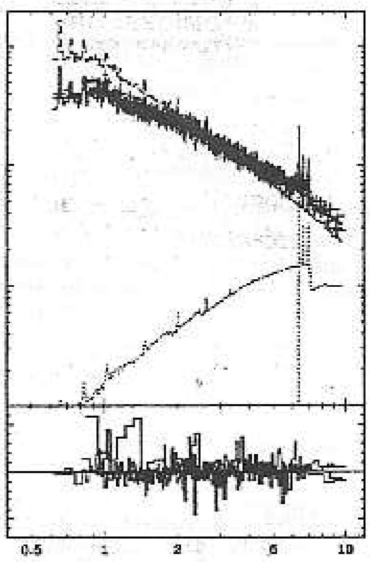

Figure 3. The ASCA spectrum of BY Cam, showing the intrinsic multi-temperature emission (dashed line) and its reflection spectrum (dotted line). The solid line shows the resultant spectum after complex absorption from the pre-shock column. The bottom panels show the residuals of this fit, indicating that it is a good description of the data.

Substituting the primary continuum for a single temperature plasma model (and its reflection and including complex absorption as above) gives a much worse fit with $\chi^2_\nu = 1380/1268$ for $kT = 18^{+5}_{-6}$ keV. The data contain significant iron L line emission which cannot be fit by the single temperature models. This is the first observational confirmation of the theoretically expected cooling of the shocked plasma in polars.

There are also GINGA data on BY Cam. These spectra extend from 2–20 keV so give better constraints on the high energy spectrum. Fitting the same models as above gives a maximum temperature of the cooling plasma of $kT_{max} = 21^{+15}_{-4}$ keV. Assuming that the shock only cools via bremsstrahlung then this implies that the mass of the white dwarf is $0.6^{+0.2}_{-0.1} M_\odot$ (see e.g. [11]). While the mass of the white dwarf in BY Cam is not well constrained observationally, it is known that it has a substantial magnetic field of 28 MG [12] so cyclotron cooling should also be important. Cyclotron cooling can dominate over bremsstrahlung for high temperature, low density material (see e.g. [13]), so it has the effect of reducing the maximum observed X-ray bremsstrahlung temperature. For reasonable mass accretion rates it seems quite likely that the shock in BY Cam has a composite structure, cooling via both cyclotron and bremsstrahlung emission.

REFERENCES

1. Cropper M., Sp. Sci. Rev. 54 (1990) 195
2. Imamura J.N, & Durisen R.H ApJ 268 (1983) 291
3. Done C., Osborne J.P., Beardmore A.P., MNRAS 276 (1995) 483
4. Ross R., Fabian A.C., MNRAS 193 (1980) 1P
5. Swank J.H., Fabian A.C., Ross R., ApJ. 280 (1984) 734
6. Kallman T.R., et al., ApJ. 411 (1993) 869.
7. Kallman T.R., Mukai K., Schlegel E.M., Paerels F.B., ApJ. 466 (1996) 973
8. Ishida M., Matsuzaki K., Fujimoto R., Mukai K., Osborne J.P., MNRAS 287 (1997) 651
9. Rainger J.F., et al 1997, in preparation.
10. Norton A.J., Watson M.G., King A.R., Lecture Notes in Physics Vol 385, eds Treves A., Perola G.C., Stella L., Springer-Verlag, (1991) p155
11. Frank J., King A.R. & Raine D., In "Accretion power in Astrophysics ", 2d edition, Cambridge, UK: Cambridge University Press (1992)
12. Schwope A.D., Cataclysmic Variables and Related Objects (1996) p189 Kluwer, Dordrecht.
13. Wu K., Chanmugam G., Shaviv G., ApJ. 455 (1995) 260.

ELSEVIER
Nuclear Physics B (Proc. Suppl.) 69/1-3 (1998) 379–382
NUCLEAR PHYSICS B
PROCEEDINGS SUPPLEMENTS

*Beppo*SAX and ASCA observations of the field containing the γ-ray transient GRO J1838-04

M.C. Maccarone [a], M. Tavani [b,c], B. Sacco [a], G. Cusumano [a], E. Gotthelf [d], R. Mukherjee [c], J. Halpern [c], J.R. Mattox [e]

[a] IFCAI/CNR, Via Ugo La Malfa 153, 90146, Palermo, Italy
[b] IFCTR/CNR, Via Bassini 15, 20133 Milano, Italy
[c] CAL, Columbia University, New York, NY 10027, USA
[d] NASA/GSFC, Greenbelt, MD 20771, USA
[e] Astronomy Dept., Boston University, 725 Commonwealth Av., Boston, MA 02215, USA

We present preliminary results of *Beppo*SAX and ASCA observations of the Galactic field containing the unidentified γ-ray transient GRO J1838-04. Several weak X-ray sources are detected within the EGRET error box. No obvious counterpart of GRO J1838-04 is evident from these observations. More multiwavelength observations are necessary to identify the nature of this non-blazar γ-ray transient.

1. The new γ-ray transient GRO J1838-04

During the viewing period VP 423 (June 20-30,1995) a new γ-ray transient (GRO J1838–04) was discovered by EGRET [9]. This source is located near the Galactic plane in a field centered at Galactic coordinates $l = 27.31°$ and $b = +1.04°$ with an elongated error box (99% confidence) of major axis $\sim 1.4°$ and minor axis $\sim 0.8°$. The average γ-ray flux above 100 MeV for the whole VP 423 is $\Phi = (3.3 \pm 0.7) \cdot 10^{-8}\,\mathrm{ph\,cm^{-2}\,s^{-1}}$. Fig. 1 shows the EGRET lightcurve of GRO J1838–04 since the beginning of the CGRO mission with the inclusion of a crucial Cycle 5 EGRET observation in October 1995 that failed to detect the source. The intensity level reached during the γ-ray flare had peak flux above 100 MeV of $(4.0 \pm 1.1) \cdot 10^{-6}\,\mathrm{ph\,cm^{-2}\,s^{-1}}$ during the last 3.5-day interval of VP 423.

The peak γ-ray luminosity for isotropic emission is $L_\gamma \simeq 7.2 \cdot 10^{34}\, d^2_{kpc}\,\mathrm{erg\,s^{-1}}$, where d_{kpc} is the source distance in kpc. This is a very intense γ-ray transient with a flux comparable with that of the Geminga pulsar [11] and of AGN flare peak intensities as for 3C 279 ($z = 0.538$) [3] and 0528+134 ($z = 2.07$) [7]. The EGRET spectrum above 30 MeV during the peak emission is consistent with a power-law of photon index

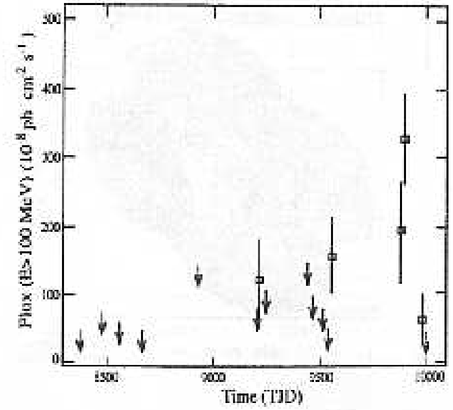

Figure 1. Time history of γ-ray flux detected by EGRET from GRO J1838–04 . TJD is the truncated Julian date (JD), TJD=JD–2,440,000.0. 1σ flux errors and 2σ upper limits are reported, the upper limits being shown as downward arrows. The time interval is from April 1991 through early October 1995. EGRET data for VPs 421 and 422 have been combined.

0920-5632/98/$19.00
PII S0920-5632(98)00245-X

2.09 ± 0.18 [9]. Neither COMPTEL or BATSE detected significant high-energy emission during the γ-ray flare of GRO J1838-04; the source is not associated with a radio-loud spectrally flat AGN.

2. Search for counterparts

The Galactic plane near GRO J1838–04 was surveyed in the radio band at 20 cm [2]. No spectrally-flat bright radio source with blazar characteristics is within the 99% confidence error box of GRO J1838–04 . Fig. 2 shows the radio sources of the Galactic plane survey [2].

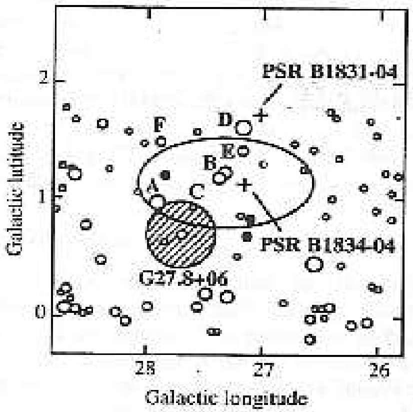

Figure 2. Radio sources of the Galactic plane survey at 20 cm with the 99% confidence EGRET error box of GRO J1838–04 marked by the solid ellipse. The circle's size is proportional to the radio flux at 20 cm: source A, 738 mJy; source B, 264+99 mJy; source C, 23+27 mJy; source D, 83+377 mJy; source E, 69 mJy; source F, 68+41 mJy. Crosses indicate the positions of the radiopulsars PSR B1831-04 and PSR B1834-04. The dashed circle approximates the extension of the supernova remnant G27.8+0.6 at 2.6 GHz. Filled circles give the positions of the RASS sources.

The brightest radio source in the error box, 27.920+0.977 (source 'A') was determined to have a constant flux ($\sim$ 500 mJy at 2.2 GHz) and a steep radio spectral index $\alpha_r \simeq -1$ from data obtained at the Green Bank radio interferometer at 2.25 and 8.3 GHz during the period December 14 1995 - January 13 1996. This radio source certainly does not resemble the radio-loud blazars associated with γ-ray sources detected by EGRET at high Galactic latitudes [6,4]. Other radio sources in the GRO J1838–04 error box are weaker and unlikely to be blazar counterpart candidates.

One radio pulsars is known in the error box, PSR B1831-04 with a relatively small spindown luminosity of $10^{32.1}$ ergs^{-1} [10]. The supernova remnant SNR27.8+0.6 partially overlaps the EGRET error box. No pulsar is associated with the remnant which appears to be of a center-filled plerionic type from its radio extended and core emission. Three X-ray sources in the ROSAT RASS database are within the 99% confidence error box of GRO J1838–04 . None is associated with the radio sources of ref. [2] (see Fig. 2).

3. *BeppoSAX* observations

BSAX observed the GRO J1838-04 field twice. A first observation was performed on April 17, 1997, centered at the Equatorial coordinates RA=279.317°, DEC=−4.243°. The exposure times were 20618 s and 9065 s for MECS and LECS, respectively. The second observation (April 20, 1997) was centered at Equatorial coordinates RA=278.928° and DEC=−4.549°, with exposure times of 23079 s and 15531 s for MECS and LECS, respectively. Table 1 gives the detected sources, rates, significance and flux.

4. ASCA observations

ASCA observed a field within the 99% confidence error box of GRO J1838-04 in April 1997. Fig. 3 shows the broad-band GIS image of the field. Table 2 gives the most significant detected sources ($\sim 5\sigma$), rates, significance and hardness ratio: AXS J18370-0421 is an unresolved hard source with significant flux above 2 keV;

Table 1
BeppoSAX MECS Candidate sources.

Source	RA_J2000 (deg)	DEC_J2000 (deg)	Energy band (keV)	Rate (10^{-3} cts/s)	S/N	Flux erg cm^{-2} s^{-1}
1SAX J18379-0424	279.487	−4.406	1.5 – 4.5 (MECS)	2.3 ± 0.66	3.5	$1.9 \cdot 10^{-13}$
"	"	"	1.5 – 10 (MECS)	2.3 ± 0.7	3.1	==
"	"	"	0.1 – 2 (LECS)	1.4 ± 0.7	2.1	==
1SAX J18363-0438	279.068	−4.649	1.5 – 4.5 (MECS)	1.5 ± 0.5	3.0	$1.0 \cdot 10^{-13}$
"	"	"	1.5 – 10 (MECS)	1.1 ± 0.6	1.9	==
"	"	"	0.1 – 2 (LECS)	0.6	==	==

Table 2
ASCA Candidate sources.

Source	RA_J2000 (deg)	DEC_J2000 (deg)	Rate[(a)] (10^{-3} cts/s)	Significance[(b)] broad	soft	hard	Hardness (h-s)/(h+s)
AXS J18370-0421	279.288	−4.356	3.39 ± 0.54	6.0	3.6	4.8	+0.17
AXS J18380-0435	279.520	−4.595	2.86 ± 0.53	5.2	4.2	3.1	−0.15
	279.493	−4.413	4.35 ± 0.56	7.5	7.0	3.4	−0.39

(a) Mean single GIS broad-band count rate in a 6 arcmin diameter aperture corrected for a constant background of $(8.50 \pm 0.15) \cdot 10^{-3}$ cts/s.
(b) Soft and hard bands refer to $E < 2$ and $E > 2$ keV, respectively.

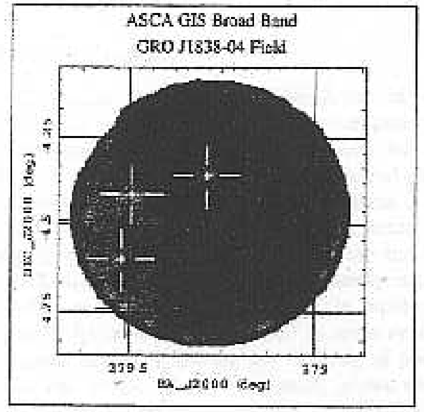

Figure 3. ASCA GIS broad map of a field within the γ-ray error box of GRO J1838-04.

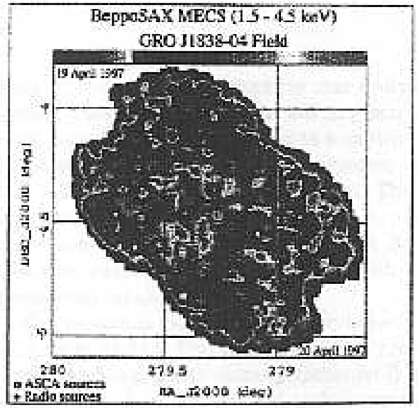

Figure 4. Mosaic of the MECS data, normalized for the same exposure time, in the energy band 1.5 – 4.5 keV. Superimposed are the ASCA (circles) and the radio (crosses) source positions within the MECS fields.

AXS J18380-0435 is a localized diffuse source (3 arcmin). Diffuse Galactic plane emission might contribute to the detected X-rays. Additional analysis is necessary to identify the nature of the detected X-ray emission.

5. Comparison between *Beppo*SAX and ASCA data

Fig. 4 shows a mosaic of the MECS data, normalized for the same exposure time, in the energy band 1.5-4.5 keV. Superimposed are the ASCA (circles) and the radio (crosses) source position inside the MECS fields. No radio source listed in [2] appears to be coincident with the detected *Beppo*SAX sources.

Concerning *Beppo*SAX and ASCA comparison, the source ISAX J18379-0424 coincides in position with the ASCA source at coordinates RA=279.493°, DEC=−4.413°. Both ASCA sources AXS J18370-0421 and AXS J18380-0435 coincide with excess of counts in the *Beppo*SAX MECS map. The source ISAX J18363-0438 corresponds to a counts excess in the ASCA map.

6. Discussion

The solid angle subtended by the Galactic plane sky area within ±2° of Galactic latitude is ∼ 0.4 steradians. The probability of finding a *bright* γ-ray blazar is then $\sim 4 \cdot 0.4/4\pi \simeq 0.1$ [9]. However, we note that all brigth blazars with a peak γ-ray flux larger than 10^{-6} ph cm^{-2} s^{-1} (E>100 MeV) have an average 5 GHz radio flux S_5 in excess of 1 Jy [4]. From the lack of such a counterpart for GRO J1838–04, the probability that this source is a blazar is substantially smaller that this estimate. Gamma-rays blazars with steep indices (as source 'A' of Fig. 2) are at least a factor of ∼8 less common than EGRET blazars with flat indices. The probability that GRO J1838–04 can be identified with source 'A' as a blazar is less than 0.003. Identification of a blazar with the weaker radio sources of Fig. 2 is even less likely. EGRET observations require $f_\gamma \lesssim 0.03 f_r$, where f_r is the fraction of spectrally-steep AGN with $S_5 \lesssim 0.25$ Jy capable of producing γ-ray flares similar to those of radio-loud and spectrally-flat AGNs with $S_5 \gtrsim 1$ Jy ($f_r \sim 0.1$) [9].

Theoretically, several Galactic systems are expected to be *time-variable* γ-ray sources, including:

(1) binary pulsars emitting γ-rays by shocked ultrarelativistic particles in pulsar winds stopped by gaseous material from companion stars (as in the case of the pulsar/Be star system PSR B1259-63 [8]),

(2) jet X-ray sources with ejection axis aligned towards the Earth,

(3) unstable pulsar magnetospheres,

(4) peculiar accretion phenomena onto compact objects,

(5) exotic transients.

To date, indication for γ-ray emission was obtained only for sources of the type (1). Variable X-ray/γ-ray emission was observed near periastron from the PSR B1259-63 system [8].

Our observations are a first step towards the identification of the GRO J1838–04 counterpart. No strong or remarkable X-ray source is detected in the γ-ray error box. More multiwavelength observations are necessary to identify the nature of the GRO J1838–04 transient.

REFERENCES

1. R.C. Hartman, et al., *ApJ*, 461, 698 (1996).
2. D. Helfand, et al., *ApJS*, 80, 211 (1992).
3. D. Kniffen, et al., *ApJ*, 411, 133 (1993).
4. J.R. Mattox, et al., *ApJ*, 481, 95 (1997).
5. M.A. McLaughlin, et al., *ApJ*, 763 (1996).
6. C.V. Montigny, et al., *ApJ*, 440, 525 (1995).
7. R. Mukherjee, et al., *ApJ*, 470, 831 (1996).
8. M. Tavani & J. Arons, *ApJ*, 477, 439 (1997).
9. M. Tavani, et al., *ApJ*, 479, L109 (1997).
10. J.H. Taylor, et al., *ApJS*, 88, 529 (1993).
11. D.J. Thompson, et al., *ApJS*, 101, 259 (1995).
12. D.J. Thompson, et al., *ApJS*, 107, 227 (1996).

ELSEVIER Nuclear Physics B (Proc. Suppl.) 69/1–3 (1998) 383–386

NUCLEAR PHYSICS
PROCEEDING
SUPPLEMENT

X-ray mapping of an IR selected star forming region with BeppoSAX NFI's

P. Soffitta[a]*, E. Costa[a], P. Kaaret[b], J. A. Tomsick[b], E. C. Ford[b] A. Santangelo[c]

[a]Istituto di Astrofisica Spaziale, C.N.R., Via del Fosso del Cavaliere, 00131, Rome, Italy

[b]Columbia Astrophysics Laboratory, 538 West 120[th] street, New York, 10027, N.Y.

[c]Istituto di Fisica Cosmica ed Applicazioni Informatica, Via U. la Malfa 153, 90156, Palermo, Italy

BeppoSAX observed an IR selected star forming region searching for Be/X-ray binaries. Since the time sca for the evolution of these systems is rather short, their progenitors (massive O and B stars), are likely found these regions. These type of stars form the central sources of HII regions in molecular clouds, and since these sa HII regions constitute some of the brightest IRAS point sources, IR emission is correlated with their presen We located HII regions as bumps in the IR emission of the galactic plane by means of the IR maps of the IR satellite. A star forming region has been selected in the Scutum '5 kpc' arm of the Galaxy.

BeppoSAX performed four pointed observations scanning the entire region where it found non catalogued ray sources. If located in the 'Scutum' arm their luminosity is within the typical range for Be/X-ray binaries quiescence. Their true nature is investigated.

1. Introduction.

The most common high-mass X-ray binaries (HMXBs) are those in which the companion is a Be star. Be/X-ray binaries account for 42% of observed HMXBs and the total inferred galactic population counts about 1000 objects [2,11]. Most Be/X-ray binaries have hard spectra, are highly variable, and in many cases they can harbor X-ray pulsars. The X-ray luminosity is powered by mass-loss from the Be star, in rapid rotation, in form of a stellar wind. In some systems episodic accretion during the crossing of periastron can occur. X-ray luminosity grows and it produce occational outbursting. The Be/X-ray binaries, generally, have long (P > 10 day) and eccentric (e > 0.2) orbits. The canonical progenitor of a Be/X-ray binary system is a binary of 10^8 solar mass B-type stars [7]. As the two stars evolve, the more massive star first fills its Roche lobe and then it accretes matter onto its companion. The angular momentum transferred widens the binary orbit and makes the companion a rapidly rotating Be star with equatorial rings or disk. The initially more massive star evolves, a short time scale, to the He burning stage a then, via a supernova explosion, to a neutron st If the supernova explosion is asymmetric, ecce tric orbits for the system can derive. The ne tron star, when it is close to apastron, perio cally crosses the equatorial rings of the Be st The end result is a Be/X-ray binary with a lo period and eccentric orbit.

The Be star is massive and its evolution is fa It is, then, likely to find these systems in groups young, high-metalicity stars (population I) whi are associated with regions of active star form tion in the spiral arms of the galaxy.

2. X-ray emission of Be/X-ray binaries.

The most characteristic feature of the X-r emission from HMXBs is their variability a their transient nature. Many HMXBs have be observed in X-rays, generally intermittently with large variations in the observed flux. Ma Be/X-ray binary systems display periodic ray emission episodes related the orbital peri Sometimes occasional outbursting can be served due to a sudden enhancement of the (eq

*soffitta@ias.rm.cnr.it

0920-5632/98/$19.00 © 1998 Elsevier Science B.V.
PII S0920-5632(98)00246-1