A Mini-Survey of Highly-Absorbed X-ray Binaries

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Results from:
Smith et al. 2008, PASJ, 60S, 43
Morris et al., arXiv:0808.3141v1

Introduction

- INTEGRAL has discovered a new class of object – highly absorbed ($N_H > 10^{23}$ cm^{-2}) Galactic sources.
- Most/all are HMXBs, but surprisingly the optical/UV extinction is 10-100x less than the X-ray absorption would suggest.
- Suzaku observations of 5 sources; three known from INTEGRAL and two Swift BAT sources.

The Observations

The Swift sources were chosen based on their flux, lack of ID,and position in the Galactic plane

Source	N_H 10^{22} cm^{-2}	Γ	E_{cut} keV	Flux[a] erg/cm^2/s
IGRJ16465-4507	72 ± 6	1.0 ± 0.5	30	1.1e-10
SWIFTJ2000.6+3210	*10*	1.85	N/A	1.6e-11
SWIFTJ1010.1-5747	*10*	2.75	N/A	1.6e-11
IGRJ16493-4348	~ 10	1.4	N/A	3.8e-11[b]
IGRJ16195-4945	14 ± 4	1.3 ± 1.1	31 ± 8	2.4e-11

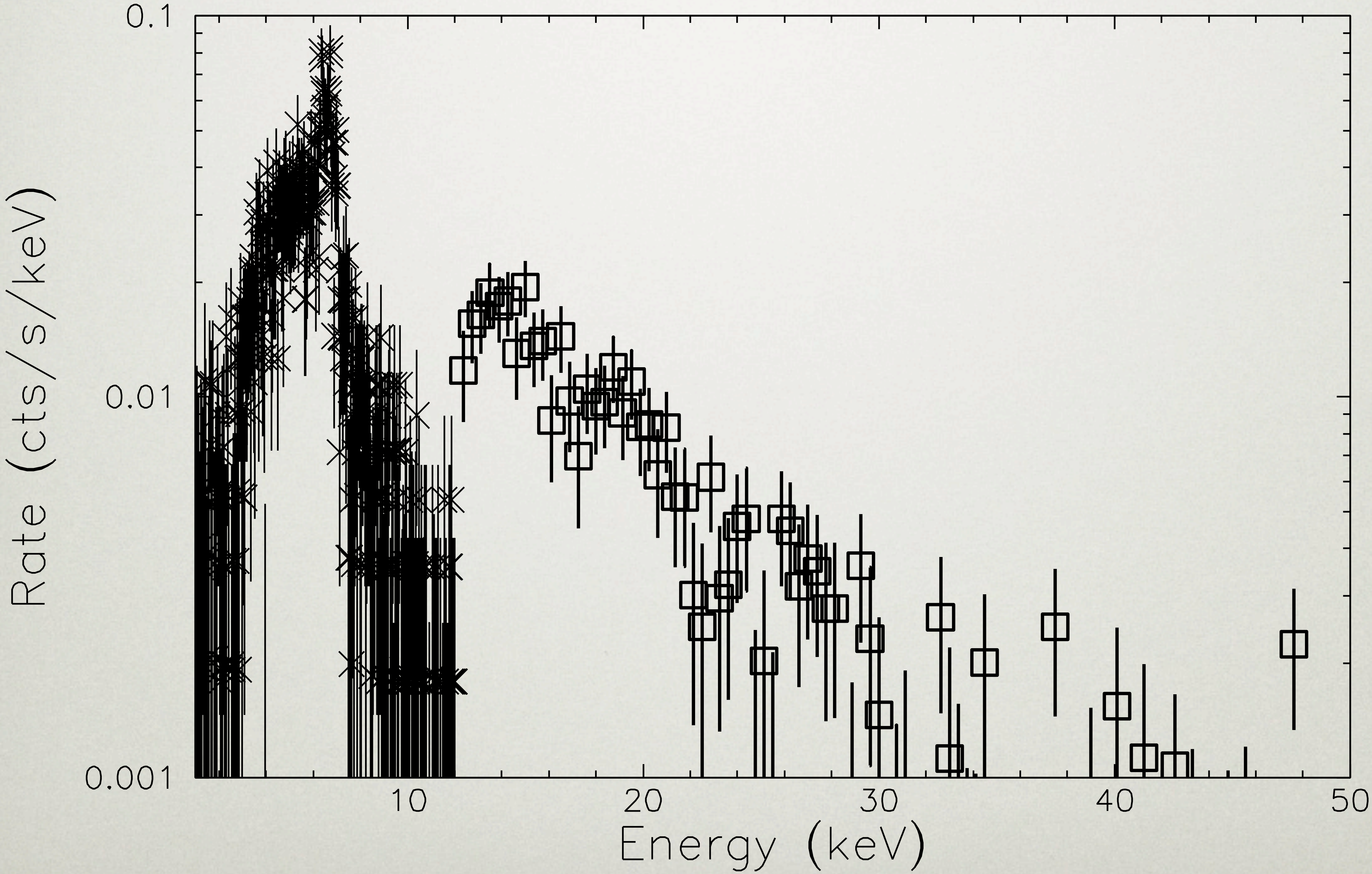
Table 2: Spectral parameters of Sources to be Observed

[a] Between 20-60 keV

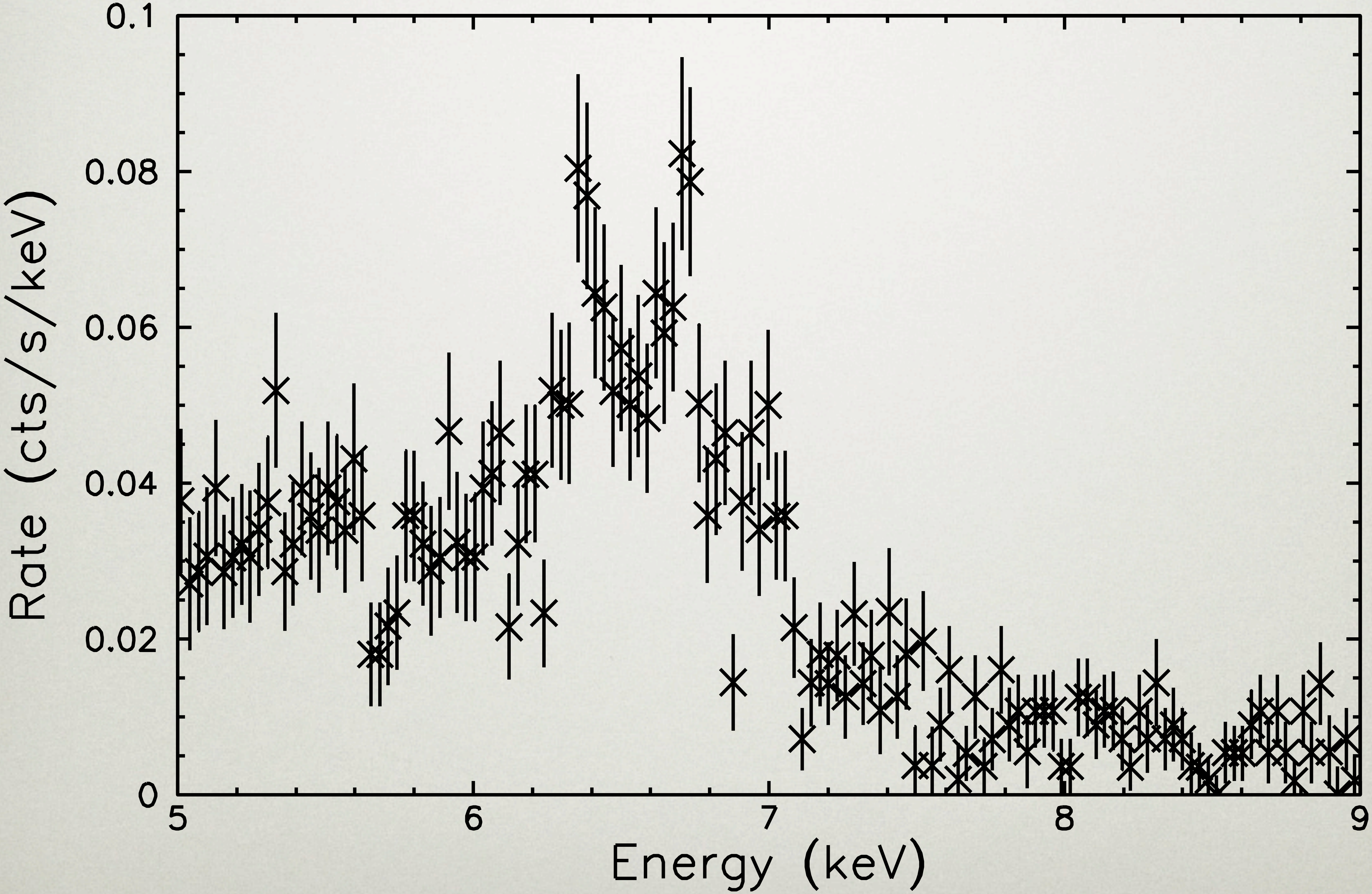
[b] Likely an upper limit due to Galactic plane emission.

We requested 20 ksec on the first four sources and 40 ksec on the last in an attempt to significantly improve on existing Chandra data and search for any periodicities.

Surprise! SwiftJ1010.1-5747



Surprise! SwiftJ1010.1-5747



SwiftJ1010.1-5747, aka The Symbiotic SS73 17

- SS73 17 was first listed as an "interesting" star in the Sanduleak & Stephenson (1973; SS73) catalog, listed as a M3ep + OB binary system. Henize (1976) noted the star shows Balmer lines in emission. Pereira et al. (2003) obstained spectra from a number of SS73 stars, and identified #17 as a Mira-type system, including a normal-type M4 giant star.
- SS73 17 **saturates the Swift UVOT**, with UVW1 magnitude > 11.3±1.09.
- Distance (estimated) is 500 (+500, -250) pc
- Suzaku saw a highly-absorbed X-ray spectrum ($N_H > 10^{23}$ cm^{-2}), equivalent to $A_V > 26$, ***although the source has B magnitude 11.3.***

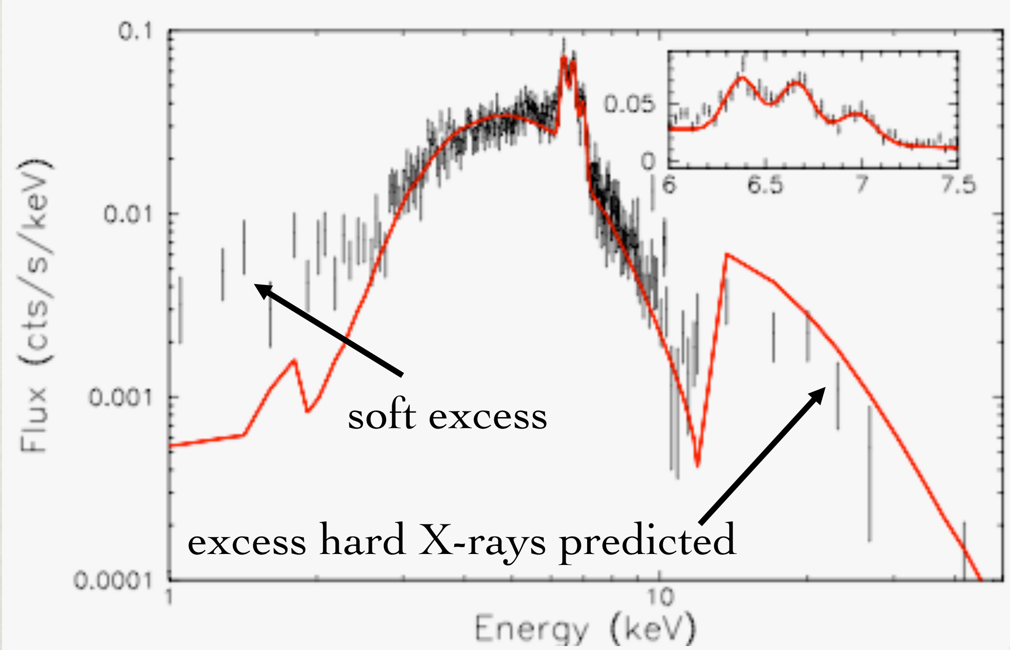
Symbiotic Spectra of SS73 17

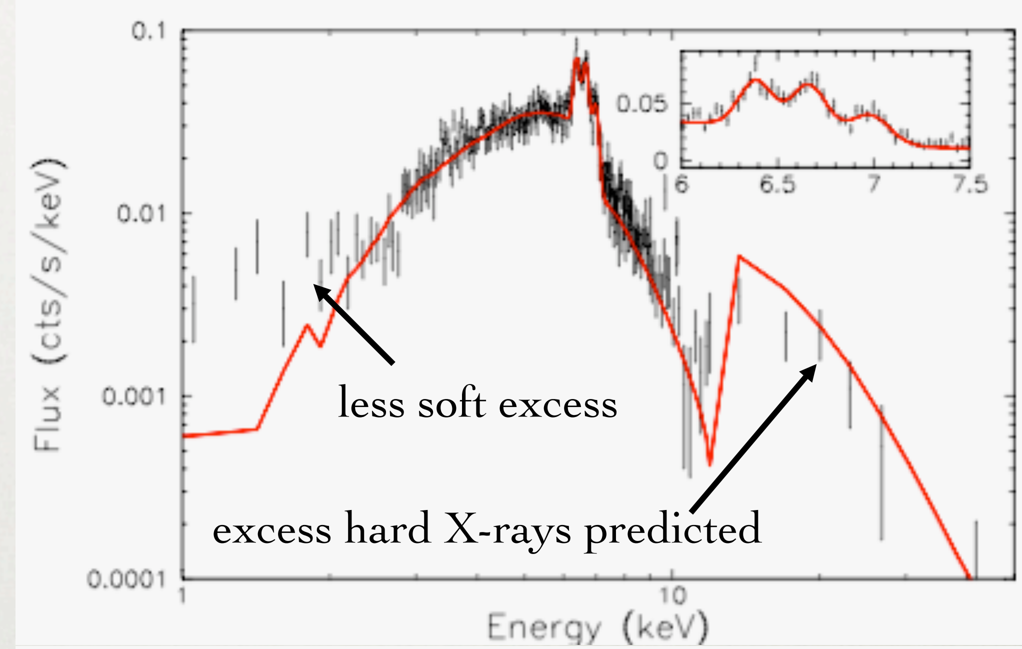
Spectra of SS73 17 from Suzaku XIS (all 4 coadded) with HXD/PIN background-subtracted spectra between 1-50 keV
The inset spectrum shows the 6-8 keV range where the iron lines appear.

Single Total Absorber Models

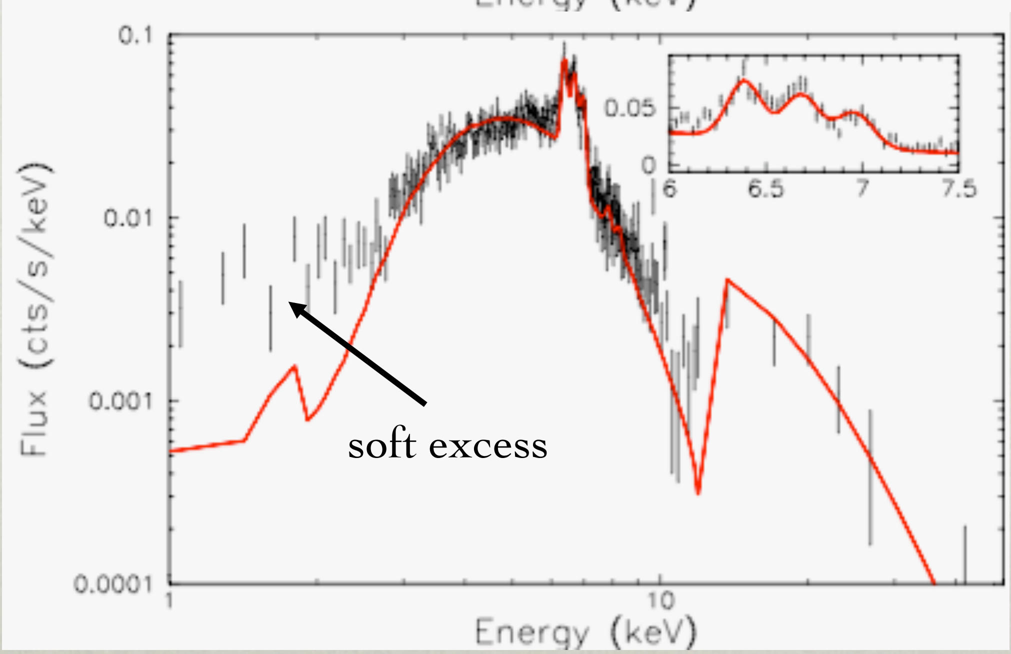
Total Absorber plus Partial Covering Models

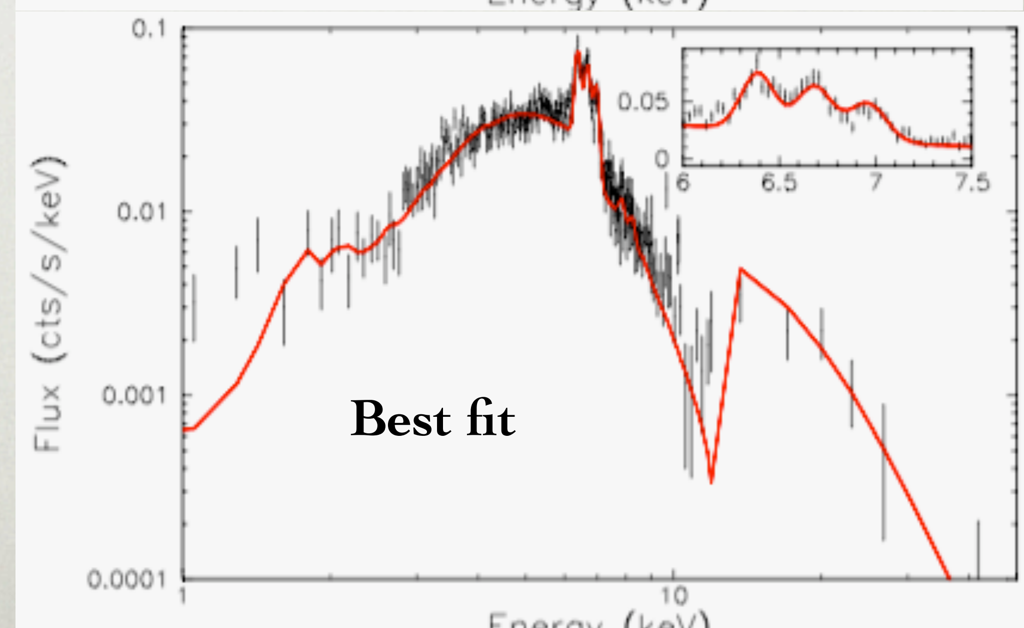
Power Law Plus Three Gaussians





Thermal APEC Model Plus One Gaussian





Understanding the Spectra

- Fe XXV and Fe XXVI lines *in thermal models* are from the hot plasma
- **We cannot distinguish (statistically) between the power-law and thermal models after including a partial absorber.** The weak soft X-ray emission is much better fit with the thermal model. Between 3-5 keV the power-law model provides a better description.
- **Physically, the thermal model is the most realistic, since it naturally explains all three iron lines.** The thermal emission could arise from an accretion column falling from the accretion disk onto the surface of the white dwarf. This column is likely to have a range of temperatures peaking around our single-temperature value (Ezuka 1999); including these could improve the 3-5 keV fit, although more complex models are not justified by the existing data.
- In similar systems, such as the symbiotic CH Cyg, the thermal origin of the plasma is confirmed by multiple emission lines from ions such as Mg, Si, and S at lower energies than the iron features. **The strong absorption seen here obscures these lines; a longer or higher resolution observation is needed to determine if in fact they are present.**

Understanding The Spectra

Fe Kα line must be generated by fluorescence

- Ezuka & Ishida (1999) showed that an 10 keV bremsstrahlung source embedded in an absorber will generate (due to absorption and fluorescence into the line of sight) a predicted equivalent width of the Fe K line of 0.67 ($N_H/10^{24}$)cm^{-2} keV. For the absorbed partial covering thermal source, we get EqW(Fe K)= 0.13 keV.
- Fluorescence due to reflection from the surface of the (assumed) white dwarf generates an additional EqW(Fe K) ~ 0.1 keV (George & Fabian 1991).
- Actual value of EqW(Fe K) = 0.26 (+0.06, -0.04) keV.
- This assumes that the reflected emission line is not absorbed before escaping, making this result an upper limit. The continuum around 6.4 keV is at least partially reflected, so our spectral models (which do not include reflection) are incomplete.

What About The Other Four Sources?

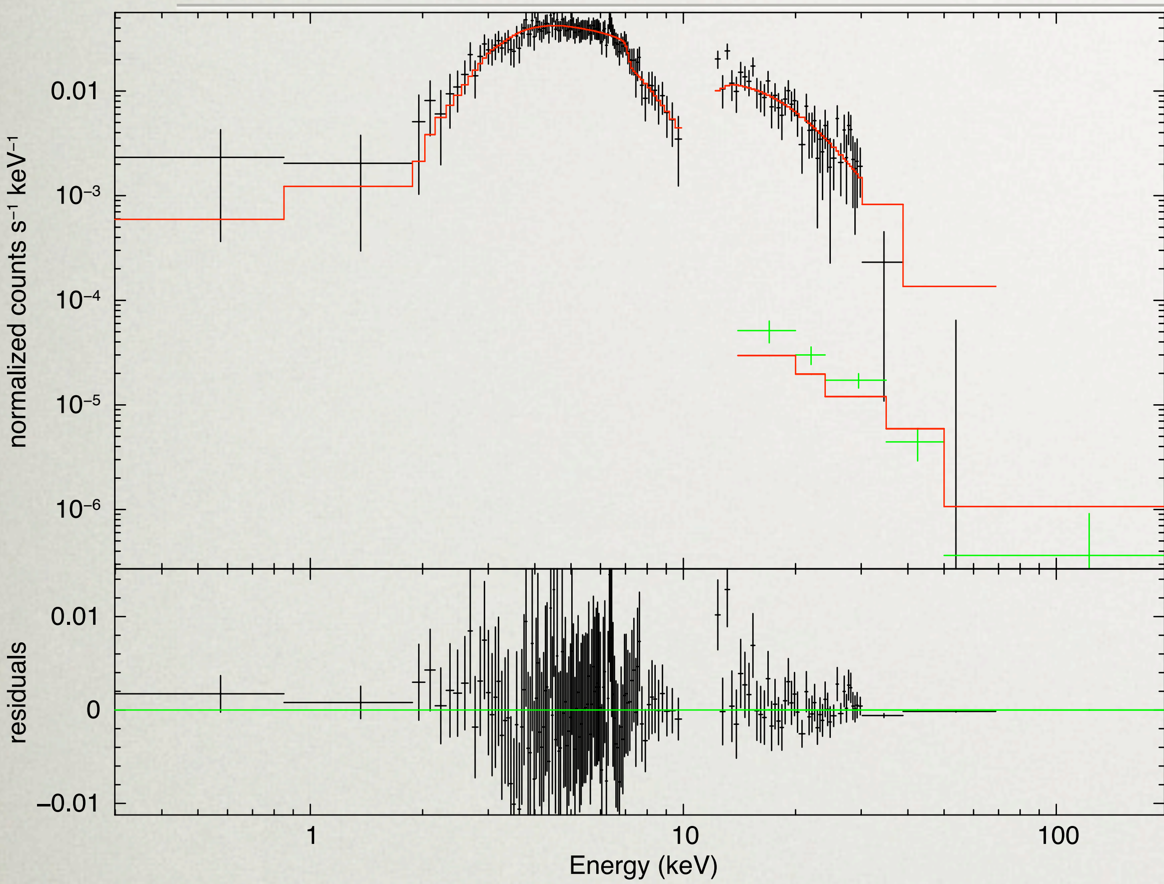
Spectral Fits

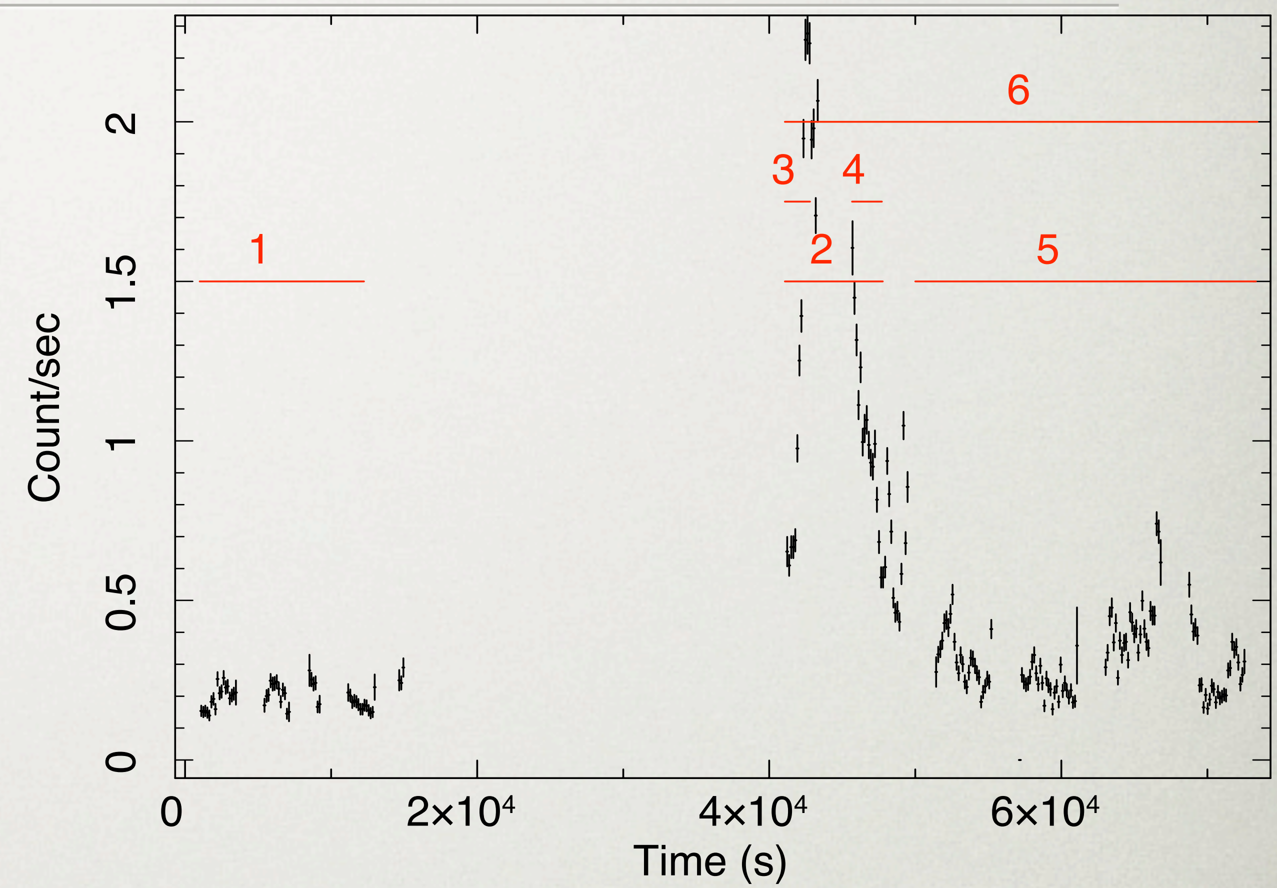
Source	N_H $(10^{22}\mathrm{cm}^{-2})$[a]	$N_{H\ part}$ $(10^{22}\mathrm{cm}^{-2})$[b]	PCF [c]	Γ [d]	Flux $(10^{-12}\ \frac{\mathrm{ergs}}{\mathrm{cm}^2\ \mathrm{s}})$[e]	Fe EW eV	$\chi^2_{\nu_{PC}}$ [f]	$\chi^2_{\nu_{PL}}$ [g]	dof [h]
IGRJ16465-4507	$2.0^{+0.7}_{-0.7}$	$7.3^{+2.8}_{-2.1}$	$0.82^{+0.06}_{-0.09}$	$2.19^{+0.35}_{-0.31}$	$8.95^{+0.2}_{-3.1}$	<135	0.859	0.994	270
IGRJ16493-4348	$8.6^{+0.9}_{-1.0}$	$26^{+9.4}_{-7.9}$	$0.62^{+0.06}_{-0.07}$	$2.37^{+0.18}_{-0.17}$	$13.5^{+0.3}_{-2.0}$	<84	0.902	1.09	389
IGRJ16195-4945	11^{+1}_{-1}	78^{+17}_{-17}	$0.53^{+0.09}_{-0.10}$	$1.80^{+0.14}_{-0.13}$	$16.1^{+0.2}_{-2.5}$	<43	0.934	0.999	614
SWJ2000.6+3210(1)	$2.3^{+0.2}_{-0.2}$	$9.3^{+1.2}_{-1.0}$	$0.68^{+0.03}_{-0.02}$	$2.21^{+0.08}_{-0.09}$	$32.0^{+0.5}_{-0.9}$	51^{+34}_{-37}	0.918	1.58	417
SWJ2000.6+3210(2)	$2.1^{+0.2}_{-0.2}$	$8.2^{+1.1}_{-1.0}$	$0.70^{+0.02}_{-0.03}$	$2.01^{+0.05}_{-0.05}$	$55.0^{+0.8}_{-0.6}$	71^{+32}_{-29}	0.897	1.66	725

All spectra are fit with an absorbed power-law, after including a second partial-covering absorber.
Weak evidence for an Fe Kα fluorescence line is seen in one observation of the Swift source.
In the second observation, this source also showed regular variations with P=1056 s.

One Last Small Surprise...

IGRJ16195-4945





Seg#	Source	N_H ($10^{22}cm^{-2}$)	$N_{H\ part}$ ($10^{22}cm^{-2}$)	PCF	Γ	Flux ($10^{-12}\frac{ergs}{cm^2\ s}$)[a]	χ^2	dof	Fe EW (eV)
1-6	Total	11^{+1}_{-1}	77^{+17}_{-18}	$0.55^{+0.09}_{-0.10}$	$1.82^{+0.14}_{-0.13}$	$16.1^{+0.1}_{-2.4}$	573.8	615	<43
1	quiescent	$3.5^{+6.0}_{-3.0}$	<10	0.95[b]	$1.58^{+1.1}_{-0.5}$	$2.85^{+0.21}_{-2.85}$	64.5	85	<356
2	total flare	11^{+1}_{-1}	72^{+17}_{-18}	$0.57^{+0.08}_{-0.10}$	$1.82^{+0.15}_{-0.15}$	$48.2^{+0.7}_{-8.2}$	289.0	337	<15
3	flare onset	10^{+2}_{-2}	48^{+23}_{-24}	$0.52^{+0.16}_{-0.22}$	$1.73^{+0.30}_{-0.26}$	$59.4^{+2.4}_{-27.1}$	69.0	120	<49
4	flare decay	11^{+2}_{-2}	65^{+36}_{-28}	$0.58^{+0.14}_{-0.21}$	$1.89^{+0.33}_{-0.30}$	$46.4^{+1.4}_{-28.6}$	95.7	119	<25
5	post-flare	$12.4^{+1.8}_{-1.7}$	121^{+30}_{-31}	$0.75^{+0.11}_{-0.18}$	$2.07^{+0.33}_{-0.32}$	$9.73^{+2.18}_{-2.54}$	237.0	266	<68
6	on	11^{+1}_{-1}	83^{+16}_{-16}	$0.55^{+0.08}_{-0.10}$	$1.75^{+0.14}_{-0.14}$	$20.4^{+0.3}_{-2.7}$	507.2	551	<43

Conclusions

- SS73 17 was a major surprise – a new member of a very small class of X-ray bright symbiotic stars.
- IGR16195-4945 flared for ~30 ks. Did the neutron star pass through a thick disk associated with the donor star?
- SwiftJ2000.6+3210 is a newly identified transient X-ray pulsar. Given the low magnetic field implied by the relatively slow rotation period of 1056 s, it is not surprising that the same mechanism that produces periodic emission near periastron is too weak to produce an observable period at apoastron.
- Due to the short nature of the observations the lack of directly observed orbital periods is not surprising.
- We find only weak evidence of Fe fluorescence emission in one source, and only upper limits to Fe lines in the other three, similar to other sources in the class. The Fe line measurements that we report here are either the first in the literature or several times more restrictive than previous measurements.