Correlative Characteristics of Double-Pulsed Gamma Ray Bursts

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Using data taken by the Burst And Transient Source Experiment on gamma-ray bursts, the correlative properties of two-pulsed bursts will be analyzed. With a code written in the Interactive Data Language, chosen bursts will first be fit as two separate pulses, and then again as a single pulse. This will aid in the reevaluation of the definition of a gamma-ray burst.

I. INTRODUCTION

As the most energetic explosion in the universe, the gamma-ray burst (GRB) presents many unanswered questions. Comprised of photons with energies of around 100keV, the GRB is difficult to detect and can only be observed using space telescopes. In a 1990s survey with the Burst And Transient Source Experiment (BATSE) aboard the Compton Gamma-Ray Observatory (CGRO), data on over 2700 gamma-ray bursts was collected [1]. Data was recorded on a 64 ms timescale in four separate energy channels: 25-50, 50-100, 100-300, and > 300 keV [2].

In previous work [3], two GRB classes have been recognized based on duration and spectral hardness. Other pulse properties provide important constraints on GRB physics; properties include temporal asymmetry, hard-to-soft spectral evolution, and broadening at lower energies [4]. In addition, many properties are significantly correlated or anti-correlated: peak flux, duration, fluence, hardness, asymmetry, and lag [5]. Each burst is defined by its duration T_{90}, or the time to accumulate between 5% and 95% of the total photon counts [2]. Many long bursts ($T_{90} > 2s$) have multiple peaks, indicating short, overlapping pulses; however, there has been some disagreement as to whether these peaks are actually separate pulses or are just different propagations of the same pulse (see Fig. 1) [6]. By more closely analyzing double-peaked bursts, questions regarding pulse emission mechanisms and GRB physics may see advancement.

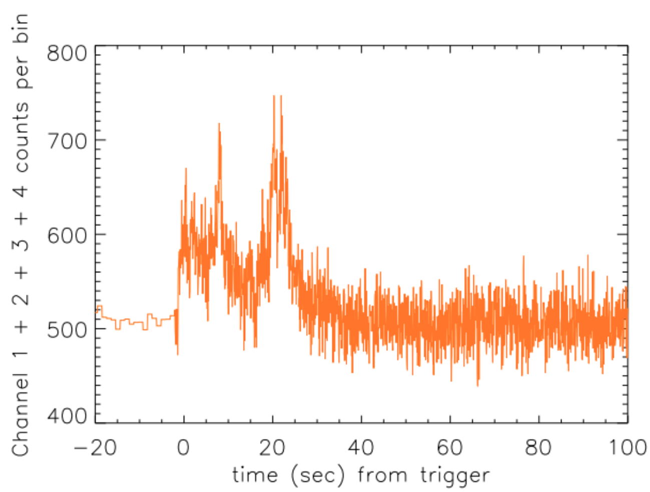

FIG. 1. BATSE trigger-1212 shows that the burst is comprised of multiple pulses; however there is debate on how many pulses this burst actually may contain.

II. GOALS

This project aims to provide a better characterization of two-pulsed gamma-ray bursts, which will then lead to other findings and outcomes. The BATSE gamma-ray catalog is still undergoing revisions; project results seek to aid the catalog's completion. Because the formal definition of a gamma-ray burst is up for debate, as well as its emission mechanisms, two- or more-pulsed bursts will be analyzed and fit with curves. Due to the speculation that bursts with two or more pulses may be multiple propagations of the same single pulse, a more thorough study into this topic will provide a new understanding on what a burst should be defined as. In turn, this information will help to clear up uncertainties regarding the current GRB pulse catalog, which can be revised with better accuracy and include more precise pulse fits. Moreover, findings from this project may give further evidence to the standard model of GRB prompt emission [4].

III. METHOD

From the BATSE data, gamma-ray bursts with double pulses will be selected for further analysis; the classification of these bursts may belong to either of the two classes as long as at least two peaks can be identified from the raw data (indicating multiple pulses). Using an already existing code written in the computer programming Interactive Data Language, all selected data will be analyzed. This code extracts pulses from the summed four-channel GRB data using Bayesian blocks [4]; curves are then fit to the pulses with a simple four-parameter empirical model [2]. This model will automatically fit each GRB as two or more pulses, and their characteristics will be recorded. Each burst will then be forced fit as only one pulse by manually altering the parameters. The characteristics of two pulses versus one pulse will be compared, such as peak flux, duration, and asymmetry. These pulse properties will be looked at to determine if their correlations change as a result of how the bursts are fit. For example, the pulse durations should correlate with pulse asymmetry whilst anti-correlating with spectral hardness and peak flux [4]. Afterwards, each fit will be run through an additional code that produces its residuals; because the residuals should have a distinct shape, they may help to indicate which pulse fit model is correct [5]. In turn, conclusions can be drawn as to whether multiple pulses are actually just one single pulse.

IV. RESOURCES

This project will rely solely on computer programming, specifically using Interactive Data Language (IDL); an already existing IDL program will be used to manipulate and analyze the data. All tasks will be performed on the College of Charleston campus, within the Department of Physics and Astronomy. Once sufficient data has been collected, access to the BATSE gamma-ray burst catalog will be required in order to update any findings. It has been confirmed that all resources are currently on hand and no other resources will be needed.

V. BUDGET

No budget will be required for this project because all needed computer hardware and data are owned by the College of Charleston.

VI. TIMELINE

- Select data for analysis (August - September 2015)
- Run data through code to create curve fits; produce residuals of all fits (September - February 2015)
- Final paper and poster finished (Early April 2016)
- Presentation of poster at School of Science and Mathematics poster session (April 2016)
- Presentation of research, off-campus, at a conference (April 2016)

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[4] Hakkila, J., & Preece, R. D., 2011, ApJ, 740, 104.

[5] Hakkila, J., & Preece, R. D., 2014, ApJ, 783, 88.

[6] Kino, M., Mizuta, A., Yamada, S., 2004, ApJ, 611, 1021-1032.