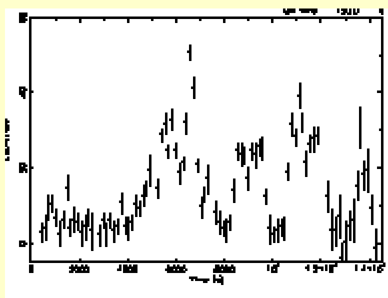
N. 2, N. 3 Lutovinov et al. 2005

18-60 keV ~ 2000 s bin time



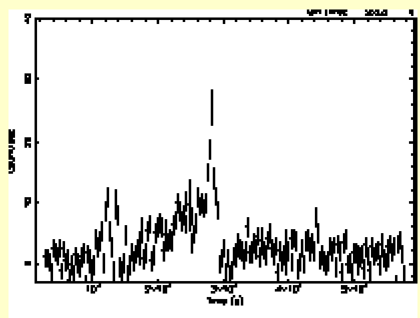
N. 4 Sguera et al. 2005

20-30 keV, 200 s bin time



N. 6 Sguera et al. 2006

20-60 keV, 150 s bin time



N. 7 Sguera et al. 2007

20-60 keV, 300 s bin time

Surprise!! Negueruela et al. (2006) identified the optical counterpart of XTE J1739-302 with a **highly reddened supergiant O8Iab(f) located at ~ 2.3 kpc**

XTE J1739-302 is a SGXB with fast X-ray transient behaviour

Quiescence L_x = 6×10^{32} erg s^{-1} peak $L_x \sim 10^{36}$ erg s^{-1}

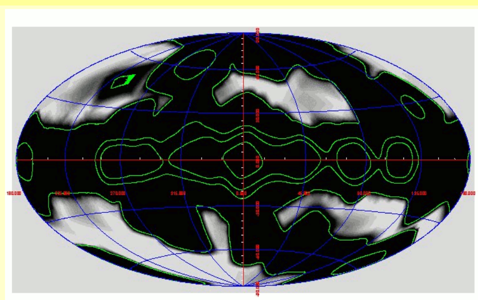
first member of the newly discovered class of Supergiant Fast X-ray Transient, SFXTs (Smith et al. 2006)

INTEGRAL is particularly suited to the detection of SFXTs:

- Large FOV (30° x 30°, full width zero response)
- good sensitivity (2000 s ScW, 20-30 keV, 3s ~ 20 mCrab)
- good angular resolution (~ 12') and PSL accuracy of = 3'
- continuous monitoring of the galactic plane

Best approach to unveil fast X-ray transient events detected by INTEGRAL is to search for on the same timescale as the outbursts themselves i.e Science Window level (~2000 s). Integrating for longer (i.e. days, weeks or months) just degrades the S/N.

Dataset of CP data from rev **46 (Feb 2003)** to rev **429 (Apr 2006)** as well as all available public data. **A total of ~ 20,000 ScWs.**



Contour levels:

10 ks, 500 ks, 1 Ms, 3Ms

To date, in just a few years

8 firm SFXTs reported in the literature

- **4 SFXTs are newly discovered sources by INTEGRAL**

- **The remaining 4 SFXTs were previously discovered by other X-ray satellites** (ASCA, BeppoSAX, RXTE), however INTEGRAL detected several fast outbursts unveiling or strongly confirming their fast X-ray transient nature

Nature of the compact object

Table 6.1: Summary of characteristics of the 8 SFXTs , •=assuming a distance of 10 kpc, ⊙ = 6 kpc

Source	Distance (kpc)	spin rate	N_H (10^{22} cm^{-2})	Lum Quies (10^{32})	No	reference	duration (hours)	lum peak (10^{36})	kT_{BB} (keV)	kT_{BR} (keV)	Γ
XTE J1739−302	~ 2.3		3–38	<5	1	Sguera et al. 2005	~ 2	~ 1.5		22^{+2}_{-3}	
					2	Lutovinov et al. 2005	~ 14	~ 1		~ 22	
					3	Lutovinov et al. 2005	~ 7	~ 0.5			
					4	Sguera et al. 2005		~ 0.8			
					5	Sguera et al. 2005	~ 1.5	~ 0.7			
					6	Sguera et al. 2006		~ 3.5			
					7	Sguera et al. 2007	~ 6	~ 1.5	$6.8^{+0.5}_{-0.5}$	22^{+4}_{-3}	$2.9^{+0.2}_{-0.2}$
IGR J17544−2619	~ 2		1.2–4.3	<2	1	Sunyaev et al. 2001	~ 2	~ 3.2	$4^{+0.2}_{-0.2}$	$9^{+0.8}_{-0.8}$	
					2	Grebenev et al. 2003	~ 8				
					3	Grebenev et al. 2004	~ 10	~ 3	$4.4^{+0.25}_{-0.25}$	$9.5^{+0.9}_{-0.9}$	
					4	Sguera et al. 2006	~ 0.5	~ 0.7	$2.9^{+0.4}_{-0.4}$	5^{+1}_{-1}	
					5	Sguera et al. 2007		~ 1.2			
AX J1841.0−0536		4.7 s	~6		1	Sguera et al. 2006	~ 7	~ 21 •	$8^{+0.9}_{-0.9}$	32^{+12}_{-8}	$2.5^{+0.3}_{-0.3}$
					2	Sguera et al. 2006	~ 1.1	~ 21 •	$9^{+0.9}_{-0.9}$		
					3	Rodriguez et al. 2004	~ 2.8	~ 18.1 •	$7.7^{+0.7}_{-0.6}$	32^{+9}_{-6}	$2.5^{+0.2}_{-0.2}$
					4	Sguera et al. 2007	~ 55	~ 4.5 •	$6.2^{+0.7}_{-0.7}$	19^{+5}_{-4}	$3.1^{+0.4}_{-0.4}$
AX J1845.0−0433	~7		~2	46	1	Sguera et al. 2007		~ 2.8		19^{+15}_{-7}	$2.5^{+0.6}_{-0.5}$
					2	Sguera et al. 2007		~ 3.5	6.2^{+1}_{-2}	21^{+25}_{-29}	$2.9^{+0.9}_{-0.7}$
SAX J1818.6−1703	~ 2		~6	36	1	Grebenev et al. 2005	~ 14	~ 3.6	$7.1^{+0.5}_{-0.5}$	25^{+5}_{-4}	$2.9^{+0.2}_{-0.2}$
					2	Sguera et al. 2005	~ 1	~ 0.7	$6^{+0.8}_{-0.7}$	$17^{+6.5}_{-4.3}$	$3.2^{+0.5}_{-0.5}$
					3	Sguera et al. 2005	~ 3	~ 0.4			
					4	Sguera et al. 2007		~ 0.3 ∗			
IGR J11215−5952	~ 6.2	187 s	~1	<12	1	Sidoli et al. 2006		~ 1.4	$6.2^{+0.6}_{-0.6}$	$19^{+5}_{-3.5}$	$3^{+0.3}_{-0.3}$
					2	Sidoli et al. 2006	~ 72	~ 1.2			$2.6^{+1.8}_{-0.6}$
					3	Lubinski et al. 2005		~ 7		$18^{+3.5}_{-2.5}$	$3.2^{+0.25}_{-0.25}$
IGR J16465−4507		227 s	~60		1	Sguera et al. 2007		~ 1.6 ⊙			
					2	Lutovinov et al. 2004		~ 3 ⊙	$6.6^{+0.7}_{-0.7}$	$21^{+6.5}_{-4.5}$	$3^{+0.3}_{-0.3}$
IGR J08408−4503	~ 2.77		~ 0.1	2	1	Mereghetti et al. 2006	~ 1	~ 0.47	6.5^{+1}_{-1}	23^{+13}_{-7}	$2.5^{+0.5}_{-0.5}$
					2	Gotz et al. 2007	~ 1	~ 1.7			

3 SFXTs are X-ray pulsars:

AXJ 1841.0-0433 is a “fast” X-ray pulsar (few seconds)

IGR J16465-4507 and IGR J11215-5952 are “slow” X-ray pulsars (few hundreds seconds)

No X-ray pulsations for the remaining 5 SFXTs but their **spectra are typical of accreting NS**

Absorption N_H

Table 6.1: Summary of characteristics of the 8 SFXTs , •=assuming a distance of 10 kpc, ⊙ = 6 kpc

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IGR J11215−5952	~ 6.2	187 s	~1	<12	1	Sidoli et al. 2006		~ 1.4	$6.2^{+0.6}_{-0.6}$	$19^{+5}_{-3.5}$	$3^{+0.3}_{-0.3}$
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Some SFXTs are **not intrinsically absorbed**, their N_H is compatible within 2s with the galactic N_H (IGR J08408-4503, IGRJ11215-5952, AX J1845.0-0433,)

Some SFXTs are **intrinsically absorbed** but their N_H is usually no greater than 10^{23} cm^{-2} (IGR J16465-4507, SAX J1818.6-1703, XTE J1739-302, AX J1841.0-0536)

XTE J1739-302 and IGR J17544-2619, evidences of variable absorption

Quiescent luminosity

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Quiescent X-ray luminosities, as measured by **XMM, Chandra or Swift/XRT**, have values or upper limits in the range **10^{32}-10^{33} erg s^{-1}**

The quiescent emission from SFXTs is not well characterized yet!

different levels of quiescence?

XTE J1739-302 was not detected by ASCA, upper limit **L_x = 6x10^{32} erg s^{-1}** (Sakano et al. 2002) but it was detected by Chandra with **L_x ~ 10^{34} erg s^{-1}** , very hard spectrum G= -0.6 (Smith et al. 2006)

AXJ 1841.0-0536 was detected by Chandra (G= 1.3±0.3, Halpern et al. 2004) with **L_x ~ 10^{34} erg s^{-1}** assuming distance of 10 kpc (Bamba et al. 2001)

IGR J17544-2619 was not detected by XMM, upper limit **L_x = 2x10^{32} erg s^{-1}** (Gonzalez-Riestra et al. 2004) but it was detected by Chandra at **L_x ~ 5x10^{32} erg s^{-1}** and very soft spectrum G= 5.9±1 (in't Zand 2005)

A complete monitoring of the quiescent emission from SFXTs is strongly needed to fully characterize it

Number of fast outbursts detected by INTEGRAL

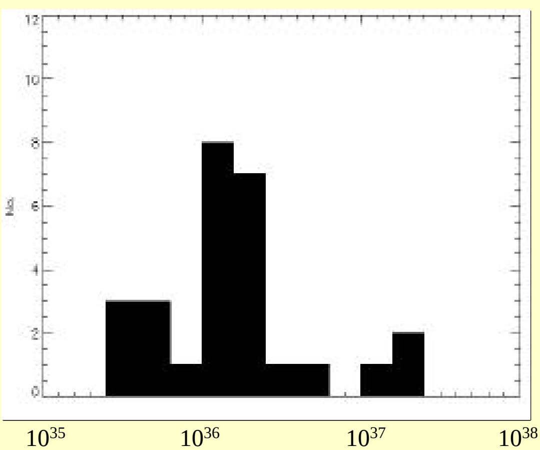
XTE J1739-302	7 outbursts	~ 5 Ms
IGR J17544-2619	5 outbursts	~ 5 Ms
SAX J1818.6-1703	4 outbursts	~ 2.5 Ms
AX J1841.0-0535	4 outbursts	~ 1.7 Ms
IGR J11215-5952	3 outbursts	~ 1.4 Ms
IGR J16465-4507	2 outbursts	~ 1.9 Ms
AX J1845.0-0435	2 outbursts	~ 1.8 Ms
IGR J08408-4503	2 outbursts	~ 1.6 Ms

short duty cycles, outbursts are relatively rare occurrences

Peak luminosities

Table 6.1: Summary of characteristics of the 8 SFXTs , •=assuming a distance of 10 kpc, ⊙ = 6 kpc

Source	Distance (kpc)	spin rate	N_H 10^{22} cm^{-2}	Lum Quies (10^{32})	No	reference	duration (hours)	lum peak (10^{36})	kT_{BB} (keV)	kT_{BR} (keV)	Γ
XTE J1739−302	~ 2.3		3–38	<5	1	Sguera et al. 2005	~ 2	~ 1.5		22^{+2}_{-3}	
					2	Lutovinov et al. 2005	~ 14	~ 1		~ 22	
					3	Lutovinov et al. 2005	~ 7	~ 0.5			
					4	Sguera et al. 2005		~ 0.8			
					5	Sguera et al. 2005	~ 1.5	~ 0.7			
					6	Sguera et al. 2006		~ 3.5			
					7	Sguera et al. 2007	~ 6	~ 1.5	$6.8^{+0.5}_{-0.5}$	22^{+4}_{-3}	$2.9^{+0.2}_{-0.2}$
IGR J17544−2619	~ 2		1.2–4.3	<2	1	Sunyaev et al. 2001	~ 2	~ 3.2	$4^{+0.2}_{-0.2}$	$9^{+0.8}_{-0.8}$	
					2	Grebenev et al. 2003	~ 8				
					3	Grebenev et al. 2004	~ 10	~ 3	$4.4^{+0.25}_{-0.25}$	$9.5^{+0.9}_{-0.9}$	
					4	Sguera et al. 2006	~ 0.5	~ 0.7	$2.9^{+0.4}_{-0.4}$	5^{+1}_{-1}	
					5	Sguera et al. 2007		~ 1.2			
AX J1841.0−0536		4.7 s	~6		1	Sguera et al. 2006	~ 7	~ 21 •	$8^{+0.9}_{-0.9}$	32^{+12}_{-8}	$2.5^{+0.3}_{-0.3}$
					2	Sguera et al. 2006	~ 1.1	~ 21 •	$9^{+0.9}_{-0.9}$		
					3	Rodriguez et al. 2004	~ 2.8	~ 18.1 •	$7.7^{+0.7}_{-0.6}$	32^{+9}_{-6}	$2.5^{+0.2}_{-0.2}$
					4	Sguera et al. 2007	~ 55	~ 4.5 •	$6.2^{+0.7}_{-0.7}$	19^{+5}_{-4}	$3.1^{+0.4}_{-0.4}$
AX J1845.0−0433	~7		~2	46	1	Sguera et al. 2007		~ 2.8		19^{+15}_{-7}	$2.5^{+0.6}_{-0.5}$
					2	Sguera et al. 2007		~ 3.5	6.2^{+1}_{-2}	21^{+25}_{-29}	$2.9^{+0.9}_{-0.7}$
SAX J1818.6−1703	~ 2		~6	36	1	Grebenev et al. 2005	~ 14	~ 3.6	$7.1^{+0.5}_{-0.5}$	25^{+5}_{-4}	$2.9^{+0.2}_{-0.2}$
					2	Sguera et al. 2005	~ 1	~ 0.7	$6^{+0.8}_{-0.7}$	$17^{+6.5}_{-4.3}$	$3.2^{+0.5}_{-0.5}$
					3	Sguera et al. 2005	~ 3	~ 0.4			
					4	Sguera et al. 2007		~ 0.3 *			
IGR J11215−5952	~ 6.2	187 s	~1	<12	1	Sidoli et al. 2006		~ 1.4	$6.2^{+0.6}_{-0.6}$	$19^{+5}_{-3.5}$	$3^{+0.3}_{-0.3}$
					2	Sidoli et al. 2006	~ 72	~ 1.2			$2.6^{+1.8}_{-0.6}$
					3	Lubinski et al. 2005		~ 7		$18^{+3.5}_{-2.5}$	$3.2^{+0.25}_{-0.25}$
IGR J16465−4507		227 s	~60		1	Sguera et al. 2007		~ 1.6 ⊙			
					2	Lutovinov et al. 2004		~ 3 ⊙	$6.6^{+0.7}_{-0.7}$	$21^{+6.5}_{-4.5}$	$3^{+0.3}_{-0.3}$
IGR J08408−4503	~ 2.77		~ 0.1	2	1	Mereghetti et al. 2006	~ 1	~ 0.47	6.5^{+1}_{-1}	23^{+13}_{-7}	$2.5^{+0.5}_{-0.5}$
					2	Gotz et al. 2007	~ 1	~ 1.7			



Peak luminosity typically in the range **10^{36}-10^{37} erg s^{-1}**

SFXTs are therefore characterized by typical **luminosity ratio** **L_{MAX}/L_{MIN} ~10^3-10^4**

Duration of fast outbursts

Table 6.1: Summary of characteristics of the 8 SFXTs , •=assuming a distance of 10 kpc, ⊙ = 6 kpc

Source	Distance (kpc)	spin rate	N_H 10^{22} cm^{-2}	Lum Quies (10^{32})	No	reference	duration (hours)	Lum peak (10^{36})	kT_{BB} (keV)	kT_{BR} (keV)	Γ
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					4	Sguera et al. 2005		~ 0.8			
					5	Sguera et al. 2005	~ 1.5	~ 0.7			
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					7	Sguera et al. 2007	~ 6	~ 1.5	$6.8^{+0.5}_{-0.5}$	22^{+4}_{-3}	$2.9^{+0.2}_{-0.2}$
IGR J17544−2619	~ 2		1.2–4.3	<2	1	Sunyaev et al. 2001	~ 2	~ 3.2	$4^{+0.2}_{-0.2}$	$9^{+0.8}_{-0.8}$	
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					3	Grebenev et al. 2004	~ 10	~ 3	$4.4^{+0.25}_{-0.25}$	$9.5^{+0.9}_{-0.9}$	
					4	Sguera et al. 2006	~ 0.5	~ 0.7	$2.9^{+0.4}_{-0.4}$	5^{+1}_{-1}	
					5	Sguera et al. 2007		~ 1.2			
AX J1841.0−0536		4.7 s	~6		1	Sguera et al. 2006	~ 7	~ 21 •	$8^{+0.9}_{-0.9}$	32^{+12}_{-8}	$2.5^{+0.3}_{-0.3}$
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					4	Sguera et al. 2007	~ 55	~ 4.5 •	$6.2^{+0.7}_{-0.7}$	19^{+5}_{-4}	$3.1^{+0.4}_{-0.4}$
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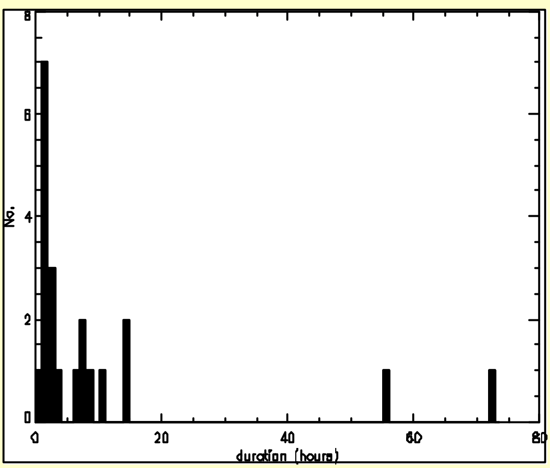
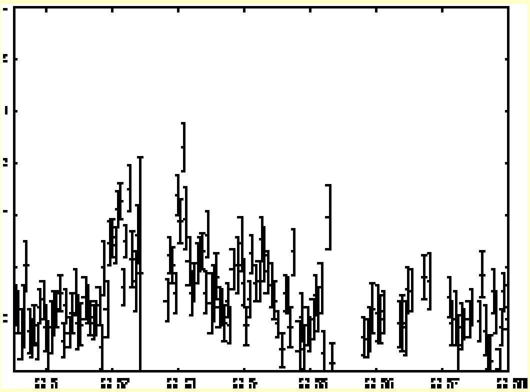
					2	Sguera et al. 2007		~ 3.5	6.2^{+1}_{-2}	21^{+25}_{-29}	$2.9^{+0.9}_{-0.7}$
SAX J1818.6−1703	~ 2		~6	36	1	Grebenev et al. 2005	~ 14	~ 3.6	$7.1^{+0.5}_{-0.5}$	25^{+5}_{-4}	$2.9^{+0.2}_{-0.2}$
					2	Sguera et al. 2005	~ 1	~ 0.7	$6^{+0.8}_{-0.7}$	$17^{+6.5}_{-4.3}$	$3.2^{+0.5}_{-0.5}$
					3	Sguera et al. 2005	~ 3	~ 0.4			
					4	Sguera et al. 2007		~ 0.3 *			
IGR J11215−5952	~ 6.2	187 s	~1	<12	1	Sidoli et al. 2006		~ 1.4	$6.2^{+0.6}_{-0.6}$	$19^{+5}_{-3.5}$	$3^{+0.3}_{-0.3}$
					2	Sidoli et al. 2006	~ 72	~ 1.2			$2.6^{+1.8}_{-0.6}$
					3	Lubinski et al. 2005		~ 7		$18^{+3.5}_{-2.5}$	$3.2^{+0.25}_{-0.25}$
IGR J16465−4507		227 s	~60		1	Sguera et al. 2007		~ 1.6 ⊙			
					2	Lutovinov et al. 2004		~ 3 ⊙	$6.6^{+0.7}_{-0.7}$	$21^{+6.5}_{-4.5}$	$3^{+0.3}_{-0.3}$
IGR J08408−4503	~ 2.77		~ 0.1	2	1	Mereghetti et al. 2006	~ 1	~ 0.47	6.5^{+1}_{-1}	23^{+13}_{-7}	$2.5^{+0.5}_{-0.5}$
					2	Gotz et al. 2007	~ 1	~ 1.7			



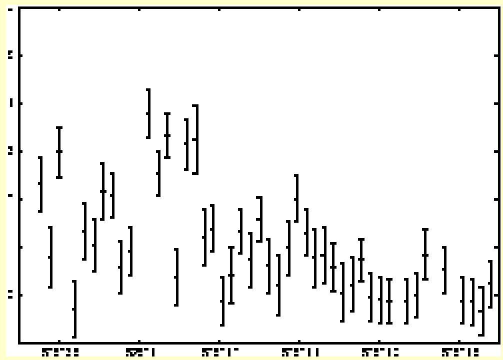
Duration less than a day
typically in the range **0.5-15 hours**

Only two outbursts **longer than a day**
~55 hours, AX J1841.0-0536
~72 hours, IGR J11215-5952

IGR J11215-5952



July 2003, 2000 s bin time, 20-40 kev,
duration ~ 3 days



May 2004, 2000 s bin time 20-40 kev,
lower limit ~ 1 day

All fast outbursts detected by INTEGRAL, RXTE or Swift/XRT lasted few days

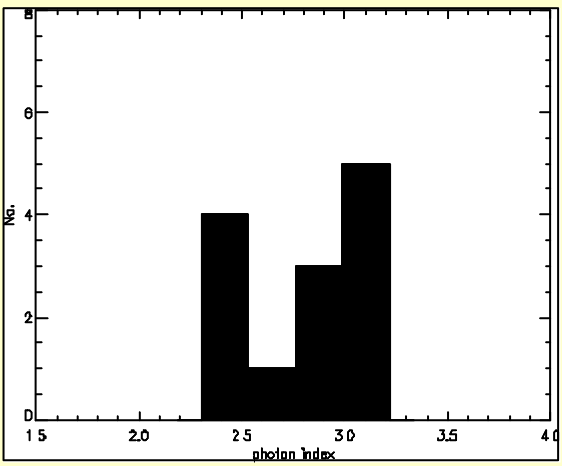
This is a key system, to date **it is the only periodic SFXT**

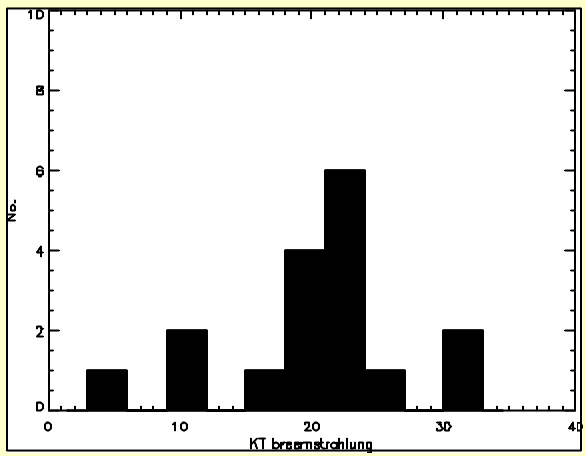
likely orbital period ~ 330 days (Sidoli et al. 2006)

it was possible to plan and perform for the first time a complete monitoring
from quiescence to outburst of a SFXT (Romano et al. 2006,Sidoli et al. 2007)

ISGRI spectra from fast outbursts

Black body, **bremsstrahlung** and **power law** describe the ISGRI spectra with comparable goodness of fit



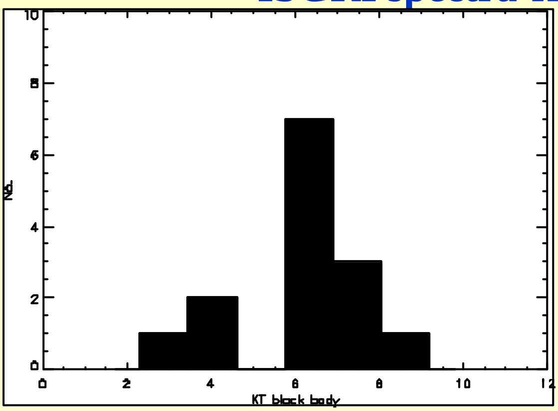


Steep power law, G = 2.3 -- 3.2

Breemstrahlung kT = 5 – 32 keV

(2/3 in the range 20-25 keV)

ISGRI spectra from fast outbursts

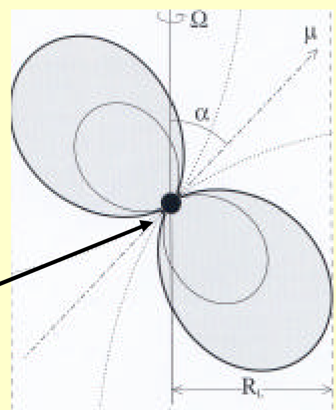


kT = 3 – 9 keV (2/3 in the range 6-8 keV)

radius or the emitting black body regions.

R_{bb} = 0.1- 0.55 Km

Too small for the radiation to be interpreted as emitted from the whole surface of a NS



Physical explanations

We do not know so far the physical mechanisms that produce the fast outbursts.

• <u>fast outbursts related to the supergiant donor star and not to the compact object</u>

• **clumpy winds?** (in't Zand et al 2005)

increasing evidences (based on optical,UV, hard X-ray) suggesting clumpy nature
of the wind of supergiant OB stars (Leyder et al. 2007, Prinja et al. 2005, Owocki et al. 1997)

• **wide eccentric orbit?** (Negueruela et al. 2005)

orbital period several tens of days? orbit size several tens of R_*?

To date, no reported periodicity for all but one SFXT, IGR J11215-5952 (Sidoli et al. 2006)

The answers will be given by knowing the system geometry of SFXTs as well as by better knowing the clumpy nature of the stellar wind

Candidate SFXTs

Unidentified X-ray sources with fast X-ray transient behaviour strongly resemblig that of firm SFXTs

IGR J16479-4514 — **2MASS – USNO-B1.0**

IGR J18483-0311 — **2MASS – USNO-B1.0**

XTE J1901+014 — **2MASS – USNO-B1.0**

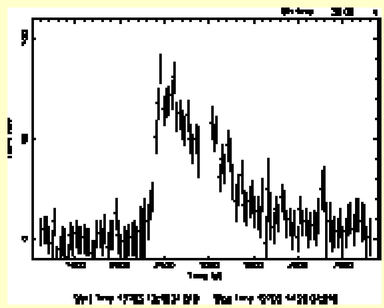
AX J1749.1-2733 — **2MASS**

IGR J16418-4532 — **2MASS**

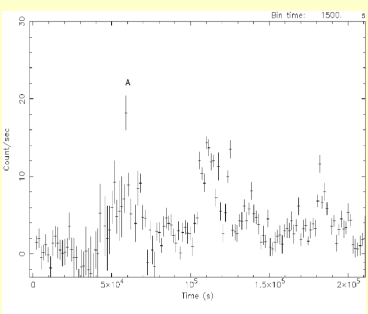
IGR J17407-2808

IGR J16195-4945

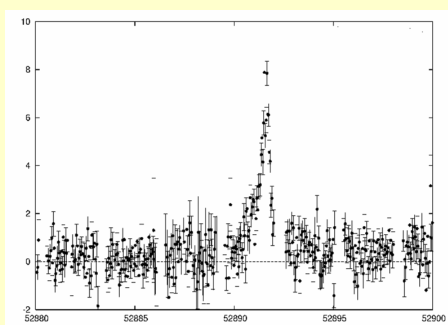
XTE J1743-363



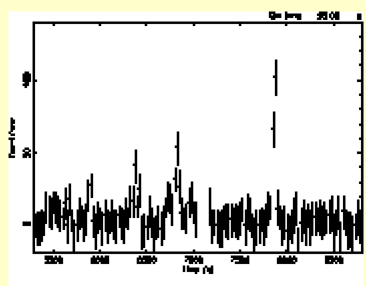
IGR J16479-4514



IGR J18483-0311



AX J1749.1-2733

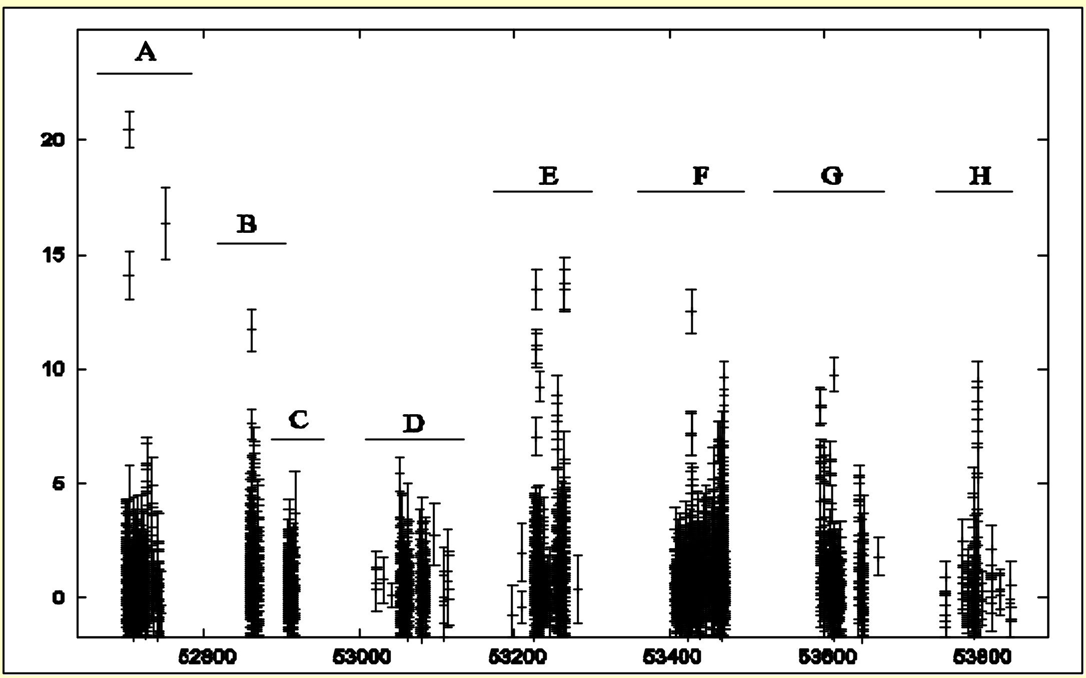


IGR J17407-2808

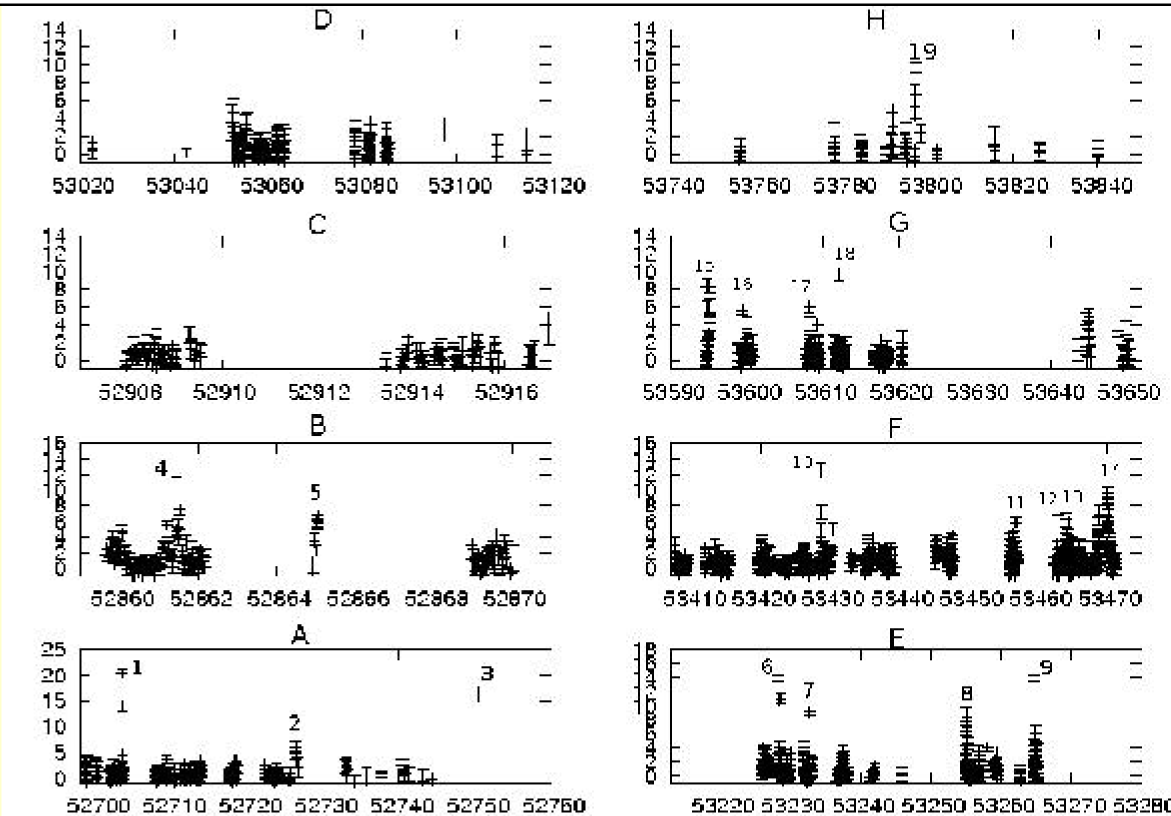
IGR J16479-4514, the 9th SFXT

Optical counterpart recently identified as supergiant **(Chaty 2007,astroph 0710.0292)**

SFXT with the highest duty cycle **(Sguera et al. 2007, submitted)**



ISGRI light curve (18-60 keV) from Feb 2003 to Apr 2006 **bin time 2000 s**



19 fast x-ray flares peak flux greater than 30 mCrab or 2.5×10^{-9} erg cm^{-2} s^{-1} (18-60 keV)

Typical peak L_X $10^{36} - 10^{37}$ erg s^{-1} Duration typically few hours, rarely few days

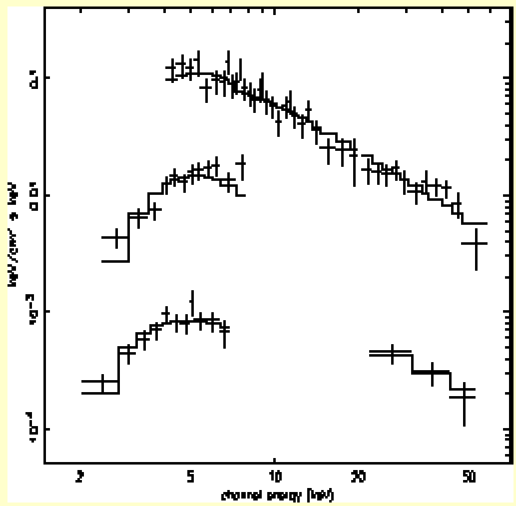
From archival data, **Swift/XRT** detected the **quiescent emission** of the source at a level of ~ **10^{34} erg s^{-1}** (2-7 keV)

Sguera et al. 2007,submitted

INTEGRAL also detected the **quiescent emission** at a level of ~ **$7x10^{34}$ erg s^{-1}** (20-60 keV)

Broad band spectrum during a fast flare
Swift/XRT+JEM-X+ISGRI (1-60 keV)
absorbed power law **G=2.5±0.2**

Broad band quiescent spectrum 2-60 kev
absorbed power law **G=2.1±0.7**



All ISGRI spectra from 19 fast X-ray flares are well fit by:
power law with **G=2-3**.
black body with **kT=6.5 -9.5**

Is there a continuum of behaviours between classical SGXBs and SFXTs?

Classical persistent SGXBs — **persistent emission** $L_X = 10^{36} - 10^{38}$ erg s^{-1}

three are know to display fast X-ray flares

i.e. Vela X-1 peak $L_X \sim 10^{37}$ erg s^{-1}

transition objects SFXTs like IGR J16479-4514 — **quiescent emission** $L_X \sim 10^{34}$ erg s^{-1}

fast X-ray flares peak $L_X = 10^{36} - 10^{37}$ erg s^{-1}

Other possible transition objects:
XTE J1743-363 (Sguera et al. 2006), IGR J16418-4532 (Sguera et a. 206, Walter et al. 2006), IGR J16195-4945 (Sguera et al. 2006, Tomsick et al. 2006)

SFXTs — **quiescent emission** $L_X = 10^{32} - 10^{33}$ erg s^{-1}

fast X-ray flares peak $L_X = 10^{36} - 10^{37}$ erg s^{-1}

Summary and conclusions

- in just a few years, **INTEGRAL doubled the population of SGXBs** in our Galaxy, in particular INTEGRAL is playing a key role in unveiling a new class of SGXBs lebelled as **Supergiant Fast X-ray Transients**

- To date **8 SFXTs reported** in just a few years, their number is increasing steadly. In addition there are **several candidate SFXTs**, optical and infrared observations are strongly needed to confirm or exclude their SFXT nature

- SFXTs spend most of the time in **quiescence ($L_x \sim 10^{32}$-10^{33} erg s^{-1})**, **short duty cycle** (outbursts are rare occurances), **peak $L_x \sim 10^{36}$-10^{37} erg s^{-1}**, typical duration **few hours** rarely even **a few days**. It seems there is a **continuum of behaviours** between classical persistent SGXBs and SFXTs

- We do not know the physical reasons behind the fast X-ray transient behaviour. The answer will be given by knowing the **system geometry (orbital period, size orbit, eccentricity)** as well as by probing the clumpy nature of the stellar wind. To this aim multiwavelength observations (optical,infrared,soft X-rays, hard X-rays) are strongly needed!