PROCEEDINGS OF SCIENCE

Hard X-ray properties of magnetic cataclysmic variables

R. Landi[*a], **L. Bassani**[a], **L. Amati**[a], **A. Bazzano**[b], **M. Fiocchi**[b] **and A. J. Bird**[c]
[a] *INAF – IASF Bologna*
[b] *INAF – IAPS Rome*
[c] *University of Southampton*
E-mail: landi@iasfbo.inaf.it, bassani@iasfbo.inaf.it, amati@iasfbo.inaf.it, angela.bazzano@iaps.inaf.it, mariateresa.fiocchi@iasf-roma.inaf.it, A.J.Bird@soton.ac.uk

Recent hard X–ray surveys have proven efficient in detecting cataclysmic variables (CVs), in particular magnetic systems (mCVs). This has allowed us to construct a sample of mCVs (mainly Intermediate Polars) selected in hard X–rays, i.e. those observed both by *INTEGRAL*/IBIS and *Swift*/BAT. A long-standing issue is the high number of magnetic systems detected among the whole CV population. Whether this observational evidence is due to selection effects or to different evolutionary time–scales and their connection with the magnetic field of the white dwarf (WD) is still to be explained. The basic idea of this work is to investigate the hard X-ray spectral characteristics of the systems included in the sample and link them to observational features like the orbital and spin periods (Porb, Pspin). In this way, it will be possible to assess their location relative to the period gap, and hence get information about the CVs evolution and accretion geometries on the surface of the white dwarf.

An INTEGRAL view of the high-energy sky (the first 10 years)" 9th INTEGRAL Workshop and celebration of the 10th anniversary of the launch,
October 15-19, 2012
Bibliotheque Nationale de France, Paris, France

[*]Speaker.

PoS(INTEGRAL 2012)051

Sample of hard X-ray selected IPs.

Source	Type[a]	BAT	IBIS	Source	Type[a]	BAT	IBIS
IGR J00234+6141	IP	yes	yes	IGR J15094–6649	IP	yes	yes
V709 Cas	IP	yes	yes	NY Lup	IP	yes	yes
1RXS J005528.0+461143	IP	yes	no	IGR J16167–4957	IP*	yes	yes
XY Ari	IP	yes	no	IGR J16500–3307	IP	yes	yes
GK Per	IP	yes	yes	IGR J16547–1916	IP*	yes	yes
1RXS J052430.2+424449	IP*	yes	no	V2400 Oph	IP	yes	yes
TV Col	IP	yes	yes	IGR J17195–4100	IP	yes	yes
TW Pic	IP*	yes	yes	IGR J17303–0601	IP	yes	yes
TX Col	IP	yes	no	AX J1740.2–2903	IP*	no	yes
V405 Aur	IP	yes	no	IGR J18173–2509	IP*	yes	yes
MU Cam	IP	yes	yes	IGR J18308–1232	IP	no	yes
1RXS J063631.9+353537	IP	yes	no	AX J1832.3–0840	IP*	no	yes
BG CMi	IP	yes	no	V1223 Sgr	IP	yes	yes
SWIFT J0732.5–1331	IP	yes	yes	IGR J19267+1325	IP*	no	yes
PQ Gem	IP	yes	no	IGR J19552+0044	IP*	no	yes
EL UMa	IP	yes	no	V2306 Cyg	IP	yes	no
1RXS J080114.6–462324	IP*	no	yes	1RXS J211336.1+542226	IP*	yes	yes
IGR J08390–4833	IP	yes	yes	V2069 Cyg	IP	yes	yes
YY Dra	IP	yes	no	IGR J21335+5105	IP	yes	yes
IGR J12123–5802	IP*	no	yes	FO Aqr	IP	yes	yes
EX Hya	IP	yes	no	AO Psc	IP	yes	yes

[a] IP* indicates that the IP nature of the objects needs to be still confirmed by measurements.

1. The sample

In this preliminary work we have focused our analysis on the sample of IPs detected so far by *INTEGRAL*/IBIS, *Swift*/BAT, or both. The number of objects in this sample amounts to 42 and also includes, as shown in the Table, those systems whose characteristics are IP–like, but their class still need to be confirmed.

2. Spectral analysis results

As a first step, we analysed the IBIS and BAT spectra in the 20–100 keV energy band independently, adopting a bremsstrahlung model in XSPEC v.12.7.1 (Dorman & Arnaud 2001). The histograms shown in Figure 1 (*upper–left panel*) depict the distribution of the bremsstrahlung temperatures in IBIS (red dashed) and BAT (blue) data set, respectively. The average temperatures are $< kT >= 23.2 \pm 1.0$ keV for the IBIS sample and $< kT >= 19.5 \pm 1.0$ keV for the BAT one. The *upper–right panel* of Figure 1 shows the correlation between the IBIS and BAT temperatures. It is quite evident from this plot that, within the uncertainties, there is an overall good agreement between the IBIS and BAT temperatures, suggesting that the sources are not affected on average by changes in their spectral shape. In the *bottom–left panel* of Figure 1 we plot instead the correlation between the IBIS and BAT 20–100 keV fluxes. In this case, despite the correlation turns out to be stringent (correlation coefficient ∼0.86), there is a clear indication for the BAT points to be systematically lower than the IBIS ones. This might be due to some systematics between the two instruments, which in AGNs has been already estimated to be around 14% assuming a power law model (Molina et al. 2012, submitted to MNRAS).

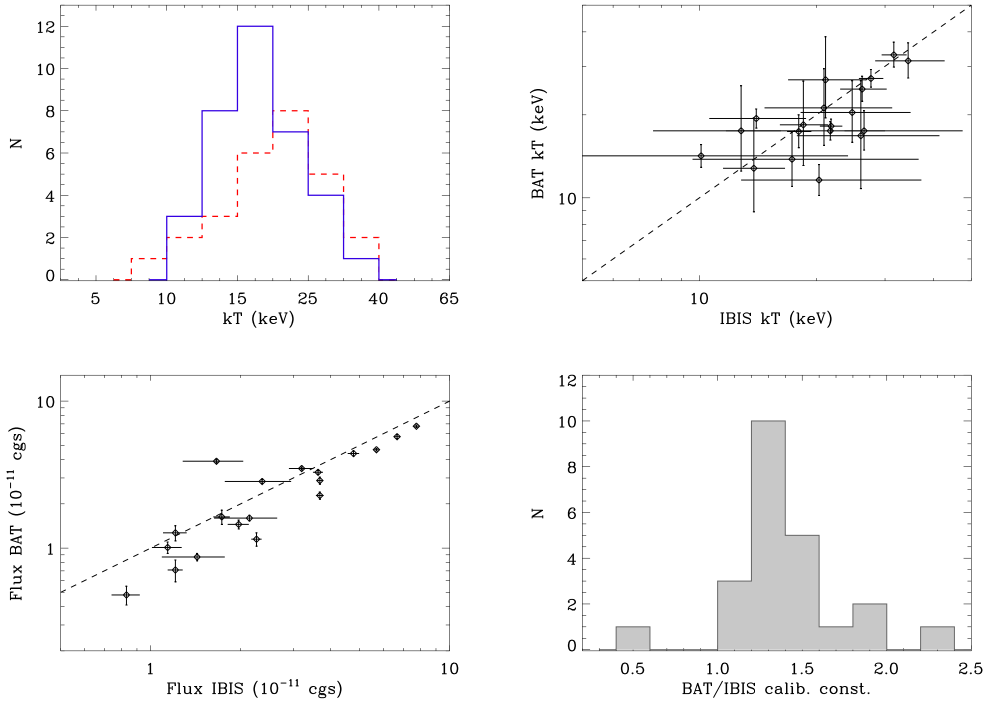

Figure 1: Bremsstrahlung temperature distribution estimated with IBIS (red dashed) and BAT (blue) data set, respectively (*upper–left panel*). Comparison between the bremsstrahlung temperatures (*upper–right panel*) and 20–100 keV fluxes (*bottom–left panel*) derived from individual fits of IBIS and BAT spectra. Histogram of the cross–calibration constant between IBIS and BAT for the selected IPs sample (*bottom–right panel*).

3. IBIS/BAT simultaneous spectral analysis

After performing the fit on the individual IBIS and BAT spectra, we combined the two data sets and fit them together. To take into account the presence of flux variability and the possible mis–match between the IBIS and BAT spectra, we have introduced a cross–calibration constant C in the fit. As for the individual data set, the model adopted is a thermal bremsstrahlung. The *bottom–right panel* of Figure 1 shows the distribution of the cross–calibration constant C. It is clear that C is systematically above unity, with an average value of 1.28 ± 0.02, similar but not equal to what found in AGNs data (1.14 ± 0.02). The slight difference may be ascribed to different effects, such as the smaller number of objects, different parameters of the model (kT) adopted for the fitting procedure, and possibly a higher source variability in CVs.

4. Searching for correlations

A previous study on a smaller sample of IPs (Scaringi et al. 2010) has shown for the first time evidence for a correlation between the hard X–ray spectral hardness and the orbital and spin periods. An attempted explanation was given by Scaringi et al. (2010) in terms of evolution of magnetic systems and accretion geometry onto the WD surface.

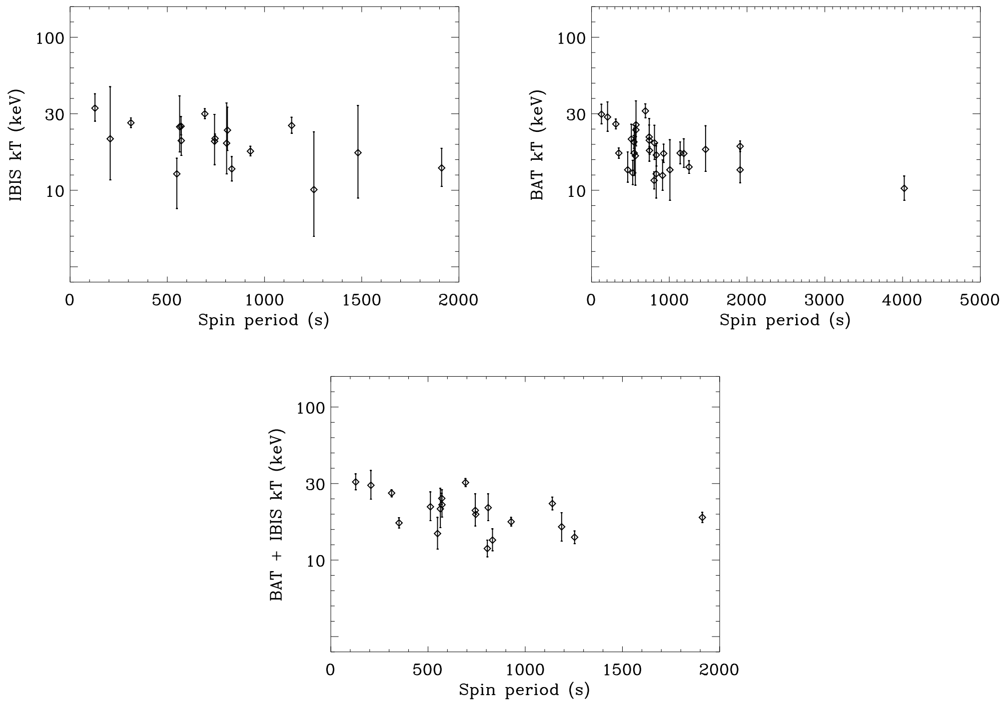

Figure 2: Correlation between IBIS (*upper–left panel*), BAT (*upper–right panel*), and joint IBIS/BAT temperatures versus the spin period (*bottom–central panel*).

In this preliminary work we have extended the sample and searched for correlations between the bremsstrahlung temperature and the orbital parameters, this time using tempertatures rather than axial ratios.

The plots in Figure 2 display the correlation between IBIS (*upper–left panel*), BAT (*upper–right panel*), and joint IBIS/BAT (*bottom–central panel*) temperatures versus the spin period. The Spearman rank correlation analysis gives the following probabilities for each data set: 98% for the IBIS data, 99.4% for the BAT data, and 99% for the combined analysis IBIS/BAT. These findings are indicative of a possible anti–correlation which needs to be investigated with further measurements. At this stage, we do not find evidence for a correlation between the bremsstrahlung temperature and the orbital period.

Considering the relevant fraction of mCVs detected at high energies so far, it is likely that they will continue to increase thanks to the contribution that X–ray and optical follow–up observations will give to the identification and classification of still unidentified high energy sources. In particular, more observations will allow us to verify the real existence of the correlation discovered and understand its origin.

References

[1] Dorman, B. & Arnaud, K. A., 2001, Astronomical Data Analysis Software and Systems X, ASP Conf. Proc., 238. Eds F. R. Harnden, Jr., F. A. Primini, & H. E. Payne (San Francisco, CA: ASP),415

[2] Scaringi, S., Bird, A. J., Norton, A. J., et al, 2012, MNRAS, 401, 2207