Classification conundrum in Gamma Ray Bursts

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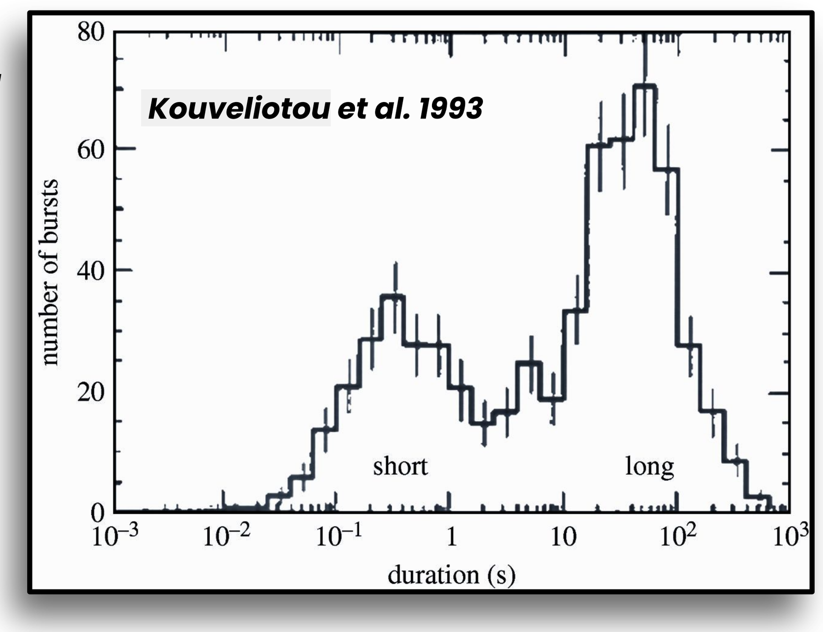
Abstract

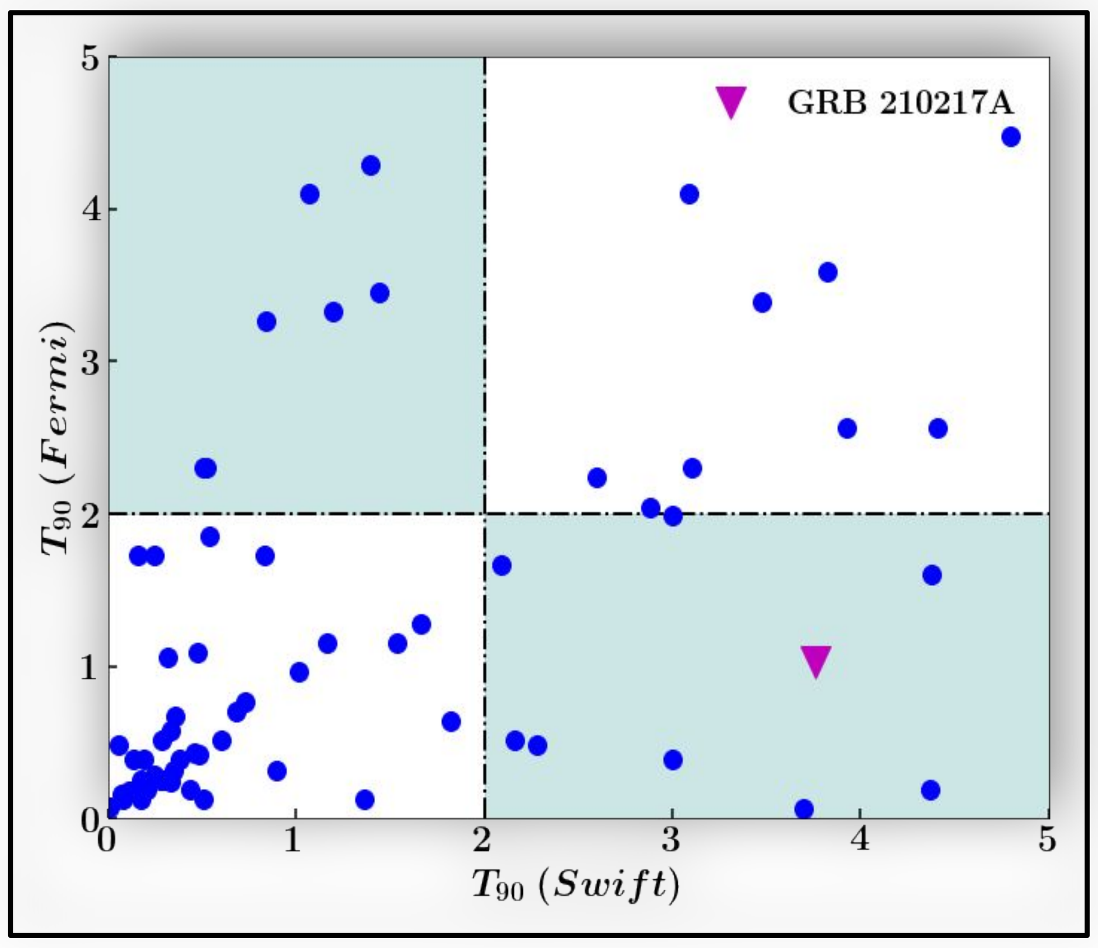
GRB 210217A is detected with different duration by Swift and Fermi. It is classified as a long GRB by Swift/BAT. On the other hand, the sub-threshold detection by Fermi/GBM classified the burst as a short/hard burst with a duration of 1.024 sec. We present the multi-wavelength analysis of GRB 210217A to identify its actual class using multi-wavelength data. We utilized the T_{90} - hardness ratio (HR), T_{90} - Ep, and T_{90} - t_{mvts} distributions of the GRBs to find the probability of GRB210217A being a short GRB. Further, we estimated the photometric redshift of the burst by fitting the joint XRT/UVOT SED and placed the burst in the Amati plane. We found that GRB210217A is an ambiguous burst showing properties of both short and long classes of GRBs.

Introduction

- Gamma-ray bursts (GRBs) are the highly energetic burst of γ-rays.
- GRBs follow the bimodal distribution dividing them into two classes of GRBs:
- Short GRBs : T_{90} < 2 sec
- Long GRBs : T_{90} ≥ 2 sec



- However, T_{90} value relies on the energy range, background fluctuations, sensitivity and trigger criteria of detector.
- It is also observed that some GRBs with T_{90} values of long GRBs have afterglow and host properties similar to the short GRBs and vice versa.
- Therefore, it is not possible to classify the GRBs based on T_{90} alone.



- T_{90} values of Swift and Fermi detected GRBs.
- 16 GRBs in the sample have different classification reported by the Swift and Fermi satellites.
- GRB 210217A is one of the recent burst lying at the boundary of short and long GRBs divide with different burst duration value reported by Swift (4.22+-1.15) and Fermi (1.024).

Other ways to classify GRBs

- Hardness Ratio, Minimum Variability time scale (t_{mvts}).
- Spectral Lag, Position in the Amati Plane, Host Properties.

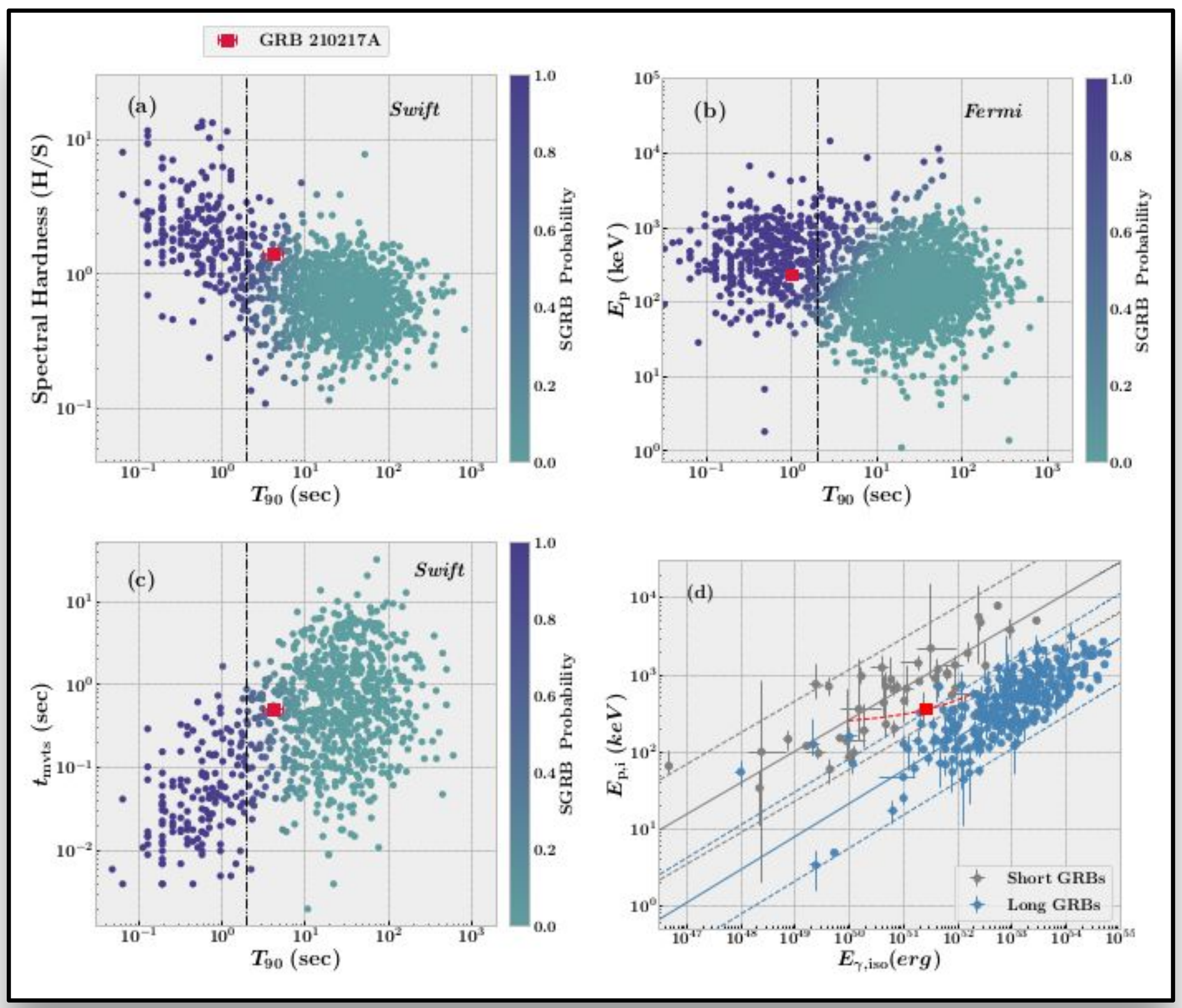
(Fishman & Meegan, 1995, Kaneko et al., 2015, Amati et al., 2002 , MacLachlan et al., 2013, Li et al. 2016)

- We performed a detailed analysis to classify GRB 210217A.

Characteristics	GRB 210217A	Detector
T_{90} (15-350 keV)	3.76 ± 0.26 sec	*Swift*-BAT
T_{100} (25-294 keV)	1.024	*Fermi*-GBM
HR	1.40 ± 0.02	*Swift*-BAT
t_{mvts} (sec)	0.512	*Swift*-BAT
Spectral lag (ms)	186^{+68}_{-65}	*Swift*-BAT
E_p	230	*Fermi*-GBM
Redshift (z)	$0.55^{+0.90}_{-0.40}$	*Swift*-XRT +UVOT
$E_{\gamma,iso}$ (erg)	$(2.61 \pm 1.4) \times 10^{51}$	*Swift*-BAT

Methods Used

- Bayesian Gaussian Mixture Model (BGMM) , Unsupervised learning useful in fitting multi-modal data for clustering (Pedregosa et al. , 2011).
- SED fitting to calculate the photometric redshift.



Results

- We fitted T_{90}- HR, T_{90}- Ep, T_{90}- t_{mvts} distributions with BGMM. The probability of GRB 210217A being a short GRB is equal to 98.2%, 96%, and 28% in these cases, respectively.
- The Swift-XRT/UVOT SED fitting yields a photometric redshift of 0.55.
- The position of GRB 210217A lies at the boundary between short and long class in the Amati plane.

Summary

- We present different methods that can be used to classify GRBs (lying close to boundary) other than T_{90}.
- We calculated the probability of GRB 210217A being a short GRB using BGMM, an unsupervised method used for classification.
- GRB 210217A lies at the boundary between short and long class in the Amati plane.
- It is hard to conclude the classification the burst. Host observations can give a clue about the class of GRB 210217A.

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