PROCEEDINGS OF SCIENCE

IGR J18136–2739: a dwarf nova caught in outburst ?

R. Landi[∗a], **V. Sguera**[a], **L. Bassani**[a], **A. Bazzano**[b], **F. Capitanio**[b], **S. Drave**[c], **A. J. Bird**[c], **L. Ferrario**[d], **D. T. Wickramasinghe**[d], **J. P. Osborne**[e], **and N. Gehrels**[f]

[a] *INAF/IASF Bologna*
Via P. Gobetti 101, 40129 Bologna, Italy
[b] *INAF/IASF Roma*
Via Fosso del Cavaliere 100, 00133 Roma, Italy
[c] *School of Physics and Astronomy, University of Southampton*
Highfield, SO17 1BJ, UK
[d] *Mathematical Sciences Institute, The Australian National University, ACT 0200, Australia*
[e] *Department of Physics & Astronomy, University of Leicester*
Leicester LE1 7RH, UK
[f] *NASA Goddard Space Flight Center*
Greenbelt, MD 20771, USA
E-mail: landi@iasfbo.inaf.it, sguera@iasfbo.inaf.it, bassani@iasfbo.inaf.it, angela.bazzano@iasf-roma.inaf.it, fiamma.capitanio@iasf-roma.inaf.it, A.J.Bird@soton.ac.uk, A.J.Bird@soton.ac.uk, Lilia.Ferrario@anu.edu.au, Dayal.Wickramasinghe@anu.edu.au, julo@star.le.ac.uk, neil.gehrels@nasa.gov

IGR J18136–2739 is a new transient *INTEGRAL*/IBIS source which has been caught in outburst during only a short period of time (26–29 August 2003). Motivated by this finding, we acquired observations with the X–ray telescope (XRT, 0.3–10 keV) on board *Swift*, in order to assess the nature of this source. At the border of the 90% IBIS error circle we detect for the first time in X–rays the dwarf nova V1830 Sgr and propose it as the likely counterpart to the IBIS source. The combined use of the spectral information afforded by XRT and IBIS indicates that the source spectrum is best fitted with either a simple power law with $\Gamma \sim 2.6$ or a thermal bremsstrahlung with $kT \sim 17$ keV; it also indicates the presence of variability in the source, as also highlighted by the occasional IBIS detection. V1830 Sgr is the second dwarf nova (DN) discovered by IBIS after SS Cyg.

The Extreme and Variable High Energy Sky – extremesky2011,
September 19–23, 2011
Chia Laguna (Cagliari) Italy

∗Speaker.

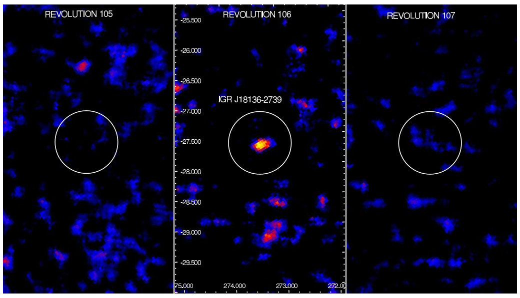

Figure 1: IBIS/ISGRI 20–40 keV image sequence corresponding to revolutions 105 (left), 106 (middle) and 107 (right). The position of IGR J18136–2739 is encircled.

1. *INTEGRAL*/IBIS detection

IGR J18136–2739 is an unidentified transient hard X–ray source detected by *INTEGRAL* during observations of the Galactic plane (Bird et al. 2010). The source has been discovered thanks to the bursticity method with which it is possible to search for variable sources by optimizing their detection time–scale: the light curve for each source in the 18–60 keV energy band is scanned with a variable–sized time window to search for the best source significance. The duration and time interval over which the source significance is maximised are recorded. The bursticity of a source is then defined as the ratio of the maximum significance on any time–scale, compared to the significance defined for the whole data set. A bursticity of 1 defines a persistent source, where the inclusion of any data maintains or increases the detection significance. Conversely, a bursticity greater than 1 implies that the significance of a source can be increased by the omission of some observations from the analysis, presumably when the source was in quiescence. A bursticity greater than 4 is instead indicative of a strongly variable source. As stated by Bird et al. (2010), the impact of this variability analysis was significant as more than 100 sources were recovered using the above methods.

IGR J18136–2739 was active only during a revolution from the 26th to the 29th August 2003, for a total ON–source exposure time of 90 ks. This is clearly evident in Figure 1, which shows a sequence of three consecutive 20–40 keV revolution significance maps: the one in which the source is detected (Rev. 106) at 6.6σ confidence level, those just before (Rev. 105), and after (Rev. 107), where nothing is detected. From the total significance map obtained by the entire set of available pointings (ON–source exposure of 6.8 Ms) we can infer for this source only a 2σ upper limit on the persistent 20–40 flux of $\sim 3\times10^{-12}$ erg cm^{-2} s^{-1}. By comparing this upper limit with the 20–40 keV flux of $\sim 2.9\times10^{-11}$ erg cm^{-2} s^{-1} estimated during the outburst phase, we derive a dynamical range of $\sim$10 in the same energy band. The source bursticity of 5.4 confirms the variable nature of this object.

The fit of the IBIS data with a simple power law is acceptable ($\chi^2/\nu = 15.1/14$) and provides a photon index $\Gamma = 3.12^{+1.25}_{-1.03}$; a good model fit ($\chi^2/\nu = 14.0/14$) is also achieved with a thermal bremsstrahlung model having $kT = 17.7^{+23.4}_{-7.9}$ keV.

Table 1: X–ray detections in both XRT observations.

Source	RA (J2000)	Dec (J2000)	Error (arcsec)	$\sigma_{\rm obs1}{}^a$	$\rm Cts^b_{obs1}$	$\sigma_{\rm obs2}{}^a$	$\rm Cts^b_{obs2}$
#1	18 13 50.94	–27 42 26.8	5.5	4.0	8.75 ± 2.20	3.6	7.17 ± 2.00
#2	18 13 17.20	–27 33 53.2	6.0	3.0	5.03 ± 1.70	–	–
#3	18 12 46.80	–27 35 50.6	6.0	–	–	2.8	4.42 ± 1.60

[a] σ represents the source signal-to-noise ratio;

[b] The count rate (in 0.3–10 keV energy range) is in units of 10^{-3} counts s^{-1}.

2. *Swift*/XRT follow–up observations

On July 29 (obs #1) and August 3 (obs #2) 2010 follow–up X–ray observations of IGR J18136–2739 were performed using XRT (X–ray Telescope, 0.2–10 keV, Burrows et al. 2005) on board the *Swift* satellite (Gehrels et al. 2004); the exposures were of 2698 and 2848 s for the first and second pointing, respectively.

Only one XRT object (source #1) is compatible with the IBIS positional uncertainty (black circle in Figure 2, left panel, 90% confidence radius of $\sim 4'.1$[1]). As shown in Table 1, this is the brightest detection in both observations; by summing the XRT pointings, source #1 is detected at a significance level of 5.3σ c.l. and is still visible above 3 keV at $\sim 2\sigma$ c.l. Source #2, detected only in the first XRT pointing, lies further away from the IBIS error circle. It has a counterpart in the USNO–B1.0 catalogue (USNO–B1.0 0624–0861561, Monet et al. 2003) with magnitude $R \sim 17.8$, and is also listed in the 2MASS survey (2MASS 18131701–2733491, Skrutskie et al. 2006) with magnitudes $I \sim 14.4$, $H \sim 13.9$, and $K \sim 16.6$. From the X–ray data we can only infer a 2–10 keV flux of $\sim 10^{-13}$ erg cm^{-2} s^{-1}, assuming a simple power law with photon index 1.8. Given that source #2 is weaker and only compatible with the 99% IBIS error circle, we assume this to be a less likely candidate. The other source (#3) detected during the second XRT pointing is too far away and too weak to be even considered here. Hence, source #1 remains the most likely association to IGR J18136–2739. The XRT positional uncertainty of few arcsec allows the unambiguous identification of source #1 with the DN V1830 Sgr, never detected in X–rays before. The X–ray spectrum of V1830 Sgr is described by a simple power law with photon index $\Gamma = 2.29^{+0.87}_{-0.93}$ and a 2–10 keV flux of 1.3×10^{-13} erg cm^{-2} s^{-1} (χ^2/ν = 2.3/6).

3. Broad–band spectral analysis

As a further step towards the characterisation of IGR J18136–2739 we combined XRT and IBIS data to obtain a broad–band spectrum of the source over the 0.3–60 keV energy band.

In all fitting procedures we left the cross–calibration C between the two instruments free to vary. A simple power law (see Figure 2, right panel) is a good description of the data ($\chi^2/\nu = 18.4/21$) and provides $\Gamma = 2.62 \pm 0.65$ and $C > 400$. Also the thermal bremsstrahlung is a good

[1]The source also lies within the 99% of the enhanced IBIS positional uncertainty assessed following Scaringi et al. (2010).

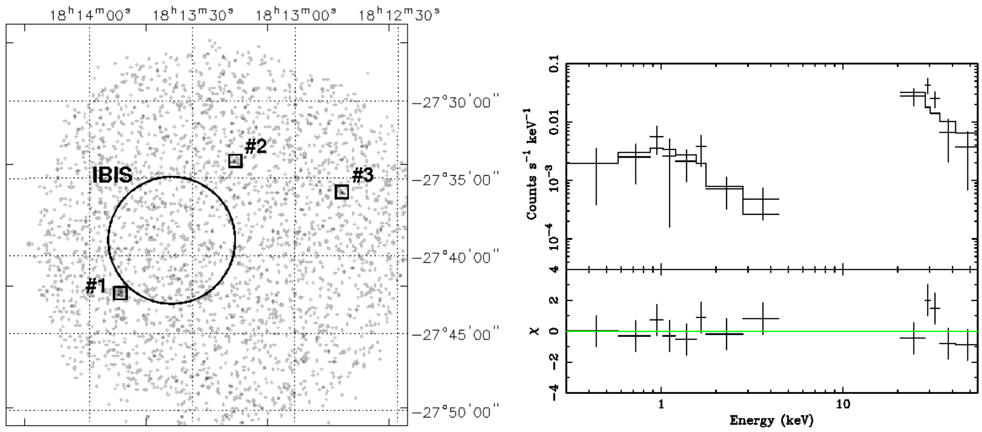

Figure 2: 0.3–10 keV XRT image showing the 3 objects detected in this sky region and the IBIS error circle (black circle, 90% confidence radius of $\sim 4'.1$); only object #1 (coincident with V1830 Sgr) is compatible with the IBIS positional uncertainty (*left panel*); Broad–band XRT/IBIS spectrum of the source assuming a simple power law and residuals to this model in units of σ (*right panel*).

model to the data ($\chi^2/\nu = 19.0/21$), yielding a $kT = 16.7^{+18.0}_{-7.0}$ keV and $C > 72$. In both cases, the high value found for the cross–calibration constant confirms the presence of strong variability that needs to be studied in–depth. We could make some guesses about the origin of the mismatch between IBIS and XRT data: either the hard X–ray emission was produced by a transient source, more likely a Galactic object, that was not caught in its outburst activity during the XRT pointings, or V1830 Sgr is the actual counterpart to the IBIS source. The second hypothesis can be supported by the variable behaviour in hard X–ray and at optical frequencies shown by DN systems. However, before claiming that this object is responsible for the hard X–ray emission, we estimated the random chance probability of finding an X–ray source within the IBIS error circle taking into account the Galactic LogN–LogS relation obtained by *ASCA* in the 2–10 keV energy band (Yamauchi et al. 2002), always with the caveat that this assumes a uniform distribution of independent sources. The probability of finding V1830 Sgr inside the IBIS uncertainty by chance is around 6%. If we compute, by adopting the same LogN–LogS relation, how many X–ray sources are expected within the XRT field of view, we find, i.e. 2.5 sources, which is in agreement with the number of sources detected by XRT.

Based on this result and lacking further information, we propose V1830 Sgr as the likely counterpart of the IBIS detection.

4. Conclusions

In this work we present the results of the follow–up observations performed with the X–ray telescope on board the *Swift* satellite of the region surrounding the new transient *INTEGRAL* source IGR J18136–2739. These measurements allow us to study this source in X–rays for the first time and propose it as the likely counterpart to the IBIS object. The discovery of another DN, after that of SS Cyg, open new issues about the nature of the mechanism involved in the high energy emission of this class of cataclysmic variables.

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