A Tale of Two Faint Bursts: GRB 050223 and GRB 050911

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Abstract.
GRBs 050223 and 050911 were discovered by the *Swift* Burst Alert Telescope (BAT) on 23rd February and 11th September 2005 respectively. The observation of GRB 050223 showed a faint, fading X-ray source, which was identified as the afterglow; GRB 050911, however, was not detected, making any X-ray afterglow extremely faint. The faintness of the afterglow of GRB 050223 could be explained by a large opening or viewing angle, or by the burst being at high redshift. The non-detection of GRB 050911 may indicate the burst occurred in a low-density environment, or, alternatively, was due to a compact object merger, in spite of the apparent long duration of the burst.

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INTRODUCTION

During its first year of operation *Swift* has triggered on 102 bursts, 87 of which were followed up by the X-ray Telescope (XRT). In almost all cases after a prompt slew, and often even after a substantial delay, an X-ray afterglow has been detected. Thus, *Swift* has significantly increased the number of few-arcsecond localisations of GRBs.

However, although many bursts are easily detectable by the XRT, some are very much fainter. Of the prompt slews (up until the start of December 2005), the only non-detections (besides GRB 050911) were GRB 050925 (although this trigger may have been due to a new SGR; Holland et al 2005; Beardmore et al. 2005), GRB 050906 (Fox et al. 2005a) and GRB 051105A (Mineo et al. 2005), which were both short bursts. [The

TABLE 1. γ- and X-ray parameters for GRBs 050223 and 050911. The times over which the X-ray fluxes were calculated are given in the last row of the table.

Burst	GRB 050223	GRB 050911	*Swift* mean
T_{90} (s)	23	16	46
15–150 keV T_{90} fluence (erg cm^{-2})	4.8×10^{-8}	3.0×10^{-7}	2.3×10^{-6}
0.3–10 keV unabs. flux (erg cm^{-2} s^{-1})	8.2×10^{-13}	UL: 1.7×10^{-14}	5.2×10^{-10}
time range post-burst (ks)	2.8–4.0	16–716	large range

afterglows of short bursts tend to be fainter and fall below the XRT detection threshold quite rapidly (e.g., Gehrels et al. 2005; Fox et al. 2005b).]

We present here the analysis of two faint bursts: GRBs 050223 and 050911. The X-ray afterglow of GRB 050223 was detected by the XRT after $\sim$ 47 minutes, whereas GRB 050911 remained undetected in an observation starting $\sim$ 4.6 hours after the burst.

DATA ANALYSIS

GRBs 050223 and 050911 were faint in both prompt and afterglow emission (see Table 1 and Figures 1 & 2). In the case of GRB 050223, the X-ray flux at 11 hours ($\sim 1 \times 10^{-13}$ erg cm^{-2} s^{-1} over 0.3–10 keV) was below all those detected by BeppoSAX (Piro 2004). The flux upper limit of 1.7×10^{-14} erg cm^{-2} s^{-1} for GRB 050911 shows that, at $\sim 10^4$ s, any X-ray afterglow emission was at least an order of magnitude fainter than all of the other long bursts detected by *Swift*, with the possible exception of GRB 050421 (Figure 1; Godet et al. 2005; Nousek et al. 2005).

GRB 050223 - a large opening/viewing angle or high redshift?

Using the standard GRB afterglow models (Zhang & Mészáros 2004), the data for this burst are inconsistent with post-jet-break evolution. A large opening angle could explain both a late jet-break and the faintness of the afterglow, as well as the BAT fluence being relatively low. Alternatively, the low afterglow flux and prompt fluence could be caused by the burst being at high redshift; *Swift* GRBs are at a mean redshift of $\sim$ 2.1, while pre-*Swift*, the mean was $\sim$ 1.2. More details on the analysis of GRB 050223 can be found in Page et al. (2005a).

GRB 050911 - a naked GRB or a short burst?

The complete non-detection of an X-ray afterglow is very unusual for *Swift* bursts, as mentioned above. Any afterglow corresponding to the burst GRB 050911 must have faded very rapidly or been extremely faint to be undetected at $\sim$ 4.6 hours. One possible

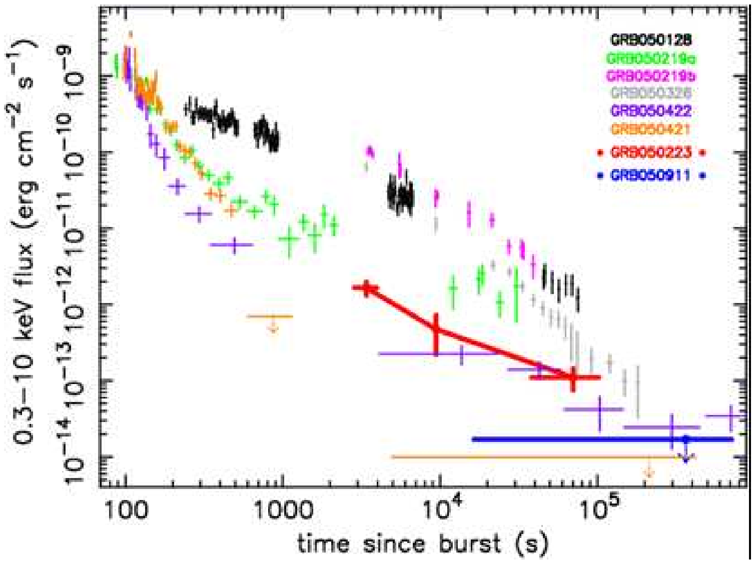

FIGURE 1. Flux light-curves for a selection of *Swift* GRBs, showing the faintness of the X-ray afterglows of GRB 050223 (thick red line) and GRB 050911 (blue 3σ upper limit). Adapted from Nousek et al. (2005).

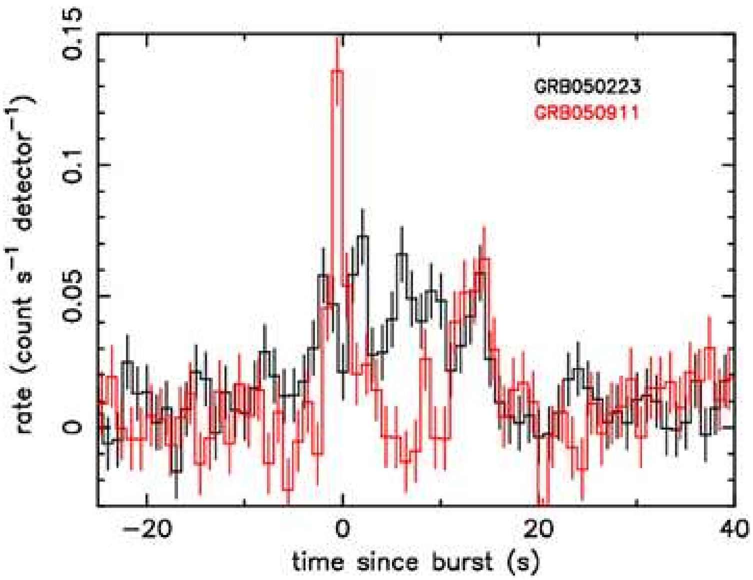

FIGURE 2. BAT light-curves (1-s bins) showing the count-rate per fully illuminated detector for each of the bursts.

explanation is the ‘naked GRB’ model, whereby the burst occurs in a low density environment, with the lack of surrounding material leading to a weak, or non-existent, forward shock. This may be the cause of the faintness of GRB 050421 (Godet et al. 2005).

Short bursts ($T_{90} < 2$ s; thought to be formed through compact object mergers) tend to show weak afterglows, fading below the XRT detection threshold within a few thousand seconds. Although $T_{90} > 2$ s for GRB 050911, there are two initial short (~ 0.5 s) spikes. Thus, GRB 050911 is like many short bursts in showing an initial short peak followed by longer, softer faint high energy emission (Lazzati, Ramirez-Ruiz & Ghisellini 2001; Connaughton 2002; Norris & Bonnell 2005). Simulations show that the later peak would not have been detected by BATSE at greater than the 1σ level; therefore, if BATSE had triggered on this weak burst at all, it is likely that it would have been classed as short.

GRB 050911 could, therefore, have been caused by a merger event: if one of the compact objects were a black hole, rather than a neutron star, the large mass ratio could lead to delayed accretion and, hence, high energy emission after 2 s (Davies, Levan & King 2005). See Page et al. (2005b) for more details.

CONCLUSIONS

The X-ray afterglows of both GRB 050223 and GRB 050911 are among the faintest observed at early times. Although *Swift* has the ability to measure faint X-ray emission out to many days after the burst, some afterglows are still too weak to be detected, indicating a difference in environment and/or formation mechanism.

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