Pulse Decay Time Analysis of Short Gamma-Ray Transients with *Fermi*-GBM

Honours Project Proposal · 2026

Level	Honours
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Project Description

Gamma-ray bursts (GRBs) are among the most luminous sources in the Universe with redshifts reaching up to $z \approx 10$, making them ideal cosmological probes. They are classified based on their emission duration (T_{90}), with short gamma-ray bursts (SGRBs) lasting $T_{90} < 2$ seconds and long gamma-ray bursts (LGRBs) exceeding 2 seconds. While the progenitors of LGRBs are well-characterised, SGRBs are occasionally confused with another class of transient known as magnetar giant flares (MGFs). MGFs arise from highly magnetised neutron stars called magnetars and exhibit temporal and spectral features similar to cosmological SGRBs. As a result, some MGFs are misclassified as SGRBs, causing uncertainties in cosmological studies.

Previous work has shown that MGFs have more rapid pulse rise times ($t_{\rm rise}$) than SGRBs, with an observed energy dependence across the 10 keV–40 MeV range. However, whether the pulse decay time ($t_{\rm fall}$), which describes how quickly the gamma-ray emission fades after peak intensity, differs between the two transient classes remains unclear. Understanding how $t_{\rm fall}$ behaves across energy channels could provide an additional classification feature for distinguishing these transients, independent of redshift.

Project Aim. To investigate whether the pulse decay time ($t_{\rm fall}$) of SGRBs and MGFs differs across *Fermi*-GBM energy channels, and to assess its potential as a classification feature independent of redshift.

Objectives

This data analysis project aims to study the pulse decay time of GRBs and MGFs using *Fermi* Gamma-ray Burst Monitor (GBM) data, including newly detected sources. The objectives are:

- Retrieve SGRB and MGF *Fermi*-GBM data, including recently detected sources
- Fit the Norris function to the pulse profiles of the sources (a Python script for the Norris function is available)
- Analyse and compare the decay time (t_{fall}) of SGRBs and MGFs
- Investigate whether t_{fall} shows an energy dependence across the ten *Fermi*-GBM energy channels (10 keV–40 MeV)
- Discuss the implications for classification and our understanding of these transients

This study will help determine whether t_{fall} differs between the two transient classes, improving classification accuracy and enhancing our understanding of these transients.

Expected Outcomes

Upon completion, the student will have produced a systematic temporal analysis of SGRBs and MGFs. Key deliverables include:

- A comparative analysis of pulse decay timescales across both transient classes.
- An investigation of the energy dependence of t_{fall} across the 10 keV–40 MeV range.
- An assessment of t_{fall} as a discriminating feature for classification.

Student Expectations

- Review introductory literature on gamma-ray bursts and magnetars.
- Perform light curve analysis and pulse profile fitting.
- Interpret and compare results across transient classes.
- Submit a written report and deliver an oral presentation.

Required Skills

Skill	Level Required
Python programming	Essential (basic level)
Linux operating system	Basic familiarity required
Statistics / data analysis	Beneficial, not required
Gamma-ray astronomy	Supervisor will provide guidance