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The flaring afterglow of GRB 050730(*)

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Summary. — We present a detailed spectral and temporal analysis of *Swift* and *XMM-Newton* observations of GRB 050730. The X-ray afterglow of GRB 050730 was found to decline with time with intense flaring activity superimposed. Evidence of flaring activity in the early UVOT optical afterglow, simultaneous with that observed in the X-ray band, was found. Strong spectral evolution in the X-ray energy band during the flaring activity was present.

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

The Gamma-Ray Burst (GRB) 050730 was discovered and located by the BAT instrument on-board *Swift* at $T_0 = $ 19:58:23 UT on 2005 July 30 [1]. The prompt emission light curve was characterized by a duration of $T_{90} = 155 \pm 20\,\mathrm{s}$. *Swift* UVOT and XRT began to observe the field of GRB 050730 about 120 seconds after the BAT trigger. The X-ray afterglow of GRB 050730 was also observed with *XMM-Newton* starting ~ 7 hours after the trigger for a net exposure time of about 25 ks.

The X-ray afterglow of GRB 050730 is characterized by a very complex temporal structure with intense and extended flaring activity (see fig. 1). We modeled the XRT and *XMM-Newton* light curve with a double-broken power law model with slopes α_1, α_2, α_3 and temporal breaks t_1, t_2, describing the underlying power law decay of the afterglow,

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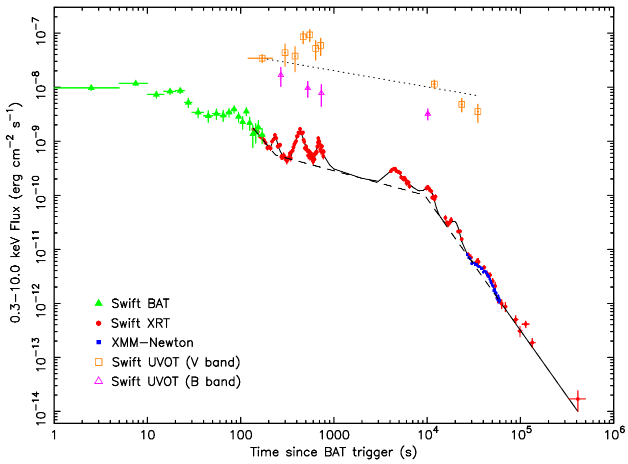

Fig. 1. – *Swift* BAT, UVOT, XRT and *XMM-Newton* light curve of GRB 050730. UVOT optical data have been arbitrarily scaled for comparison with the X-ray band. The solid line is the best-fit model to the XRT and *XMM-Newton* light curve. The dashed line represents the underlying double-broken power law decay. The dotted line is a power law model with decay index $\alpha = 0.3$.

plus seven Gaussian functions modeling the flaring episodes. We found for the first power law a decay index $\alpha_1 = 2.1 \pm 0.3$ followed, after a first time break at $t_1 = 237 \pm 20\,\mathrm{s}$, by a shallower decay with index $\alpha_2 = 0.44^{+0.14}_{-0.08}$. A second temporal break is found at $t_2 = 10.1^{+4.6}_{-2.2}\,\mathrm{ks}$ followed by a steep decay with index $\alpha_3 = 2.40^{+0.09}_{-0.07}$. The early ($T_0 + 200\,\mathrm{s}$–$T_0 + 800\,\mathrm{s}$) UVOT V light curve presents flaring activity at $\sim T_0 + 500\,\mathrm{s}$, almost simultaneously with the brightest X-ray flare observed with XRT.

The 0.3–10 keV XRT average spectrum from $T_0 + 133\,\mathrm{s}$ to $T_0 + 794\,\mathrm{s}$ (first *Swift* orbit) is well fit by a single power law model with photon index $\Gamma = 1.70 \pm 0.03$ and an excess absorbing column density of $N_{\mathrm{H}}^{z} = (1.28^{+0.26}_{-0.25}) \times 10^{22}\,\mathrm{cm}^{-2}$, in the rest frame of the GRB host ($z = 3.969$ [2]). We also split the first *Swift* orbit in seven distinct time intervals to study the spectral evolution during the rise and the decay portions of each flare. The

Table I. – *Results of single power-law spectral fits to the 0.3–10 keV spectrum of the first Swift orbit of the GRB 050730 afterglow. A local ($z = 0$) absorption column fixed at the known Galactic value of $N_{\mathrm{H}}^{\mathrm{G}} = 3.0 \times 10^{20}$ cm^{-2}* [3] *was used in the fits.*

Segment	Time interval (s)	$N_{\mathrm{H}}^{z} \times 10^{22}$ (cm^{-2})	Γ	χ^2_r (d.o.f.)
Initial decay	133–205	$1.8^{+0.9}_{-0.8}$	$1.42^{+0.08}_{-0.08}$	0.86 (76)
Rise flare 1	205–233	$1.6^{+2.5}_{-1.6}$	$1.29^{+0.16}_{-0.16}$	0.86 (24)
Decay flare 1	233–313	$3.1^{+1.3}_{-1.1}$	$1.82^{+0.12}_{-0.12}$	1.30 (51)
Rise flare 2	313–433	$2.1^{+0.8}_{-0.7}$	$1.71^{+0.08}_{-0.08}$	1.10 (93)
Decay flare 2	433–601	$0.9^{+0.5}_{-0.5}$	$1.70^{+0.07}_{-0.07}$	1.11 (111)
Rise flare 3	601–681	$0.7^{+0.8}_{-0.7}$	$1.77^{+0.12}_{-0.12}$	0.87 (46)
Decay flare 3	681–781	$1.0^{+0.6}_{-0.6}$	$2.01^{+0.10}_{-0.10}$	0.81 (65)

time-resolved spectral best fits (see table I) clearly show evidence for spectral variation during the flares and an overall softening of the spectra with time associated with a decrease of the rest frame column density.

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