PhD Supervisor: Prof. Paul Groot (UCT/SAAO/Radboud)
Co-Supervisor: Dr Itumeleng Monageng (SAAO/UCT)
Email address: paul.groot@uct.ac.za, p.groot@saao.ac.za
Registration: Student will be expected to register at the University of Cape Town (UCT)
Project Title: **Luminous eclipsing variables in the Local Group of Galaxies**
Type: **MSc**, within the UCT/SAAO-based SARChI group of Paul Groot

Project Description

1 Problem Statement

Massive and luminous stars are rare within a given stellar population but leave a strong impact on the evolution of a galaxy. They explode as supernovae or hypernovae, injecting energy and mass into the interstellar medium. They leave behind black holes and neutron stars that often develop into strong X-ray sources and can eventually merge in gravitational wave events. They are prodiguous emitters of ultraviolet radiation that ionizes the nearby Universe and they are short-lived, thereby speeding up the cycle of chemical enrichment in the Universe.

However, they are also exceedingly rare, with only 1-2% of a given stellar population being born with masses sufficient to lead to supernova explosions. Studies of these systems are therefore riddled with population biases due to the small number of available systems in our Milky Way Galaxy. In addition, they are often highly obscured in our own Milky Way due to intervening dust and gas.

To study these systems as part of a larger population of stars, we must extend our studies into the Local Group of Galaxies. Owing to their high luminosity we can detect these systems out to several megaparsecs.

2 Aims and Objectives

The aim of the MSc project is to identify, study and characterise massive, luminous binary systems through their eclipses, out into the Local Group of galaxies. Traditionally the study of massive stars has been concentrated on the Magellanic Clouds, which are prodiguously forming stars and also relatively nearby, but with modern surveys we can push our studies out much further. In synoptic surveys, a single B-type star can be detected out to Mpc distances, thereby bridging to the nearest galaxies.
The basis of the MSc study is formed by the MeerLICHT and BlackGEM Local Transient Surveys, which monitor the mass concentrations in the nearby Universe on a nightly basis in multiple filter bands.

In particular this multi-filter data is unique and also uniquely suited to the detection of massive luminous variables as it, uniquely, includes the optical *u*-band, which is the bluest band that can be used from the ground and also the band in which the massive stars are the brightest. In these data the bulk of the stars in external galaxies will be too faint to be detected, with the exemption of massive, hot (and therefore blue) stars. Using the many single observations already obtained, deep co-added reference frames will be built for each nearby galaxy. From each individual observation, this reference frame will be subtracted to reveal the variable stars.

We will pay particular attention to the eclipsing systems, as they can subsequently be modeled precisely using light curve model algorithms. Where possible, SALT spectroscopy will be used to determine binary orbits. The objective of the study is to built a concensus of the population of massive binaries that is not limited by the low number of observable systems in our Milky Way. The evolution

of the detected systems will be ‘fast-forwarded’ to determine the expected supernova and gravitational wave merger rate per galaxy.

3. Potential Impact

The impact of this study is manifold:

a) An unbiased view of the population of massive, eclipsing binaries in external galaxies.

b) A better evolution of the future population of supernovae, gamma-ray bursts and gravitational wave events per galaxy.

c) A better understanding of the evolution and formation of the most massive binaries.

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