Study of crustal and surface magnetic field of radio pulsars

1. Level of the Project: Masters

2. Name of primary supervisor: Prof. Subharthi Ray

3. Institution of supervisor: University of KwaZulu-Natal

4. Name of co-supervisor: Dr Kathleen A Sellick

5. Institution of co-supervisor: University of KwaZulu-Natal

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7. Project title: Study of crustal and surface magnetic field of radio pulsars

8. Description of project, including the aims and anticipated outcomes, what will be expected of the student, and any special qualifications required (maximum 500 words).

Please also stipulate if any specific skills are required (eg, computational skills): The student will be required to have knowledge in electromagnetism. Also, some basic coding skills in Python (or C) will also be advantageous for the project, as the project will be semi analytic in nature.

Project:

The theoretical concepts of neutron stars date back to 1934 by Baade and Zwicky. However, their existence (in the form of radio pulsars) was first discovered by Jocelyn Bell in 1967 in her PhD work. Radio pulsars are isolated neutron stars that emit electromagnetic beams in the radio frequency. The origin of the radio emission from these pulsars is purely due to the electrodynamics of the strong magnetic field at the surface and in the stellar magnetosphere. Thus, it involves a self-sustained mechanism where strong magnetic field produces electron-positron plasma, which travels along the open field lines of the pulsar polar caps emitting synchrotron radiation, that are finally bunched out in the form of coherent radiation and ejected as radio beams. The general picture of the emission mechanism has been broadly understood. However observational features from the radio pulsars like mode changing, nulling, subpulse-drifting, etc., poses direct challenges to the existing theories and about the detailed electro-magnetic processes taking place not only at the stellar magnetosphere, but also at the surface and in the outer crust of the neutron stars.

Neutron stars constitute a system where all of the fundamental forces are present in enormous amount – the strong and the weak nuclear forces, the extremely strong magnetic fields (10^12 – 10^14 Gauss) and a strong surface gravitational force. Thus, it is an ideal platform to study the nature of these fundamental forces in their extreme states.

In the project, the electro-magnetic induction equation within the crustal matter of the neutron star, will be studied – both without and with the effect of strong gravitational forces. Specifically, the contribution of the Hall oscillation from the toroidal to the poloidal field will be studied. The long-term goal of this study will be to find the effect of this contribution on the Ohmic diffusion of the magnetic field through the crustal matter, that will finally reflect in the magnetic field at the surface of the neutron star. The resultant surface magnetic field will be further studied and applied to the radio emission mechanism of the pulsars.

(Some) References:

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