1. Level of the project, i.e. Honours or Master's
Honours

2. Name of supervisor
Dr. Monica Barnard
Name of co-supervisor
Prof. C. Venter

3. Institution of supervisor and co-supervisor
Centre for Space Research, North-West University, Potchefstroom 2520, South Africa

6. Contact details of supervisor and co-supervisor
monica.barnard@nwu.ac.za OR monicabarnard77@gmail.com
christo.venter@nwu.ac.za OR christo.venter7@gmail.com

7. Project title
Investigating the high-energy gamma ray emission from the Vela pulsar as curvature and synchro-curvature emission.

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).

Pulsars are rapidly rotating, highly magnetized neutron stars that emit pulsed radiation across the entire electromagnetic spectrum. Despite advances in space-based and ground-based Cherenkov instruments operating in the high to very-high energy bands, our understanding of the local environments of these extreme astrophysical objects, i.e., specifically their magnetospheres, electrodynamics, and particle physics, remains incomplete. This study investigates the high-energy curved spectrum of the Vela pulsar using observational data from the Fermi Large Area Telescope (LAT) and H.E.S.S. II. It addresses the ongoing debate regarding the dominant mechanism responsible for pulsed GeV gamma-ray emission from pulsars, comparing curvature and synchro-curvature (SC) radiation, which may occur in the current sheet. Recognizing the complex magnetic field structure of pulsar magnetospheres that leads to a spatially varying perpendicular B-field ($B\perp$), we will conduct a comparative analysis of these emission mechanisms. Starting with the single-particle case, we will predict energy-dependent light curves and phase-averaged spectra within a global force-free magnetic field configuration that inherently features this varying $B\perp$. By analyzing how these $B\perp$-variations influence the emitted radiation, the study aims to differentiate between emission mechanisms and provide a more realistic explanation for the Vela pulsar's high-energy emission, thereby contributing to a better understanding of pulsar magnetospheres.

The student is expected to do the project independently, i.e., a background study, generating results, report writing, present the project, and plan time wisely. The supervisor is available during the course of the project to assist with planning, having discussions for explaining material or answer questions related to the project, and preparing the student for the presentation.

The student should have a B.Sc. degree in physics, mathematics, programming, or other related fields, as well as a basic knowledge of programming in any language (preferably Python / C / C++), or be willing to learn.

Timeline for project:
Background study / preparation for analysis: 1 week.
Actual analysis: 3 weeks.
Preparation of oral presentation and written report: ~4 weeks.

Oral presentation: 15 min on project and answer questions.
Written project: not more than 20 pages of text, excluding figures and references.