PhD Supervisor: Prof. Paul Groot (UCT/SAAO/Radboud)
Co-Supervisor: Prof.dr. Ben Stappers (Manchester)
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Registration: Student will be expected to register at the University of Cape Town (UCT)
Project Title: **Fast optical and radio transients in the Nearby Universe**
Type: **PhD**, within the UCT/SAAO-based SARChI group of Paul Groot

Project Description

1 Problem Statement

Our understanding of the physics and behaviour of compact binaries and objects (white dwarfs, neutron stars and black holes) is far from complete. Large gaps remain in our grasp of the physics of compact objects themselves, of their formation and evolution in a binary setting, and of the role short-lived episodes such as stellar mergers, common-envelope evolution and novae, kilonovae, supernovae and hypernovae play in the evolution of the binary as well as in the formation of the compact object itself.
Time-domain astronomy is particularly suited to study these objects as they are often variable on human time scales (seconds to years), in contrast to e.g. galaxies that evolve on time scales of centuries to billions of years.
A particular problem is the physics, formation and evolution of compact objects in ultracompact binaries: systems where both components are a white dwarf, neutron star or black hole. These systems manifest themselves in e.g. gravitational wave merger events, but our understanding of these populations is scarce at best as they are generally intrinsically dim. Advancing technology now makes it possible to study these systems in the Nearby Universe, which is our Milky Way Galaxy and its direct environments such as the Magellanic Clouds and the Local Group of galaxies. Both in radio as well as in the optical, it is now possible to study these events at time scales of seconds and faster. The last years have allowed glimpses into this fast time scale Universe with the discovery of Fast Radio Bursts, Micronovae, ultracompact binary systems and of course gravitational wave events.

2 Aims and Objectives

The aim of the PhD project is to use the newest technological advances in radio and optical wavelength ranges to increase our understanding of the population, evolution and physics of compact objects and compact binaries. Usage will be made of the MeerKAT radio array and its extensive archive, as well as new data, on the Magellanic Clouds, which will be reanalysed using the state-of-the art techniques developed in Manchester in the group of Prof. Ben Stappers. At the same time the MeerLICHT and BlackGEM optical wide-field telescopes, led by Prof. Paul Groot, will be used to study the same Magellanic Clouds, preferably at the same time as the MeerKAT observations to provide a simultaneous optical-radio view of the transient sky. This is particularly relevant for e.g. establishing the prompt optical luminosity of Fast Radio Bursts, the optical-radio correlation of RRATS and the population of extremely slow rotating neutron stars now being uncovered.
The optical wide-field fast-synoptic telescope ‘Flash’ is currently being assembled at the University of Cape Town and will be deployed at the Sutherland Observatory after commissioning. It will allow a wide-field, >1 Hz cadence of the optical sky, which is largely unexplored. Flash will be used to understand the optical behaviour of Galactic populations at cadences faster than 1s. This includes flaring stars, micronovae, fast radio bursts and possibly also gravitational wave merger events.
The student will be actively involved in the installation, commissioning of the Flash telescope as well as the operations of the Flash and MeerLICHT telescopes.

3. Potential Impact

The impact of this study is manifold:

a) detections of optical emission from fast radio bursts will allow us to constrain the physics of these bursts as well as their origin, which is still unknown

b) optical emission from RRATS and extremely slows rotating pulsars can give insight in their emsision physics, which is currently not understood.

c) detections of flaring emission from low-mass stars will provide insight into the impact UV-radiation may have on the habitability of exoplanets around low-mass stars

d) there is the potential of finding completely new astrophysical phenomena as this is largely unexplored parameter space.

4. Alignment with National Imperatives

This project aligns with the following national imperatives:

i) NRF Broad Category: Environmental, Material, Physical and Technology: Astronomy is a physical-technical discipline and strong usage will be made of cutting-edge technology in South Africa (MeerKAT, MeerLICHT, SALT, SAAO telescopes).

ii) National Priority: Transformation: the training of transformed, science-and-technology based researchers is the basis of South Africa's future in the Fourth Industrial Revolution.

iii) Grand Challenge: Astronomy: this project is astronomy, where usage is made of South Africa's cutting-edge technology to understand the Universe and our place in it.

iv) Sustainability Goals: Quality Education. Astronomy is a STEM-discipline that forms the basis of the future development of South Africa and an educated population.

5. National Infrastructure Platforms:

SAAO, SARAO/MeerKAT, SALT, MeerLICHT, IDIA/Ilifu, Flash