The rising X-ray afterglow of GRB 080307

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Although many X-ray afterglows follow a "canonical" steep-shallow-standard decay pattern, some break the mould. The start of the X-ray light-curve of GRB 080307 showed an unusual smooth rise, at the beginning of which the emission softened. After this brightening, the emission followed a simple power-law decay, with no requirement for breaks. It is conjectured that the early softening is related to the tail of the prompt emission, which then fades rapidly away, allowing the rise of the afterglow to be seen. The optical afterglow was briefly detected by Gemini, and the host galaxy by WHT, though no redshift was determined.

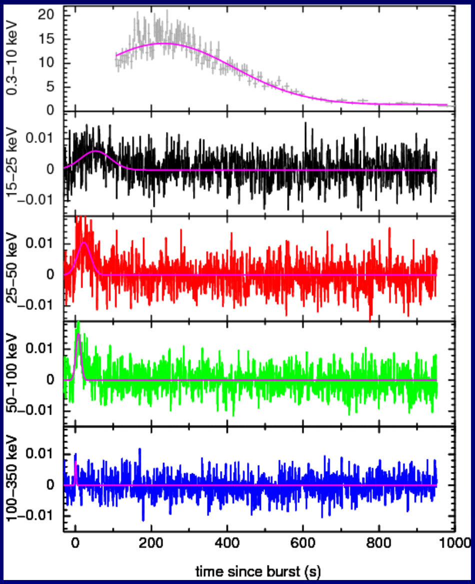


FIG. 1. The light-curve peak becomes broader and occurs later in the softer energy bands.

GRB 080307 was a long GRB (T_{90} ~ 126 s), detected by Swift-BAT. As Fig. 1 shows, the emission clearly softened over time, with the peaks broadening and moving to later times at lower energies (including the X-rays).

The X-rays peak around 200 s after the burst, forming a "hump" in the light-curve. At the start of this hump, the X-ray emission softens as shown in Fig. 2.

The later data imply a possible need for excess absorption. If this is the case, then time-sliced spectra during the hump show evidence for multiple components, best parameterised by two power-laws. This could be interesting, but is hard to explain – and is less than a 3-sigma effect.

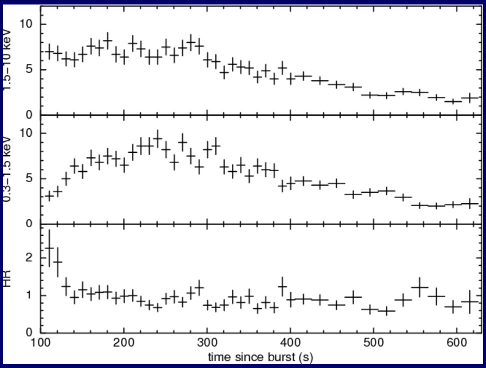
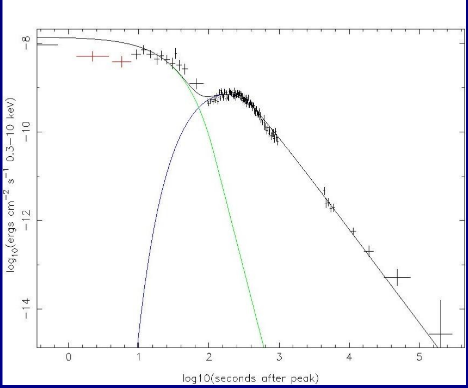


FIG.2. The hardness ratio softens at the beginning of the light-curve "hump".

FIG.3. The hump could be caused by the rise of the afterglow.



The hump at the start of the X-ray light-curve could have two possible explanations: the increase in brightness could either be a flare [seen in about 50% of X-ray light-curves - Burrows et al. (2007)], or it could be the signature of a rising afterglow (a prediction which is rarely seen in Swift light-curves). There is no evidence for an expanding thermal component in the hump spectra, despite the similarity in shape to the supernova burst GRB 060218 (Campana et al. 2006). No indication of a supernova was found for GRB 080307 in the optical data, either.

The hump has a much longer duration than is normal for a flare at early times (e.g. Chincarini et al. 2007) and shows an initial softening trend for a few tens of seconds; the spectral evolution appears to cease before the peak of the emission which is unusual for flares. The X-rays also rise and fall smoothly, different from the FRED-like profiles often seen for flares. Figure 3 shows an attempt to model the BAT-XRT light-curve with two exponential-to-power-law components (Willingale et al. 2007). In this case, the rising X-ray emission is the onset of the afterglow; this is a better fit than considering the increase as a flare, but that possibility cannot be entirely discounted. We could even be seeing a combination of both: an internal-shock flare occurring as the external-shock afterglow begins to rise.

The softening at the beginning of the hump could be the tail-end of the prompt emission. Figure 3 shows that the BAT light-curve is dropping steeply at this time, which may be why the afterglow rise is clearly seen. Kobayashi & Zhang (2007) have shown that forward shock emission can appear as a smoothly-rising curve,.

Conclusion

The X-ray light-curve of GRB 080307 shows a weird hump, at the start of which the emission softens. It is proposed that Swift caught the rise of the X-ray afterglow in this burst, possibly because of the sudden, rapid drop-off of the prompt emission.

References:

Burrows et al., 2007, Phil. Trans. A., 365, 1213 Campana et al., 2006, Nature, 442, 1008 Chincarini et al., 2007, ApJ, 671, 1903

Kobayashi & Zhang, 2007, ApJ, 655, 973 Willingale et al., 2007, ApJ, 662, 1093