RISING OPTICAL AFTERGLOWS SEEN BY TAROT

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Abstract. We present the multi-wavelength study of those gamma-ray bursts observed by TAROT. These events are characterized by the presence at early time of a rising in their optical light curves lasting a few hundred of seconds. In one case (GRB 060904B), a flare occurs at similar time in the X-ray band, while in the other cases the X-ray light curves appear smooth during the optical rise. We investigate the possible nature of this behavior and conclude that a multi-component emission is mandatory to explain the optical-to-X-ray afterglow.

1 Introduction

Since the discovery of Gamma-Ray Burst (GRB) afterglows, in 1997 (Costa et al. 1997), tens of GRB optical afterglows have been detected by ground-based rapid response telescopes. Early optical afterglow data play a relevant role to obtain information on the physics of the central engine, and possibly to constraint the initial Lorentz factor of the fireball (*e.g* Zhang et al. 2003). This paper is devoted to the analysis of the GRB observations made by TAROT during the period 2001-2007 when the first telescope started to be fully operational.

2 GRB observations with TAROT

TAROT observed 59 GRBs between 2001 and 2007. During that period, 13 optical transients were detected. Six of them are time resolved allowing the measure of the decay index. 12 GRBs were observed when the gamma emission was still active amongst them 3 were positively detected by TAROT. Figure 1 displays all the detected optical emissions and the first upper limit in the case of negative detections. Half of the afterglows with detectable OT exhibit an increase in brightness until few hundreds of seconds (GRB 050904, GRB 060904B, GRB 070420, GRB 071010A).

3 A rising in detail : GRB 060904B

The optical light-curve of GRB 060904B is shown in Fig. 1. Before the end of the prompt phase, the optical emission features a rise, reaching R=16.8 at maximum. During that rising part, the X-ray and gamma-ray emissions features a giant flare, well fit by a Band model and an hard-to-soft behavior, characteristic of prompt related emission (Klotz et al. 2008). Several phenomena can contribute to a late rising of the optical afterglow (see Klotz et al. 2008), all of them imply a double component to explain the observed emission.

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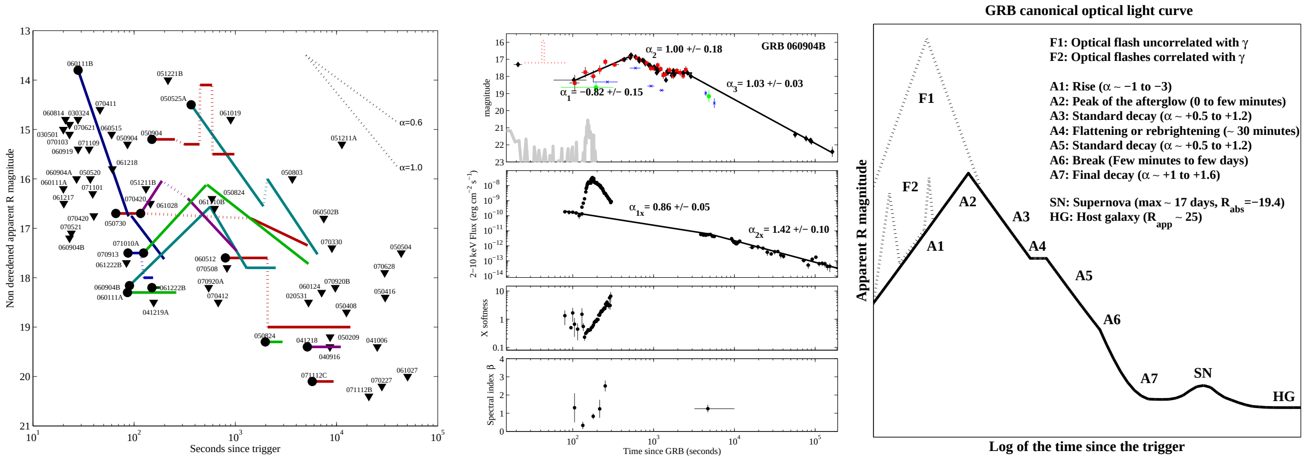

Fig. 1. Left : the TAROT data: upper limits for the first time bin (triangles) and light curves of the detected sources (thick lines). The upper right slopes illustrate some typical afterglow decays. Middle : Time resolved parameters of GRB 060904B. Top panel: Optical light-curve. Red squares are TAROT data (plus the limiting magnitude during 23s to 83s indicated by the dotted line). Black diamonds are R measurements of other observatories. Green disk and blue x are from literature for V and B band respectively. The BAT light curve is displayed as the light gray curve offseted arbitrarily. Fits are based on a power law. Second panel: X-Ray light-curve from XRT data. The count rate has been converted to flux units using the best fit spectral model of late afterglow. Third panel: softness ratio defined by (0.3-1.5 keV)/(1.5-10 keV). Bottom panel: X-ray band spectral index. Right : Canonical optical light curve of a typical GRB.

4 Toward a canonical light curve

Ten years of GRB optical observations allow to derive a global view of their light curves (presented in figure 1). Components F1 and F2, two type of flash emissions, have been observed only when the GRB is still in its active phase: F1 variations are not correlated with the gamma–ray activity, while F2 emission follows the gamma–ray activity. Often, neither F1 nor F2 are detected. A1 is only observed when the peak of the afterglow A2 occurs tens to hundreds seconds seconds after the GRB. A3 is the usual afterglow power law decay. The A4 flattening is more rare and occurs usually between 15 and 30 min in the source rest frame (see discussion in Klotz et al. 2005). The nature of the A6 break, previously supposed to be the jet break, is now under debate (e.g. Covino et al. 2006). The SN component is the supernova light curve signature that has been detected only for the nearest sources. The final HG segment is the host galaxy background flux. TAROT observations are usually sensitivity limited to the A5 phase.

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