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Probing the nature of short swift bursts via deep INTEGRAL monitoring of GRB 050925

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Abstract

We present results from *Swift*, *XMM-Newton*, and deep INTEGRAL monitoring in the region of GRB 050925. This short *Swift* burst is a candidate for a newly discovered soft gamma-ray repeater (SGR) with the following observational burst properties: (1) galactic plane ($b = -0.1°$) localization, (2) 150 ms duration, and (3) a blackbody rather than a simple power-law spectral shape (with a significance level of 97%). We found two possible X-ray counterparts of GRB 050925 by comparing the X-ray images from *Swift* XRT and *XMM-Newton*. Both X-ray sources show the transient behavior with a power-law decay index shallower than −1. We found no hard X-ray emission nor any additional burst from the location of GRB 050925 in ~5 ms of INTEGRAL data. We discuss about the three BATSE short bursts which might be associated with GRB 050925, based on their location and the duration. Assuming GRB 050925 is associated with the H_{II} regions (W 58) at the galactic longitude of $l = 70°$, we also discuss the source frame properties of GRB 050925.

Keywords: Gamma-ray; Burst

1. Introduction

The origin of the short (<2 s) class of gamma-ray bursts (GRBs) is receiving huge attention in the field of high-energy astrophysics. Thanks to the rapid position notices and response by *HETE-2* and *Swift*, afterglow emission has been found for a handful of short GRBs (e.g., Berger et al., 2007). Less than arc-second positions, which are provided by X-ray and optical afterglows, enable us to study the host galaxies of short GRBs. Surprisingly, unlike the long duration GRBs which always have host galaxies with a high star-forming rate (Bloom et al., 2002), short GRBs emerge from both star-forming and non-star forming galaxies (e.g., Villasenor et al., 2005). This suggests that a substantial range of lifetimes is needed for the progenitors of short GRBs. This discovery tightens the case for a different origin for short and long GRBs.

On the other hand, some fraction of short bursts might be from local and extra galactic flares of soft gamma-ray repeaters (SGRs). SGRs are believed to be highly

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magnetized isolated neutron stars (Duncan and Thompson, 1992). They produce short spikes (a few tens of milliseconds) (Woods, 2003) and sometimes a giant flare (Hurley et al., 1999; Palmer et al., 2005) in γ-rays. Although it is possible to detect giant flares of extragalatic SGRs from nearby galaxies, their fraction of such flares among short GRBs is still not clear (e.g., Palmer et al., 2005; Lazzati et al., 2005), Furthermore, a small flare from a previously unknown SGR in the galaxy might be detected as a short burst in γ-rays.

2. GRB 050925

2.1. Swift/BAT prompt emission

On 25 September 2005, the *Swift* Bust Alert Telescope (BAT) instrument detected GRB 050925, which only lasted for ~100 ms and possibly consists of two pulses (Fig. 1). The BAT ground analysis position of this burst is (R.A., Dec.) = (20^h 13^m 56.9^s, 34° 19′ 48″) (J2000) which corresponds to the galactic coordinate of $(l, b) = (72.320°, -0.101°)$ (Sakamoto et al., 2010). Its location is in the galactic plane ($b = -0.1°$). The T_{90} and T_{50} duration is 90 ms and 40 ms respectively. The fluence in the 104 ms time window (T_{100} interval) in the 15–150 keV band is $(7.7 \pm 0.9) \times 10^{-8}$ erg s cm^{-2}. The peak flux in the 10 ms time window is estimated to be $(1.2 \pm 0.1) \times 10^{-6}$ erg s cm^{-2} s^{-1}.

As seen in Fig. 2, the prompt emission spectrum of this burst shows a better fit to a blackbody (BB) spectrum with a temperature of 15.1 ± 0.5 keV (χ^2/dof = 75.3/57) over a simple power-law (PL) spectrum (χ^2/dof = 87.7/57). To quantify the significance of this improvement, we performed

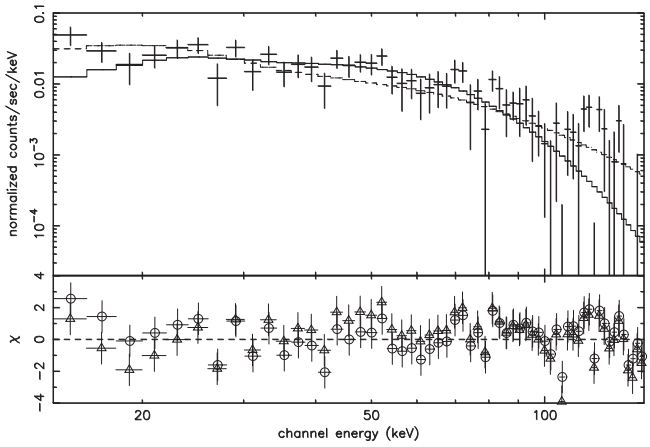

Fig. 2. The BAT time-integrated spectrum of the burst (104 ms duration). The best fit with a blackbody model is shown in a solid line (upper) with circles in a residual panel (bottom), whereas, the best fit with a simple power-law model is shown in a dashed line (upper) with triangles in a residual panel (bottom).

10,000 spectral simulations assuming the best fit spectral parameters in a simple power-law model and determined in how many cases the blackbody fit gives χ^2 improvements of equal or greater than $\Delta\chi^2 = \chi^2(\mathrm{PL}) - \chi^2(\mathrm{BB}) = 12.4$ over the simple power-law model. We found equal or higher improvements in χ^2 in 691 simulated spectral out of 10,000. Thus, the chance probability of having an equal or higher $\Delta\chi^2$ of 12.4 with the blackbody model when the parent distribution is a simple power-law model is 7%. A blackbody with a temperature of ~10 keV is a typical spectral model for short SGR bursts in the BAT energy range (e.g., Olive et al., 2005; Fenimore et al., 1994). GRB 050925 belongs to a softer region compared to the other

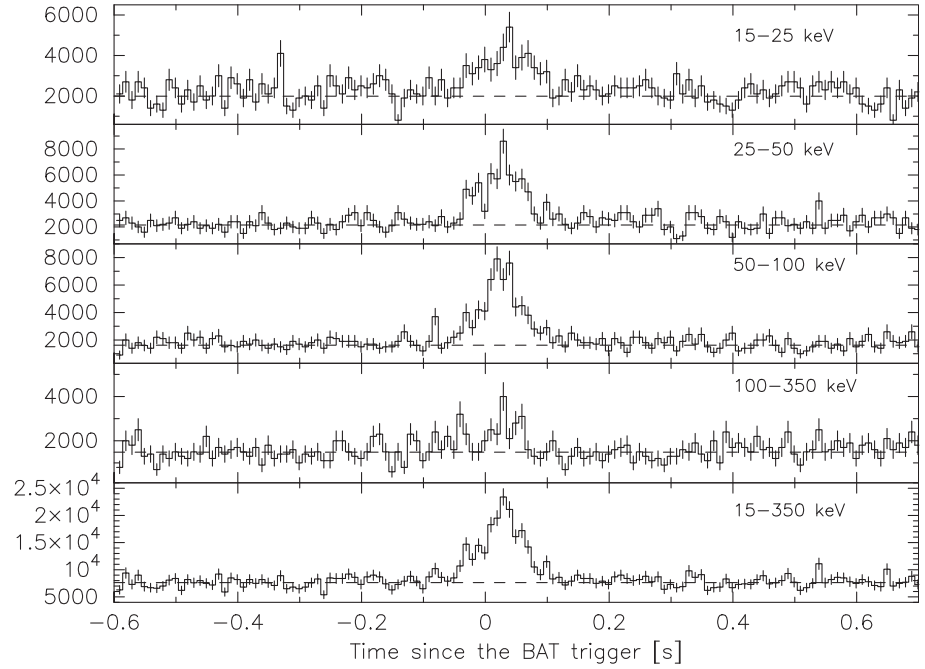

Fig. 1. The BAT five channel light curves in 10 ms binning. The background has not been subtracted.