Investigating Fast Radio Burst Populations with `frbpoppy`

Project level: Honours
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Background

Fast Radio Bursts (FRBs) are millisecond-duration, high-fluence radio transients of extragalactic origin. Since their discovery, they have become one of the most compelling mysteries in modern astrophysics. While thousands of events have been detected, the underlying progenitor mechanisms—ranging from magnetar flares to catastrophic compact object mergers—remain a subject of intense scientific debate.

A central challenge in FRB research is understanding the divergence between "repeater" and "one-off" populations. Current observations are heavily influenced by complex selection effects, including telescope beam patterns, frequency-dependent sensitivity, and propagation effects like dispersion and scattering in the Intergalactic Medium (IGM). To learn the FRBs, it is essential to distinguish between intrinsic source properties and artifacts introduced by our observational limitations.

In this project, we explore a physically motivated approach to investigate FRB populations by combining a rigorous literature study with computational population synthesis using `frbpoppy`. Instead of relying solely on raw catalog data, this method allows us to simulate "cosmic" populations and pass them through virtual survey filters to directly model how detection thresholds warp our understanding of FRB volumetric rates and luminosity functions.

Project statement

In this project, the student will investigate the statistical properties of FRB populations by integrating archival data analysis with advanced simulation tools.

The student will:

- **analyse** current literature on FRB phenomenology, focusing on the Macquart relation and dispersion measure (DM) distributions;
- **install and configure** the `frbpoppy` framework within a Linux-based environment to generate synthetic pulsar and FRB populations;
- **investigate** the effect of instrument-specific selection functions (e.g., CHIME/FRB and ASKAP profiles) on population detection;
- **compare** simulated distributions against real-world observational data to identify potential selection biases;
- **and develop** statistical comparisons to evaluate whether the observed dichotomy in FRB classes is an artifact of instrumental sensitivity.

The project will involve computational modeling, statistical analysis, and signal processing using modern astrophysics tools such as Python and Linux-based research software. The student will contribute to an active research problem in high-energy transients, with opportunities for participation in conference presentations depending on project progress.

Recommended skills and interests

The project is suitable for students interested in:

- high-energy radio transients;
- computational astrophysics;
- and scientific programming.

The analysis will primarily be performed using Python and Linux-based astronomy software tools. Prior experience in programming is helpful but not mandatory, as training will be provided during the project.

Students will gain experience in:

- statistical signal analysis;
- scientific programming in Python;
- and modern computational research workflows used in astronomy.