Project Proposal: Optimising Detrending and Transit-Search Methods for Exoplanet Detection in KELT-South Light Curves

Background

Wide-field ground-based transit surveys such as **KELT-South** produce large numbers of stellar light curves that are affected not only by astrophysical variability, but also by systematic trends introduced by the atmosphere, instrumentation, and observing conditions. These systematics must be removed carefully before one can search for exoplanet transit signals. At the same time, the choice of transit-search algorithm can significantly affect the ability to detect shallow, periodic transit events. Classical methods such as **Box Least Squares (BLS)** remain widely used, while more modern approaches such as **Transit Least Squares (TLS)** attempt to model more realistic transit shapes.

Aim

The aim of this project is to determine which combination of detrending method and transit-search algorithm is best suited to the detection of exoplanet transit signals in KELT-South light curves.

Research Questions

The student will address the following questions:

- How effectively do different detrending methods remove systematic noise from KELT-South light curves?
- Which detrending approaches best preserve shallow transit-like signals?
- How do **BLS** and **TLS** compare when applied to detrended KELT-South data?
- Which combination of detrending and search method gives the best balance between sensitivity, robustness, and practicality?

Methodology

The student will work with a representative subset of KELT-South light curves from one selected field. They will first inspect the data and characterise basic properties such as cadence, scatter, outliers, and gaps. A small number of detrending approaches will then be implemented and compared, for example:

- a simple baseline detrending method,
- an ensemble-based method such as **SysRem**,
- an ensemble-based method such as **TFA**.

The resulting detrended light curves will be evaluated using statistical measures such as RMS scatter and simple diagnostics of correlated noise. After detrending, the student will apply both **BLS** and **TLS** to search for periodic transit-like signals. To compare methods fairly, synthetic transit

signals will be injected into selected real light curves over a realistic range of periods and depths appropriate to the KELT-South survey regime. The student will then assess how well different combinations of detrending method and search algorithm recover these signals.

Expected Outcomes

By the end of the project, the student should be able to:

- explain the origin and impact of systematic trends in survey photometry,
- implement and compare multiple detrending techniques,
- apply and evaluate two important transit-search algorithms,
- quantify detection performance using objective recovery statistics,
- identify and justify an optimal workflow for transit detection in KELT-South data.

Deliverables

The final outputs should include:

- a short literature review,
- a documented Python workflow for detrending and transit searching,
- a comparison of detrending and detection performance across selected methods,
- a concise final report summarising methods, results, limitations, and recommendations for future pipeline development.

Educational Value

This project combines methodological comparison, signal detection, and quantitative evaluation in a single coherent study. It teaches important aspects of scientific research, including hypothesis formulation, fair testing of alternative methods, careful interpretation of results, and the need to justify conclusions with evidence. Even if no genuine exoplanet candidate is found, the project will still produce a scientifically meaningful outcome by identifying the most effective analysis strategy for this class of data.

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