

Swift Observations of GRB 070521

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1 Revisions

- Updated XRT light curve with data up to 4.9×10^5 s.
- Addition of E_p from Konus/*Wind* spectrum.

2 Introduction

BAT triggered on GRB 070521 at 06:51:10 UT (Trigger 279935) (Guidorzi *et al.*, *GCN Circ.* 6431). This was a 1.024-s rate-trigger on a long burst. XRT observations began at $T + 77$ s and discovered the X-ray afterglow. UVOT began observing at $T + 82$ s and did not find any optical counterpart. Our best position is the XRT location calibrated with UVOT astrometry RA(J2000)= 242.6608 deg ($16^{\text{h}}10^{\text{m}}38.60^{\text{s}}$), Dec(J2000)= $+30.2560$ deg ($+30^{\text{d}}15'21.8''$) with an error of 1.7 arcsec (90% confidence).

Konus/*Wind* detected GRB 070521, which showed strong spectral evolution. The spectrum extracted over the 80% of the total counts was fit with a cutoff power-law model, with a peak energy $E_p = 222_{-21}^{+27}$ keV and a power-law photon index $\alpha = 0.93 \pm 0.12$ (90% confidence; Golenetskii *et al.*, *GCN Circ.* 6459).

3 BAT Observation and Analysis

Using the data set from $T - 240$ s to $T + 377$ s from recent telemetry downlinks, the BAT ground-calculated position is RA(J2000) = 242.659 deg ($16^{\text{h}}10^{\text{m}}38.1^{\text{s}}$), Dec(J2000)= $+30.261$ deg ($+30^{\text{d}}15'37.9''$) with an uncertainty of 1.1 arcmin (radius, sys+stat, 90% containment). The partial coding was 47%.

The mask-weighted light curve shows five main peaks the first of which starts at $\sim T - 10$ s and the last ends at $\sim T + 50$ s. T_{90} (15–350 keV) is 37.9 ± 2 s (estimated error including systematics).

The time-averaged spectrum from $T - 14.5$ s to $T + 49.7$ s is best fit by a power law with an exponential cutoff. This fit gives a photon index 1.10 ± 0.17 , and E_p of 195 ± 123 keV ($\chi^2/\text{dof} = 50/56$). For this model the total fluence in the 15–150 keV band is $(8.0 \pm 0.2) \times 10^{-6}$ erg cm^{-2} and the 1-s peak flux measured from $T + 30.48$ s in the 15–150 keV band is 6.7 ± 0.3 ph $\text{cm}^{-2} \text{s}^{-1}$. A fit to a simple power law gives a photon index of 1.38 ± 0.04 ($\chi^2/\text{dof} = 58/57$). All the quoted errors are at the 90% confidence level (Palmer *et al.*, *GCN Circ.* 6440).

4 XRT Observations and Analysis

Using 3 intervals of overlapping XRT/UVOT V-band data totalling 866 s of GRB 070521 (Guidorzi *et al.*, *GCN Circ.* 6452) the refined XRT position, using the UVOT to astrometrically correct the XRT field, assuming a fixed mapping between the XRT and UVOT instruments, is RA(J2000) = 242.6608 deg ($16^{\text{h}}10^{\text{m}}38.60^{\text{s}}$), Dec(J2000)= $+30.2561$ deg ($+30^{\text{d}}15'21.8''$) with an error radius of 1.7 arcsec (90% confidence). The UVOT astrometry is performed relative to USNOB1.

This is 6.6 arcsec from the initial X-ray position (Guidorzi *et al.*, *GCN Circ.* 6431), 4.0 arcsec from the XRT position notice, and 17 arcsec from the BAT refined position (Palmer *et al.*, *GCN Circ.* 6440). Among the optical sources proposed (Ofek *et al.* *GCN Circ.* 6433, Hattori *et al.* *GCN Circ.* 6444, Perley *et al.* *GCN Circ.* 6451), we note that the closest one is the Keck S3 (Perley *et al.*, *GCN Circ.* 6451) lying 2.0 arcsec away.

The XRT light curve (Fig. 2) of the final dataset, which includes 62 ks total exposure in PC mode and lasts up to $T + 4.9 \times 10^5$ s, shows an initial flaring behaviour followed by a power-law decay. More specifically, we modelled it with a single component of the model by Willingale *et al.* (2007)[1]: we fixed the rise time $t_c = 0$, because this must have occurred prior to the XRT observations. The remaining best-fit parameters were found to be $\alpha_c = 1.70^{+0.08}_{-0.06}$ (final power-law index) and $T_c = 7.0^{+0.9}_{-0.7}$ ks (when the power-law component takes over). The fit is not very good ($\chi^2/\text{dof} = 110.5/86$; null hypothesis probability of 3.8%) due to the initial flares (90% confidence intervals).

We extracted a spectrum of the PC data from $T + 4.7$ ks to $T + 13$ ks. This can be fit with an absorbed power law with a photon index of 2.11 ± 0.16 and column density of $(7 \pm 1) \times 10^{21} \text{ cm}^{-2}$ significantly in excess of the Galactic value ($2.8 \times 10^{20} \text{ cm}^{-2}$; Dickey & Lockman, 1990).

The absorbed (unabsorbed) 0.3–10.0 keV flux for that spectrum is 1.6×10^{-11} (3.2×10^{-11}) $\text{ergs cm}^{-2} \text{ s}^{-1}$.

Detailed light curves in both count rate and flux units are available in both graphical and ASCII formats at http://www.swift.ac.uk/xrt_curves/.

5 UVOT Observation and Analysis

The UVOT observed the field of GRB 070521 starting at $T + 82$ s. We do not find any source in any of the UVOT observations inside the refined XRT error circle (Guidorzi *et al.*, *GCN Circ.* 6452).

The $3\text{-}\sigma$ upper limits for detecting a source in the first finding chart (FC) exposure and co-added frames are reported in Table 1 (Marshall & Guidorzi, *GCN Circ.* 6454).

The values are not corrected for the expected Galactic extinction corresponding to a reddening of $E_{B-V} = 0.03$ mag towards the direction of the burst (Schlegel *et al.* 1998).

Filter	Start (s)	End (s)	Exposure (s)	Mag
White (FC)	82	182	98	>20.6
White	82	24605	1884	>22.3
V	187	17181	1451	>20.4
B	5304	23879	1967	>22.0
U	5099	22968	1278	>21.7
UVW1	4894	18810	1111	>21.1
UWM2	4869	18085	1279	>20.8
UVW2	5713	12897	792	>21.1

Table 1: $3\text{-}\sigma$ upper limits from UVOT observations.

References

- [1] Willingale, R. *et al.* 2007, *ApJ*, accepted (astro-ph/0612031)

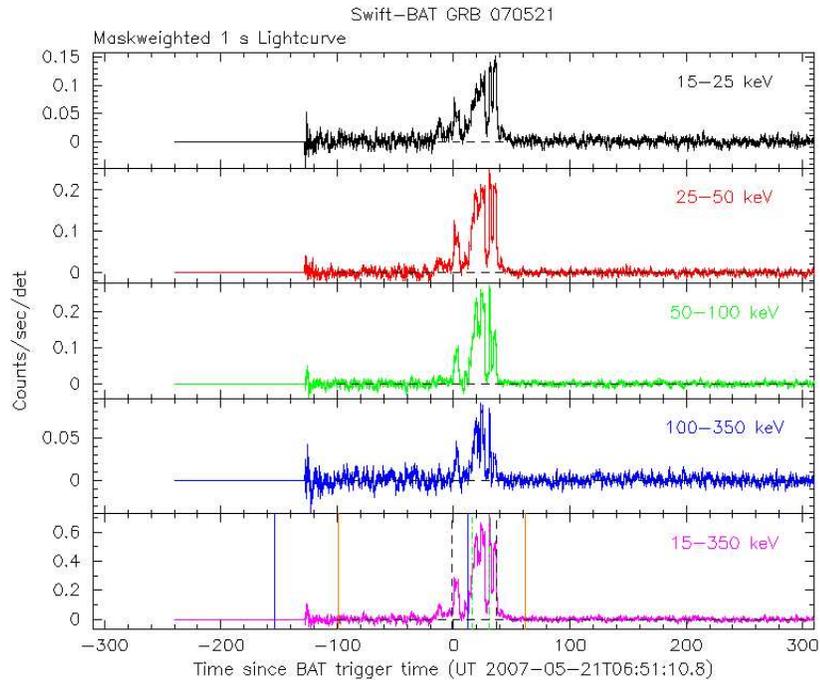


Figure 1: BAT Light curve. The mask-weighted light curve in the 4 individual plus total energy bands. The units are counts/s/illuminated-detector (note illum-det = 0.16 cm^2) and T_0 is 06:51:10 UT.

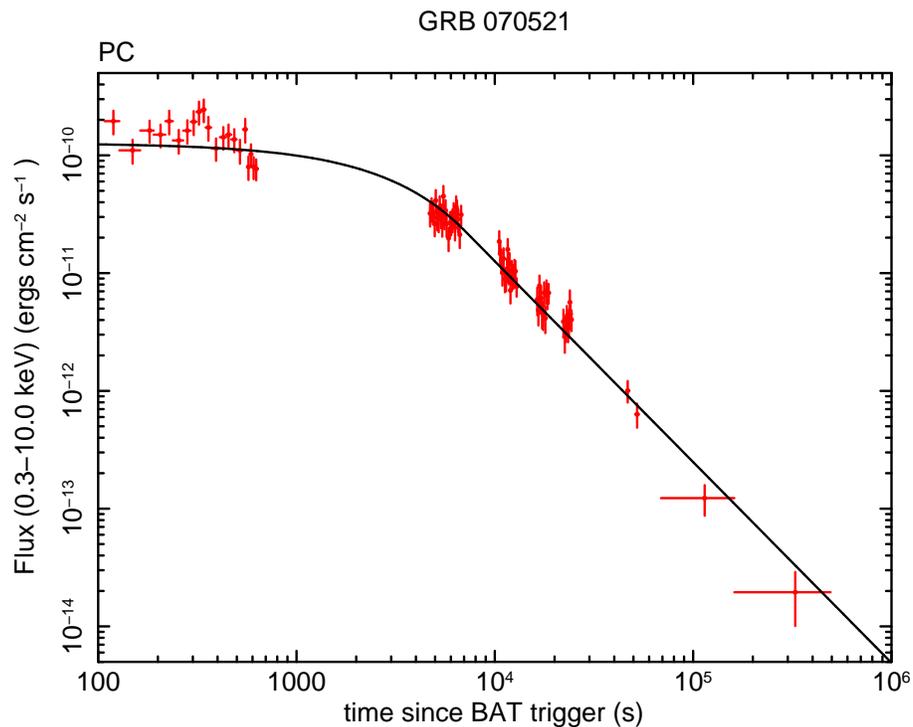


Figure 2: XRT Lightcurve. Flux in the 0.3-10 keV band: Photon Counting mode. The approximate conversion is $1 \text{ count/s} \sim 5.9 \times 10^{-11} \text{ erg cm}^{-2} \text{ s}^{-1}$.