Extragalactic jets from every angle
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To BE*am* or not to BE*am*...

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Abstract. We discuss the lack of a clear jet-break in the optical and X-ray afterglow light curve of GRB 130427A, which suggests that a very large isotropic energy is emitted in this burst.

Keywords. gamma rays: bursts, black hole physics

1. Context and Discussion

The association of long energetic gamma ray bursts (GRBs) with type Ib/c supernovae (SNe) represents one of the established pillars in GRB physics. The observed events' sequence could be explained in the context of a single progenitor scenario, the standard Collapsar model (MacFadyen and Woosley 1999), where a rotating very massive star, near its final gravitational collapse, generates the collimated GRB emission, followed by the SN emerging from the optical GRB afterglow. In recent years some indications suggests the possibility of a binary system progenitor for energetic GRBs-SNe (Rueda & Ruffini 2012), as well the possibility of magnetar formation process after the GRB-SN event (Nomoto et al. 2011). GRB 130427A represented a very interesting GRB-SN case, being very near ($z = 0.3399$) and very energetic : its isotropic energy estimated by the Fermi spacecraft is $E_{iso} = 8 \times 10^{53}$ erg (Ackermann *et al.* 2014). GRB 130427A was also detected in the GeV energy range by the Fermi-LAT detector (Preece *et al.* 2014), as well as in the soft X-rays by Swift-XRT and in optical by several on-ground telescopes (Maselli *et al.* 2014). After 18 days from the initial trigger, it was reported the discovery of an emerging supernova (de Ugarte-Postigo *et al.* 2013; Melandri *et al.* 2014), characterized by the presence of broad lines features, typical of an hypernova associated with GRBs (della Valle 2011).

In this work we discuss the Swift X-ray and optical light curve data of the GRB 130427A afterglow, which were followed up to 40 days in the optical by the Palomar 60 telescope (Perley *et al.* 2014) and up to $\sim$ 180 days on X-rays, see Fig. 1. We have then fitted both light curves searching for any possible break, which would point out the spreading of the GRB jet (Kulkarni *et al.* 1999). The best-fit of both light curves emission is given by a simple power-law function with respective indices of $\alpha_X = -1.28 \pm 0.03$ and $\alpha_{opt} = -1.09 \pm 0.01$, showing no break in their combined emission up to 50 days from the burst, as also reported in (Perley *et al.* 2013). We note that in Maselli *et al.* (2014), a possible break is suggested to be at $t \sim 37000$ s, but the following index decay is not in agreement with the theoretical expectations of late jet-break emission (Sari *et al.* 1999). With the limit of 50 days, which corresponds to the last observation of the Palomar 60

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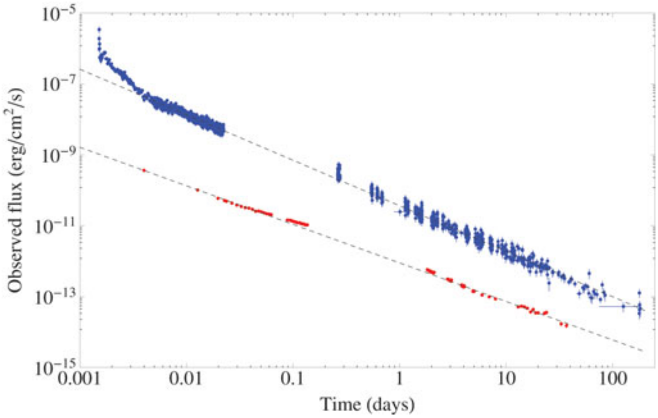

Figure 1. Swift XRT (blue data) and Palomar 60 r'-band (red data) light curves of the afterglow of GRB 130427A and corresponding best-fit function (dashed lines).

telescope, we have estimated the jet opening angle from the formula reported above, which provides a lower limit value of $\theta = 19.4°$. The corresponding collimated energy emitted in the burst, $E_\gamma = E_{iso}(1 - cos\theta)$, results to be larger or equal than 4.56×10^{52} erg, which is the expected amount of kinetic energy emitted in a SN event (Nomoto *et al.* 2011). The possible break reported by Maselli *et al.* (2014) could be ascribed to an alteration of the circumburst density medium, as reported by Kouveliotou *et al.* (2013), which would imply the possibility that a previous explosion preceding the GRB event happened, as also reported in other normal core-collapse events (Smartt 2009). From our analysis (see Fig. 1), we do not hint for the existence of any break up to 182 days after the burst, which would imply a $\theta = 31.6°$ and $E_{iso} \geqslant 1.2 \times 10^{53}$ erg.

The lack of detection of a clear jet break implies a large jet opening angle and at the same time a kinetic energy emitted in the GRB emission of $E_{iso} \sim 10^{53}$ erg, therefore suggesting the possibility that this GRB has been powered by the spin-down of a Kerr black hole (van Putten *et al.* 2011) or calling for more exotic mechanisms. It represents also a test for the underlying GRB emission mechanisms. The multi-wavelength dataset available for this GRB, from radio to very high energy frequencies, represents a strong test for any model trying to explain the physics underlying GRB emission.

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