Death of Massive Stars: Supernovae and Gamma-Ray Bursts
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Trigger Simulations for GRB Detection with the Swift Burst Alert Telescope

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Abstract. Understanding the intrinsic cosmic long gamma-ray burst (GRB) rate is essential in many aspects of astrophysics and cosmology, such as revealing the connection between GRBs, supernovae (SNe), and stellar evolution. *Swift*, a multi-wavelength space telescope, is quickly expanding the GRB category by observing hundreds of GRBs and their redshifts. However, it remains difficult to determine the intrinsic GRB rate due to the complex trigger algorithm adopted by *Swift*. Current studies of the GRB rate usually approximate the *Swift* trigger algorithm by a single detection threshold. Nevertheless, unlike the previously flown GRB instruments, *Swift* has over 500 trigger criteria based on count rates and additional thresholds for localization. To investigate possible systematic biases and further explore the intrinsic GRB rate as a function of redshift and the GRB luminosity function, we adopt a Monte Carlo approach by simulating all trigger criteria used by *Swift*. A precise estimation of the intrinsic GRB rate is important to reveal the GRB origins and their relation to the black-hole forming SNe. Additionally, the GRB rate at high redshifts provides a strong probe of the star formation history in the early universe, which is hard to measure directly through other methods.

Keywords. Gamma-ray Bursts

1. Introduction and Method

We adopt a Monte Carlo approach to explore the intrinsic cosmic long GRB rate, luminosity function, and other GRB characteristics. *Swift* triggers GRB detections mainly based on the photon count rates. In order to maximize the GRB observations, *Swift* has hundreds of trigger criteria to cover a wide range of possible burst durations and pulse shapes. Each criterion uses different time ranges for the background and foreground periods to calculate the corresponding signal-to-noise ratio (Fenimore *et al.* 2003; Graziani *et al.* 2003). If the signal-to-noise ratio passes the threshold adopted by the criterion, the event is "triggered" and will go through further procedures to confirm the nature of the event. In our program, we simulate all these criteria with different background/foreground time ranges, signal-to-noise thresholds, viewing angles related to the detector, and in different energy bands. Accurately mimicking the complex trigger algorithm adopted by *Swift* allows us to investigate possible systematic biases of *Swift*'s detections, and thus explore intrinsic GRB characteristics, such as their rate and luminosity function.

In order to preform a Monte Carlo simulation, we need to create a mock GRB sample based on some assumed GRB characteristics. We will then run the mock sample through the trigger code that simulates the *Swift* trigger algorithm. If the original assumptions of the GRB characteristics are accurate, the properties of the triggered events in the mock sample should match those of the actual GRB sample detected by *Swift*.

We generated the first mock GRB sample using the GRB rate and luminosity function in Wanderman & Piran (2010). These authors obtained the GRB rate and luminosity function by directly inverting the observed rate from *Swift*, with some empirical weighting factors to describe the probability of a burst being detected by *Swift* and acquiring redshift measurements. We also adopt the distribution of the GRB spectral index found in Sakamoto *et al.* (2009) to assign spectra to GRBs in our mock sample. Additionally, the GRB light curves (pulse shapes) in our mock sample are created based on Norris *et al.* (2005), which provides fitting functions for light curves of 23 GRBs detected by *Swift*.

2. Preliminary Results

Figure 1 shows our preliminary results based on the GRB characteristics discussed above. The red histogram plots the redshift distribution of the (normalized) number of the GRBs in the mock sample triggered by our code that simulates the *Swift* trigger algorithm. The blue histogram shows the redshift distribution of the actual *Swift*-detected GRBs for comparison (numbers are also normalized). Note that this *Swift*-detected GRB sample is a sub-sample of all GRBs observed by *Swift*. This sub-sample is selected by Fynbo *et al.* (2009), using criteria for choosing GRBs that produce an event sample that is relatively unaffected by selection biases in redshift measurements.

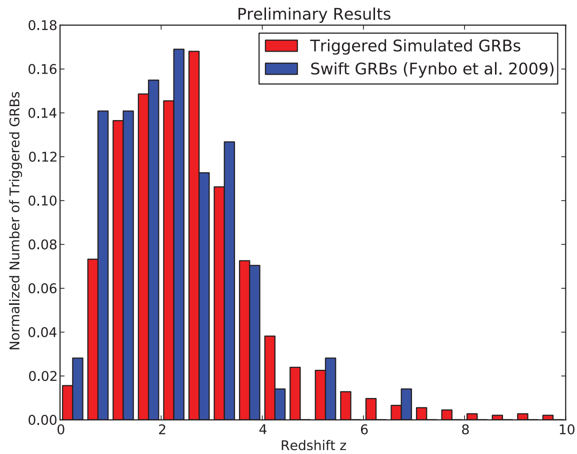

Figure 1. The normalized histogram of the triggered GRBs as a function of redshift. All numbers are normalized to the total number of triggered events. The triggered events from our simulation are plotted in red; the selected *Swift* GRBs sample (Fynbo *et al.* 2009) is plotted in blue for comparison.

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