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Registration: Student will be expected to register at the University of Cape Town (UCT)  
Project Title: **Compact Binaries from the MeerLICHT and BlackGEM All Sky Surveys**  
Type: **MSc**, within the UCT/SAAO-based SARChI group of Paul Groot

## **Project Description**

### **1 Problem Statement**

The vast majority of all stars reside in binary and/or higher-order systems. A large fraction of these systems will interact with each other during the course of their evolution, leading to very compact binary settings where a stellar remnant (white dwarf, neutron star or black hole) is accompanied by a low-mass star and/or another stellar remnant. Such compact systems are the host of the strongest X-ray sources in a Milky Way Galaxy, as well as the progenitors of low-frequency gravitational wave emission, to be detected by the LISA satellite constellation.

Such (ultra-)compact binary systems are rare ( $\sim 1:10^7$  within a stellar population), but offer unique laboratories to study the final phases of binary evolution as well as the physics of accretion when mass-transfer occurs. The currently known population of ultracompact objects is still less than 100, preventing a detailed population view, and thereby limiting our understanding of these objects. In particular the Southern Hemisphere has been poorly explored, despite hosting the majority of all visible stars in our Milky Way Galaxy.

### **2 Aims and Objectives**

The aim of the project is to detect and study new (ultra)compact binaries systems in the Southern Hemisphere, with a particular emphasis on double degenerate systems: binaries consisting of two compact objects (white dwarfs, neutron stars or black holes), as these offer rich laboratories for studying evolutionary scenarios, for understanding internal physics, and are the leading sources for the detection of low-frequency gravitational waves.

The basis for the project will be formed by the MeerLICHT and BlackGEM multi-colour optical surveys, being conducted at Sutherland (MeerLICHT) and ESO La Silla (BlackGEM). From their All Sky Surveys, combined with data from the Gaia satellite, and their synoptic surveys, candidate ultracompact binary systems will be selected and followed-up with the Lesedi, LCO and SALT facilities at SAAO. Systems will be selected from their colours and their variability, in particular the occurrence of outbursts and/or eclipses. Particular attention will be paid to ‘drop-out’ systems, where the signal disappears completely during particular phases. The MeerLICHT/BlackGEM data processing pipe-line is particularly well suited to find such disappearing sources.

The objective for the MSc study is to gain a better understanding of the physics and population of such systems through the increased number of objects in combination with detailed observational studies.

### **3. Potential Impact**

The impact of this study is manifold:

a) the detection of new LISA ‘verification binaries’: systems with the shortest orbital periods, the strongest gravitational wave signal and the shortest orbital evolutionary time scales.

b) the possible detection of supernova Type Ia progenitors amongst the most *massive* of double degenerate systems. Although SN Type Ia's are the most commonly detected type of supernovae and commonly used to trace the accelerated expansion of the Universe, their origins remain elusive.

c) the study of tides in ultracompact binaries, which not only illuminates the internal structure of white dwarfs but whose impact on the orbital evolution of these systems is currently poorly understood.

#### **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, SAAO/MeerKAT, SALT, MeerLICHT, IDIA/Ilifu