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BVR_cI_c light curves of GRB 970508 optical remnant and magnitudes of underlying host galaxy

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Abstract. The observations with the SAO-RAS 6-m telescope in July-August 1998 show that the GRB 970508 optical remnant has varied very little since November 1997. We can conclude that we observe a proper host galaxy without a GRB optical remnant. The fitting results of the light curve of the GRB remnant plus the host galaxy until about 400 days after the primary event are reported here. The best χ^2-fits with a power law, for most of the filters used, are not acceptable. Some intrinsic variability of the GRB optical remnant fading is possible, which demands a more complex law presenting the largest multiband homogeneous data set from a single telescope.

Key words: gamma-rays: bursts — galaxies: photometry

The GRB 970508 OT is the second optical source related to a gamma-ray burst registered by the BeppoSAX satellite. The optical variable object was first reported by H. Bond as a possible optical counterpart of GRB 970508 (Bond 1997) and was independently found in our data (R_c band, 1-m telescope) only about 0.5 day later. Observations of the GRB 970508 optical remnant were continued with the 6-m telescope in the standard BVR_cI_c bands till Aug. 1998 (Sokolov et al. 1999).

The BVR_cI_c magnitudes of the optical counterpart did not already change in magnitude error range during the last half-year from November 1997 to August 1998. We can conclude that we observe a pure host galaxy without the optical remnant of GRB 970508. If the brightness changes within the errors, and the brighness decay of the optical remnant can still be described by a power-law relation for about a year after the burst occurence, then the flux can be determined by fitting the observed BVR_cI_c light curves with a two-component model, the sum of the GRB 970508 optical remnant fading according to a power-law, and a constant brightness of the host galaxy: $F = F_o \times t^\alpha + F_c$. To investigate the possible variability of a faint source, one should avoid any systematic shifts in the observational data due to different photometric systems in various instruments. That is why, for these fits we used the homogeneous data set from the 6-m telescope only. In Table 1 the host galaxy magnitudes and fluxes are presented for 3 cases: (1) the proper late-time BVR_cI_c observations in Jul.- Aug. 1998 without any fits, (2) the fits with different slopes and corresponding χ^2/(d.o.f), (3) the same χ^2 fits with an average power-law slope $<\alpha>= -1.25 \pm 0.05$. So, in cases (2) and (3) we indicated not observed, but some theoretical values for some model fits and fluxes corresponding to t tending to infinity.

Table 1. Magnitudes and fluxes for the host galaxy of GRB 970508. **(1)** The late-time observational magnitudes in Jul.-Aug. 1998. **(2)** χ^2 fits: $F = F_o \times t^\alpha + F_c$ with $\alpha_B = -1.32 \pm 0.05$, $\alpha_V = -1.24 \pm 0.07$, $\alpha_{R_c} = -1.25 \pm 0.04$, $\alpha_{I_c} = -1.18 \pm 0.07$. **(3)** The χ^2 fits for $<\alpha>= -1.25 \pm 0.05$

Band	Magnitude	log F_c $\left(\frac{\text{erg}}{\text{cm}^2\ \text{s}\ \text{Å}}\right)$	$\frac{\chi^2}{\text{(d.o.f)}}$
(1)			
B	25.77 ± 0.19	-18.52 ± 0.07	
V	25.25 ± 0.22	-18.54 ± 0.09	
R_c	24.99 ± 0.17	-18.66 ± 0.07	
I_c	24.07 ± 0.25	-18.58 ± 0.10	
(2)			
B	25.99 ± 0.11	-18.60 ± 0.05	14.2/11
V	25.65 ± 0.17	-18.70 ± 0.07	36.6/14
R_c	25.16 ± 0.09	-18.73 ± 0.04	52.7/19
I_c	24.17 ± 0.28	-18.62 ± 0.11	44.3/12
(3)			
B	26.15 ± 0.16	-18.67 ± 0.06	18.9/12
V	25.61 ± 0.16	-18.69 ± 0.07	36.1/15
R_c	25.16 ± 0.09	-18.73 ± 0.04	52.7/20
I_c	23.99 ± 0.25	-18.55 ± 0.10	47.1/13

The light curves for case (2) are presented in Fig. 1. From large χ^2 values we conclude that a single power law plus a constant is not a good approximation of all observational data. On the other hand, we have shown (Sokolov et al. 1998) that in the first days after the maximum the χ^2 best fit was not a power law ($\chi^2 = 4.5/7$) but an exponential one ($\chi^2 = 0.97/7$). The identical exponential brightness fading was observed in 4 bands simultaneously. It is during the exponential flux decrease about 4 days after the maximum that the GRB 970508 optical remnant has a stable power law spectrum with a slope -1.10 ± 0.08 (Metzger et al. 1997; Sokolov et al. 1998; Zharikov et al. 1998).

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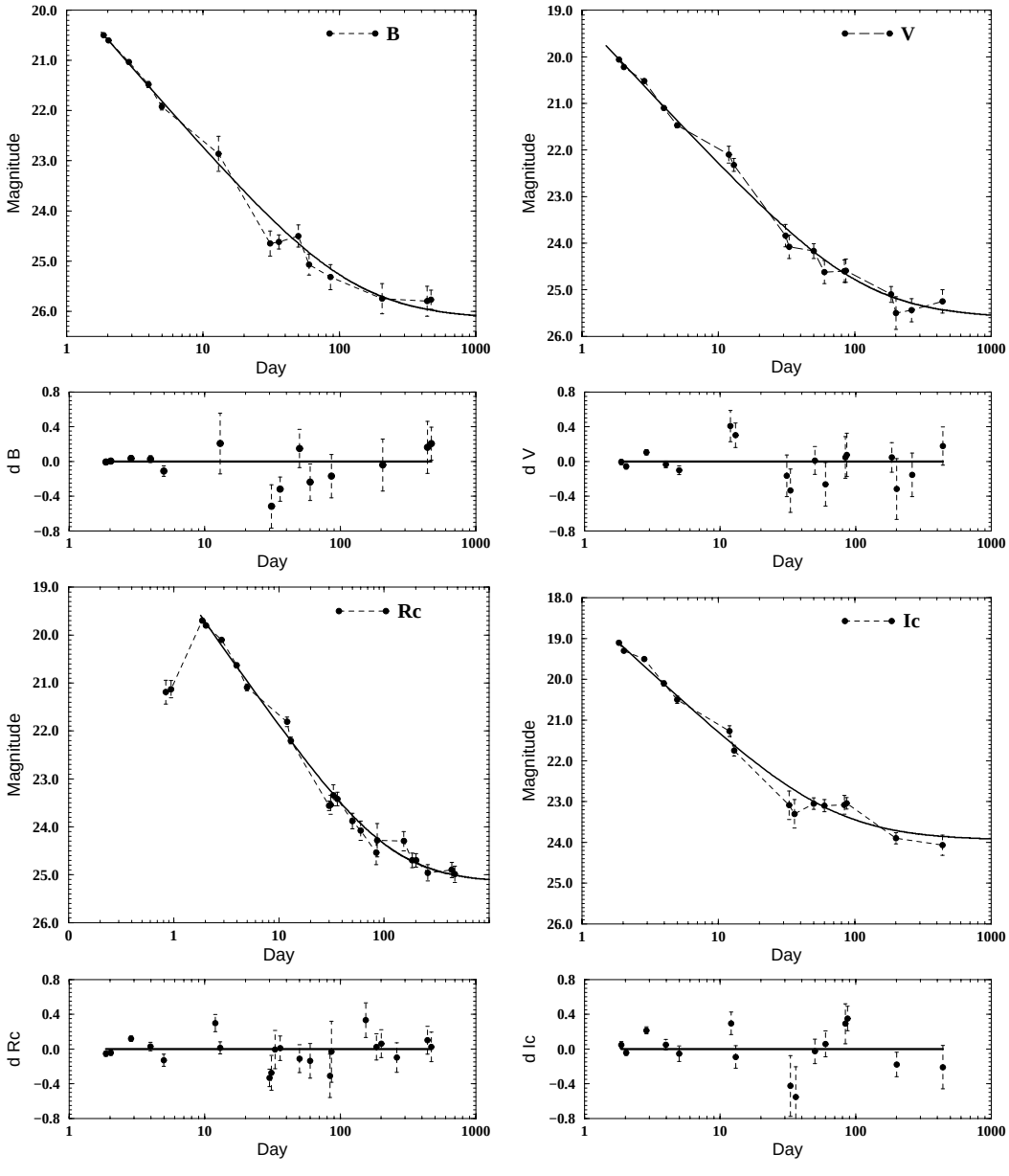

Fig. 1. The BVR_cI_c light curves of the GRB 970508 optical remnant. The lines correspond to $F = F_o \times t^\alpha + F_C$ fits for each band, t is time from the GRB trigger. The lower panels: the fits to the power law plus constants subtracted from the observational data

The disregarding of these 5 points in Fig. 1 in all BVR_cI_c bands or (which is the same) an arbitrary increase of observational errors $3-4$ times does not improve considerably the fitting with $F = F_o \times t^\alpha + F_c$. In particular, elimination of 5 points (with the smallest uncertainties, $0.03-0.07$ mag) immediately after the brightness maximum in R_c band in Fig. 1 yields $\chi^2/(\text{d.o.f}) = 16.8/14$. So a further intrinsic variability fading of the GRB 970508 optical remnant is possible, which demands a more complex law for the presenting of all multiband BVR_cI_c data set.

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