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A Stochastic Approach to Reconstruct Gamma-Ray-burst Light Curves

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Gamma-ray bursts (GRBs), as they are observed at high redshift (z = 9.4), are vital to cosmological studies and investigating Population III stars. To tackle these studies, we need correlations among relevant GRB variables with the requirement of small uncertainties on their variables. Thus, we must have good coverage of GRB light curves (LCs). However, gaps in the LC hinder the precise determination of GRB properties and are often unavoidable. Therefore, extensive categorization of GRB LCs remains a hurdle. We address LC gaps using a stochastic reconstruction, wherein we fit two preexisting models (the Willingale model; W07; and a broken power law; BPL) to the observed LC, then use the distribution of flux residuals from the original data to generate data to fill in the temporal gaps. We also demonstrate a model-independent LC reconstruction via Gaussian processes. At 10% noise, the uncertainty of the end time of the plateau, its correspondent flux, and the temporal decay index after the plateau decreases by 33.3%, 35.03%, and 43.32% on average for the W07, and by 33.3%, 30.78%, 43.9% for the BPL, respectively. The uncertainty of the slope of the plateau decreases by 14.76% in the BPL. After using the Gaussian process technique, we see similar trends of a decrease in uncertainty for all model parameters for both the W07 and BPL models. These improvements are essential for the application of GRBs as standard candles in cosmology, for the investigation of theoretical models, and for inferring the redshift of GRBs with future machine-learning analyses.

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