Testing Gravity Using Stellar Pulsations

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Motivation for the Project

The expansion of the Universe is accelerating and nobody knows why. Gravity pulls normal matter together so what is pushing it further apart? Cosmologists call this *Dark Energy*. The leading theory is Einstein's general relativity with the acceleration driven by a cosmological constant but the value required is 30 orders of magnitude smaller than quantum physics predicts. For this reason, alternative theories of gravity that can *self-accelerate* are an active field of modern cosmology research but we need to test these alternatives against general relativity's predictions. This project aims at studying stellar pulsations in self-accelerating theories of gravity, known as Galileon theories, as a new and novel test.

Outline of the Project

Alternative theories of gravity predict a deviation in the Newtonian force law. The structure of stars is determined by a balance of outward pressure and inwards gravity so if you change the theory of gravity you change the structure of the star. All stars oscillate but some, such as Cepheid and RR Lyrae Stars, are unstable and pulsate and the period of these pulsations are modified by changing the theory of gravity. The purpose of this project is to derive the new equations for the perturbations and solve them for interesting stars to find the new pulsation frequencies. These can be compared with real data to rule out the theory.

What You Will Learn

The aim of this project is for you to learn about various aspects of modern cosmology and gravitation theory but, more importantly, for you to learn about life as a physics researcher and all the skills that go along with it.

Some things I hope you will take away from this project are:

- Knowledge of modern areas of cosmology and gravitation research
- Knowledge of stellar structure and stellar perturbation theory
- How to read papers
- How to work collaboratively
- Day to day workings and goings-on of a top-level research department such as ICG
- New mathematical and computing skills
- A better idea of whether physics research is right for you and the sort of area you might be interested in

Desirable Background Knowledge

This project is best suited to a third or fourth year undergraduate with a keen interest in stellar physics, gravitation or cosmology.

The project is self-contained and does not require knowledge of general relativity or field theory but familiarity with the following subjects will be useful:

- Thermodynamics and statistical physics
- Stellar structure and evolution
- Partial differential equations and spherical harmonics

There will be a numerical component to this project and the following skills would be useful

- Knowledge of at least one high-level computing language
- Knowledge of solving coupled differential equations numerically
- Knowledge of solving boundary value (eigenvalue) problems using the shooting or matrix methods

Basic knowledge of FORTRAN would make the project easier but is not essential.

Eligibility

Please note that this project is funded under the SEPnet summer placement scheme and only students studying at SEPnet institutions are eligible for the project. Please see the link for a list of SEPnet institutions.

Further Information

If you are interested in this project and have any further questions please email me at jeremy.sakstein@port.ac.uk.