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Swift observations of GRB 051109B(*)

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Summary. — We present Swift observations of GRB 051109B, a soft long burst triggered by the Burst Alert Telescope (BAT). The soft photon index of the prompt emission suggests it is an X-Ray Flash (XRF) or, at least, an X-Ray Rich (XRR) burst. The X-ray light curve displays the canonical shape of many other GRBs, a double-broken power law with a small flare superimposed at $\sim T_0 + 1500\,\mathrm{s}$, and its extrapolation to early times smoothly joins with the BAT light curve. On the basis of the derived optical to X-ray flux ratio, it cannot be classified as a dark burst.

PACS 98.70.Rz – γ-ray source; γ-ray bursts.

1. – Introduction

The γ-ray light curve of GRB 051109B shows a single soft peak, without a strong emission above 100 keV (see fig. 1, left panel). The estimated duration in the 15–350 keV energy band is $T_{90} = 15 \pm 1\,\mathrm{s}$ [1]. A faint afterglow was detected by the X-Ray Telescope (XRT) $\sim$ 86 s after the burst and monitored for the following 6 days. Although the burst location was promptly observed by ground-based telescopes (*e.g.*, at $T + 52\,\mathrm{s}$ by the ROTSE-IIIb telescope) [2] and by the UVOT (at $T + 84\,\mathrm{s}$) [3], no optical counterpart was detected.

A nearby ($z = 0.08$) barred spiral galaxy has been proposed by [4] as the putative host galaxy. The field of GRB 051109B was then re-observed by Swift on Aug 2006 but no late-time X-ray emission was seen in the 17 ks exposure PC image with a 3σ upper limit of $9.8 \times 10^{-4}\,\mathrm{cts\,s^{-1}}$.

2. – Swift data

The time-averaged spectrum of the prompt emission is well fit by a simple power law with a photon index of 1.9 ± 0.3. A cut-off power law or a Band model do not improve significantly the fit, however fixing the first index α of the Band function -1, we put an upper limit to the peak energy of 70 keV at the 90% confidence level. The fluence in the 15–150 keV energy band is $\sim 2.1 \times 10^{-7}\,\mathrm{erg\,cm^{-2}}$ and, using the redshift value of

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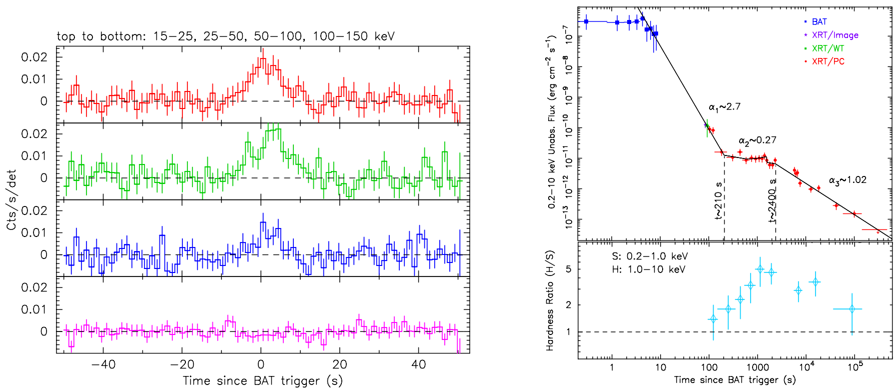

Fig. 1. – GRB 051109B light curves in different BAT energy bands (left) and 0.2–10 keV light curve as observed with BAT and XRT (right). Also shown in the lower panel the XRT/PC hardness ratio light curve.

0.08, we put a lower limit of $\sim 3 \times 10^{48}$ erg to the isotropic energy. Extrapolating the power law model in the whole 1–10^4 keV (rest frame) band we computed an upper limit of $E_{\mathrm{iso}} < 1.3 \times 10^{49}$ erg. The average XRT spectrum can be modeled with an absorbed power law of $N_H = (0.22 \pm 0.6) \times 10^{22}\,\mathrm{cm}^{-2}$ and a photon index $\Gamma = 2.1 \pm 0.2$. The fluence emitted by the afterglow in the X-ray band is $\sim 3.5 \times 10^{-7}\,\mathrm{erg\,cm}^{-2}$, comparable to that of the prompt emission.

The combined BAT and XRT light curve, shown in fig. 1, displays many of the features seen by Swift for other GRBs. The X-ray hardness ratio (fig. 1) shows a spectral evolution between the three standard phases of the afterglow emission, in particular a hardening related to the small flare peaking at $\sim T + 1500$ s. From spectral and timing analysis we derived a spectral index p of the radiating electrons of ~ 2.1 for $\nu_{\mathrm{X}} > \nu_{\mathrm{c}}$.

3. – Discussion

Due to the narrow energy band of the Swift BAT, it is hard to costrain low peak energy values, however the lack of emission above 100 keV and the soft spectral index of the prompt emission suggest GRB 051109B can be identified, at least, as an XRR burst.

The X-ray lightcurve has a well known shape: an initial fast decay in the first 200 s, interpreted as off-axis prompt emission; a plateau, attributed to energy injection into the afterglow; a final decay of index ~ 1 in agreement with standard afterglow models. Using our best fit model and the data reported in [5], corrected for extinction, we found $F_X \sim 3.7 \times 10^{-13}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ and a $F_{\mathrm{opt}} \sim 11\,\mu$Jy at $T + 11$h. We verified that GRB 051109B lies well above the region of dark bursts defined in [6].

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