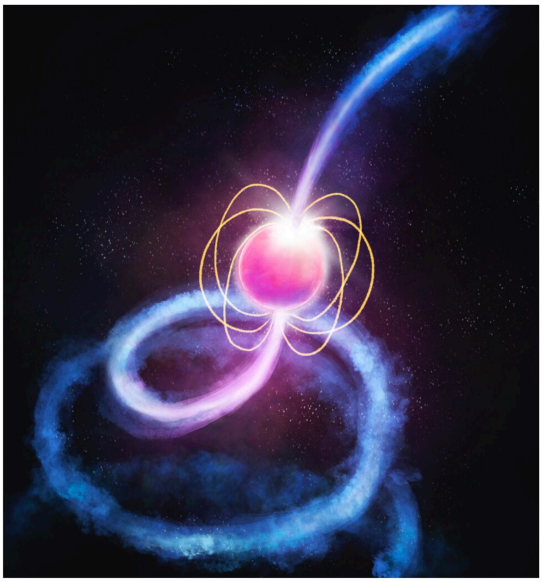
Unlocking the secrets of the pulsar emission mechanism

Supervisors: Ramesh Bhat (Curtin), Bradley Meyers (Curtin), Sam McSweeney (Curtin)

Description: Pulsars are like cosmic lighthouses that emanate intense beams of electromagnetic radiation from their magnetic poles; their role in advancing fundamental physics and astrophysics has been undeniable. They have been proven to be versatile tools to further our understanding of the fundamentals of physics, from nuclear to cosmological scales. Astonishingly however, the physical processes that govern the emission of electromagnetic radiation from these exotic stars still elude us - the pulsar radio emission mechanism remains an outstanding problem in modern astronomy. For many years, the investigation predominantly focused on in-depth studies of individual objects or some of the specific phenomena. There has been seen a resurgence of low-frequency telescopes, development of wide-band instrumentation, and the emergence of multiple major radio astronomy facilities in the lead up to the Square Kilometre Array (SKA) project – the largest and most sensitive radio telescope in the world, currently under construction in Western Australia and South Africa. This project aims to leverage these new opportunities and explore some novel approaches to the problem through a combination of high-quality data from the new generation telescopes, and developing a new framework for the analysis and interpretation. The main objectives are:

1. In-depth investigation of various phase modulation phenomena in pulsar radio emission; e.g. single-pulse studies of specialised targets that exhibit multiple such phenomena.
2. Investigate the frequency dependence of pulsar radio emission and phase modulation phenomena, by leveraging a growing body of low-frequency data (e.g., from the SMART pulsar survey) and similar large data sets emerging from other facilities.
3. Further develop the framework for interpretation as well as the exploration of theoretical ideas; e.g. signatures of retardation/aberration effects in the pulsar profiles and their application for the inference of emission heights.

Besides the excitement of venturing into one of the long-standing problems in astrophysics, there is now renewed interest in this inherently challenging problem, largely stemming from the recent advancements in the field of fast radio bursts and long period transients, whose emissions share intriguing parallels, as well as from recent progress by international pulsar timing array projects, where ultimately the intricacies of pulsar emission processes will dictate the precision attainable with pulsar clocks.



Radio emission from a pulsar (Credit: ICRAR)

This project is ideal for a candidate with a sound background in physics and astrophysics, and a strong aptitude for the exploration of novel ideas for relevant observational interpretations and developing theoretical framework. A background in radio astronomy with research experience is an additional advantage.