BOOTES Observation of GRB 080603B

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Abstract

We report on multicolor photometry of long GRB 080603B afterglow from BOOTES-1B and BOOTES-2. The optical afterglow has already been reported to present a break in the optical lightcurve at 0.12 ± 0.2 days after the trigger. We construct the lightcurve and the spectral energy distribution and discuss the nature of the afterglow.

Keywords: gamma-ray bursts, individual, GRB 080603B.

1 Introduction

GRB 080603B was a long gamma-ray burst detected on June 3, 2008, at 19:38:13 UT by *Swift*-BAT [14]. The burst was also detected by *Konus*-WIND [5] and *INTEGRAL*-SPI/ACS [18].

In X-rays, the afterglow was detected by *Swift*-XRT, providing a rapid and precise localization [13].

The optical afterglow was observed by several telescopes – ROTSE III [19], TAROT [9–11], TLS Tautenburg [8], RTT150 [24], the Liverpool Telescope [15], Xinglong EST [23], the 1.0 m telescope at CrAO [21, 20], the 1.5 m telescope of Sayan observatory [12] and from Maidanak [6]. In infrared by PAIRITEL [16], spectroscopy was obtained by the NOT [4] and the Hobby-Eberly Telescope [2], providing a redshift of $z = 2.69$.

An upper limit on radio emission was set by the VLA [1].

2 Observations

At both BOOTES stations, the GRB happened during twilight, delaying follow-up by $\sim$ 1 h. Despite the delay, the optical afterglow is well detected in the data from both telescopes.

The 60 cm telescope BOOTES-2/TELMA, in La Mayora, Málaga, Spain, started taking data at 20:29:19 UT, i.e. 51 minutes after the GRB trigger. A sequence of r'-band exposures was taken, and later, after confirming the detection of the optical transient, i', g' and Y band images were obtained. In the near infrared Y band, despite 600 s of integration, the afterglow was not detected.

The 30 cm telescope BOOTES-1B, located in El Arenosillo, Huelva, Spain, [7] obtained 368 unfiltered images totalling more than 6 hours of integrated light until the end of the night. The images were combined to improve signal-to-noise, to yield 11 data points for the period between 1.2 and 5.2 hours after the GRB. One point has a large error due to clouds crossing the field of view.

The best fit astrometric position of the afterglow, obtained from the weighted average of all available images from BOOTES-2 is

$$\alpha = 11:46:07.73 \quad \delta = +68:03:39.9 \quad (J2000),$$

about 1.6° SE from star λ Dra.

Photometry was done in the optimal aperture using IRAF/Daophot. Calibration was performed against three SDSS (DR8) [3] stars. The stars are marked on the identification chart (Figure 3) and their brightnesses are in the Table 1. Our unfiltered, “Clear”, best fit magnitude Clear=$A_1 * g' + A_2 * r'$ used for BOOTES-1B calibration is also mentioned.

For the summary of our observations, see Table 2.

Table 1: Calibration stars used

ID.	g'	r'	i'	Clear
1	18.00	17.50	17.32	17.52
2	18.80	17.35	16.04	17.35
3	19.88	18.42	17.09	18.47

3 Fitting the lightcurve

The lightcurve, as already shown by [24] shows a smooth transition between two decay slopes $\alpha_1 = -0.55 \pm 0.16$ and $\alpha_2 = -1.23 \pm 0.22$. The break occurs at $t_b = 0.129 \pm 0.016$ days.

There is no hint of chromatic evolution within the lightcurve, so all filters were scaled and fitted together with the r'-band. The fitting of the lightcurve was performed in $\log t / \log f$ space, where power law functions, typical for gamma-ray bursts, show as straight lines. We used a hyperbolic transition between two slopes (smoothly broken power-law):

Table 2: Optical photometric observations of the optical afterglow of the GRB 080603B

UT Date of mid exp.	$T - T_0$ [h]	tel.	filter	T_{exp} [s]	mag	δ mag
Jun 3.855805	0.902	B-2	r'	3×120 s	17.46	0.07
Jun 3.859348	0.987	B-2	r'	2×120 s	17.59	0.13
Jun 3.862188	1.056	B-2	r'	2×120 s	17.31	0.05
Jun 3.864311	1.107	B-2	r'	120 s	17.57	0.08
Jun 3.865747	1.141	B-2	r'	120 s	17.30	0.07
Jun 3.867151	1.175	B-2	r'	120 s	17.46	0.06
Jun 3.868946	1.218	B-1B	Clear	10×60 s	17.53	0.07
Jun 3.870011	1.243	B-2	g'	3×120 s	18.29	0.04
Jun 3.874248	1.345	B-2	g'	3×120 s	18.24	0.04
Jun 3.876758	1.405	B-1B	Clear	10×60 s	17.54	0.06
Jun 3.879225	1.465	B-2	g'	4×120 s	18.14	0.03
Jun 3.884248	1.585	B-2	r'	3×120 s	17.50	0.09
Jun 3.884664	1.595	B-1B	Clear	10×60 s	17.70	0.06
Jun 3.889912	1.721	B-2	r'	3×120 s	17.70	0.15
Jun 3.892654	1.787	B-1B	Clear	10×60 s	17.75	0.06
Jun 3.893455	1.806	B-2	r'	4×120 s	17.74	0.06
Jun 3.899839	1.959	B-2	g'	5×120 s	18.42	0.19
Jun 3.900620	1.978	B-1B	Clear	10×60 s	17.79	0.06
Jun 3.906961	2.130	B-2	g'	5×120 s	18.42	0.04
Jun 3.908509	2.167	B-1B	Clear	10×60 s	17.87	0.09
Jun 3.914867	2.320	B-2	r'	4×120 s	18.15	0.13
Jun 3.916482	2.359	B-1B	Clear	10×60 s	17.91	0.11
Jun 3.922694	2.508	B-2	i'	5×120 s	17.89	0.05
Jun 3.931774	2.726	B-2	r'	7×120 s	18.01	0.06
Jun 3.934988	2.803	B-1B	Clear	35×60 s	18.30	0.32
Jun 3.940845	2.943	B-2	i'	5×120 s	17.88	0.07
Jun 3.947882	3.112	B-2	r'	5×120 s	18.12	0.08
Jun 3.956941	3.330	B-1B	Clear	20×60 s	18.45	0.07
Jun 3.971736	3.685	B-1B	Clear	21×60 s	18.38	0.06
Jun 3.977109	3.814	B-2	r'	5×120 s	18.26	0.18
Jun 4.006997	4.531	B-1B	Clear	78×60 s	18.79	0.07

$$h(a,b) = a + \frac{b}{2}\sqrt{1+\frac{a^2}{b^2}}$$

$$m(t) = m_0 - 2.5\alpha_2 \log\frac{t}{t_b} + h(-2.5(\alpha_1-\alpha_2)\log\frac{t}{t_b}, G)$$

where α_1 and α_2 are pre-break and post-break decay indices, t_b is the break time, m_0 is an absolute scaling parameter of the brightness and G expresses smoothness of the break.

Although the early point by ROTSE [19] was not used, it agrees with the backward extrapolation of the α_1 slope and so supports this simple interpretation.

We constructed a spectral energy distribution (SED) by fitting the needed magnitude shift of the R-band lightcurve model to the photometric points from BOOTES, UVOT [14] and PAIRITEL [16] obtained in other filters. While the points from UVOT are practically contemporaneous to BOOTES, PAIRITEL observed rather later (0.32 days after the trigger), so the SED is therefore model-dependent in its infrared part. The synthetic AB magnitudes equivalent to $t = 0.1$ days are in Table 3.

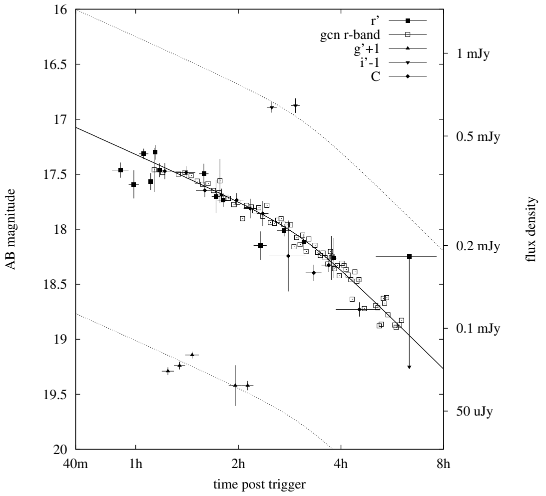

Fig. 1: Detail of the optical light curve of GRB 080603B showing the observations by BOOTES (filled symbols) and from the literature (empty symbols)

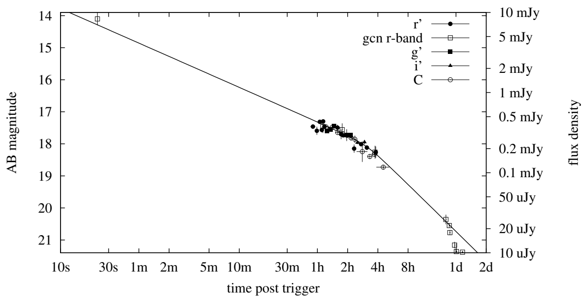

Fig. 2: Overall view of the light curve of GRB 080603B

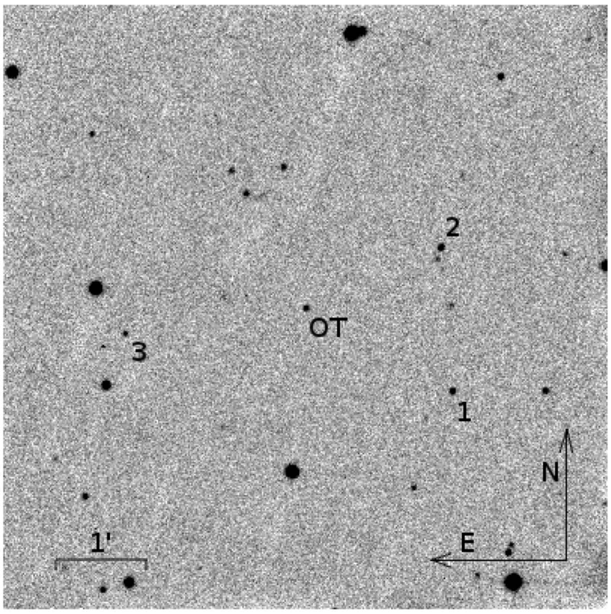

Fig. 3: The finding chart of the afterglow of GRB080603B. Combination of images taken by BOOTES-2

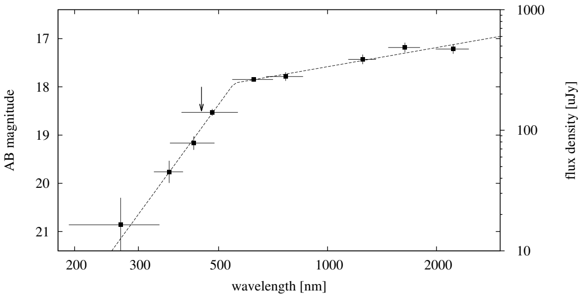

Fig. 4: The spectral energy distribution of the afterglow in rest frame. The small arrow marks Ly-α position for $z = 2.69$

Table 3: The spectral energy distribution in AB magnitudes equivalent to 0.1 days after the trigger. († UVOT, ‡ PAIRITEL)

Filter	$m_{\rm AB}$	$\Delta m_{\rm AB}$
W†	20.98	0.56
U†	19.83	0.23
B†	19.22	0.14
g'	18.57	0.07
r'	17.88	0.05
i'	17.81	0.09
J‡	17.44	0.10
H‡	17.19	0.10
K‡	17.22	0.10

The SED shows a clear suppression of radiation above 4 500 Å, i.e. a redshifted Ly-α line. No radiation is detected above the Lyman break at 3 365 Å. A rather shallow power law with an index $\beta = -0.53 \pm 0.06$ was found redwards from r' band. The fit was performed using the $E(B-V) = 0.013$ mag [22].

The strong suppression of light for wavelengths shorter than r' band is likely due to the Ly-α absorption within the host galaxy and Ly-alpha line blanketing for $z = 2.69$.

4 Discussion

The values of $\alpha_2 = -1.23 \pm 0.22$ and $\beta = -0.53 \pm 0.06$ both point to a common electron distribution parameter $p = 2.05 \pm 0.20$ ($\alpha = (3 * p - 1)/4$, $\beta = (p-1)/2$) [17]. Such a combination suggests a stellar wind profile expansion and a slow cooling regime.

The pre-break decay rate $\alpha_1 = -0.55 \pm 0.16$ remains unexplained by the standard fireball model. It is unlikely that the break at $t_b = 0.129 \pm 0.016$ would be a jet break. It is quite possible that the plateau is not really a straight power law, and that some late activity of the inner engine may be producing bumping of hydrodynamic origin.

We note that the literature contains a number of observations suggesting a rapid decay by about one day after the GRB. Without having all the images, it is, however, impossible to decide whether this is a real physical effect or a zero-point mismatch.

5 Conclusions

The 0.6 m telescope BOOTES-2 in La Mayora observed the optical afterglow of GRB 080603B in three filters. The 0.3 m BOOTES-1B in El Arenosillo observed the same optical afterglow without a filter.

Using the data we obtained at BOOTES and from the literature, we construct the lightcurve and broadband spectral energy distribution.

Our fit of the obained data privides the decay parameters $\alpha_2 = 1.23 \pm 0.22$ and $\beta = -0.53 \pm 0.06$, which suggest a slow cooling expansion into a stellar wind.

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