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Optical follow-up of GRB afterglows from UPSO, Naini Tal

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Abstract. Successful optical photometric observations of five GRB afterglows namely GRB 990123, GRB 991208, GRB 991216, GRB 000301c and GRB 000926 have been carried out from State Observatory Naini Tal till 2000. The results and light curve parameters of these GRBs are summarised here. The optical light curves of these GRBs exhibit break (i.e., early and late time power law decay with different indices) generally around 2 days after the burst. The observed steepening in the afterglow light curves may be due to non-isotropic emission from the burst ejecta in the course of time. The non-isotropic energy emission from these GRBs is $\leq 10^{52}$ ergs and can be understood in terms of current popular models for the origin of GRBs.

1. Introduction

Gamma-Rays Bursts (GRBs) are short and intense flashes of cosmic high energy (10 KeV-10GeV) photons. The study of GRBs was revolutionized after BeppoSAX started providing positions of some GRBs with the accuracy of a few arcminutes within a few hours of the burst. External shocks from the central engine of the GRB which after colliding with the circumsteller matter slows down the ejecta is believed to produce the afterglows of X-rays followed by UV, optical, IR, millimetre and radio which losts for months. This appears to provide a good description of the properties of the GRB afterglows observed so far. Multi-wavelength observations of GRB afterglows are of crucial importance for understanding and constraining the active emission mechanisms of GRBs as well as for study of nature, structure and composition of their surroundings. Optical transient (OT) of a GRB usually has apparent R magnitude between 18-22, if it is detected within a day or so after the burst. The 1-m class optical telescopes equipped with modern CCD detector are therefore capable of observing them. Hence State Observatory, Naini Tal started optical follow-up observations of GRB afterglows in 1999 under an international collaborative programme coordinated by one of us (AJCT) using the 104 - cm Sampurnanand telescope equipped with modern CCD camera. We present here the parameters of those five GRB afterglows whose successful photometric observations have been carried out from State Observatory till 2000. Details of observations, data reductions and analysis can be found in our earlier papers (cf. Sagar et. al. 1999, 2000a, 2000b, 2001).

2. Results and discussions

All published data on the GRB afterglows discussed here in combination with our measurements are used to study their optical flux decay and spectral indices. A break in the optical light curve is clearly seen in the case of GRB 990123 (Castro-Tirado et al., 1999, Kulkarni et al., 1999), GRB 991216 (Halpern et al., 2000, Sagar et al., 2000a), GRB 000301c (Berger et al., 2000, Sagar et al., 2000b) and GRB 000926 (Sagar et al., 2001, Price et al., 2001). In the case of GRB 991208 (Sagar et al., 2000a), it appears that all published observations have been carried out after the occurrence of the break. The values of optical flux decay constants and spectral indices for the GRB afterglows under discussion are listed in Table 1. The steepening in the optical light curves occurred within 2.5 days in all cases, except in the case of GRB 000301c where it is 7.5 days. The values of spectral indices have not shown any change corresponding to the break in the light curve. In addition to break in the light curve, GRB 000301c shows a short term flare type variability. The overall flux decay in observed optical light curves can be understood either in terms of transition of burst ejecta from relativistic to non-relativistic expansion (Dia and Lu, 2000) or in terms of collimated ejection, where the observed light curve breaks and steepens when the Lorentz factor for expansion drops below the inverse jet opening angle (Rhoads 1999). The GRBs under discussion have their gamma-ray fluence > 10^{-6} erg/cm^2 and the isotropic energy emission ≥ 10^{53} erg. Observed breaks in the optical light curves of the GRBs under discussion with no corresponding change in spectral index are attributed to the presence of jets in the bursts. The emission from these GRBs, are therefore non-isotropic due to a finite opening angle of jets. Due to this non-isotropic emission the energy emission from all observed GRBs reduces to ≤ 10^{52} erg. Such energy values then become compatible with the predictions of current popular stellar death models for the origin of GRBs (Piran 1999).

Table 1. Parameters of GRB afterglows under discussion, the α_1 and α_2 are early and late time optical flux decay constants (i.e., $F(t) \propto t^{-\alpha}$). t_b (days) is time when flux decay changes it's slope and β is spectral index (i.e. $F(\nu) \propto \nu^{-\beta}$) at particular epoch Δt. All times are in days.

Objects	α_1	t_b	α_2	β	Δt(days)
GRB 990123	1.10 ± 0.03	2.04 ± 0.46	1.65 ± 0.06	0.68 ± 0.05	0.8
GRB 991208	......	~2	2.15 ± 0.04	0.75 ± 0.03	8.5
GRB 991216	1.22 ± 0.04	≤ 2.5	1.53 ± 0.05	1.01 ± 0.12	1.6
GRB 000301c	1.18 ± 0.14	7.51 ± 0.63	3.01 ± 0.53	0.73 ± 0.06	4.8
GRB 000926	1.45 ± 0.06	1.74 ± 0.11	2.57 ± 0.10	0.94 ± 0.02	2.26

References

Berger E. et al., 2000, Astro-ph/0005465

Castro-Tirado A.J., et al., 1999, Science, 283, 2069

Dia Z.G., Lu T. 2000, A&A, 376, 501

Halpern J.P., et al., 2000, ApJ (in press)

Kulkarni S.R., et a., 1999, Nature, 398, 389

Piran T., 1999, Physics Reports 314, 575

Price P.A. et al., 2001, ApJ letters (Submitted), astro-ph/0012303

Rhoads J.E., 1999, ApJ, 525, 737

Sagar R., Pandey A.K., Mohan V., Yadav R.K.S., Nilakshi, Bhattacharya D., Castro - Tirado A.J., 1999, BASI, 27, 3/astro-ph/9902196

Sagar R., Mohan V., Pandey A.K., Pandey S.B., Castro - Tirado A.J., 2000a BASI, 28, 15/astro-ph/0003257

Sagar R., Mohan V., Pandey S.B., Pandey A.K., Stalin C.S., Castro-Tirado A.J., 2000b, BASI, 28, 499/astro-ph/0004223

Sagar R., Pandey S.B., Mohan V., Bhattacharya D., and A.J. Caastro-Tirado, 2001, BASI, 29, 1/Astro-ph/0010212