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Registration: Student will be expected to register at the University of Cape Town (UCT)
Project Title: **Where are the black hole – white dwarf binaries?**
Type: **MSc**, within the UCT/SAAO-based SARChI group of Paul Groot

Project Description

1 Problem Statement
The vast majority of stars are part of binary or higher-order systems. At the end of the binary evolution these evolve in systems with one or two stellar, degenerate, remnants: white dwarf, neutron stars or black holes. Many populations of such single-degenerate or double-degenerates are known: Cataclysmic Variables with a white dwarf, AM CVn systems with two white dwarfs, low-mass X-ray binaries with a neutron stars, ultracompact X-ray binaries with a neutron star and a white dwarf, binary pulsar systems with two neutron stars and since relatively recently gravitational wave sources have shown binary neutron star, neutron star black hole and binary black hole systems.

Conspicuously absent from this list of combinations are white dwarf – black hole systems. For a proper understanding of the final stages of binary evolution it is imperative that we understand why this is. Is it an observational selection bias? Is it an evolutionary process whereby they cannot form or are exceedingly rare? These questions are being addressed in this MSc project.

2 Aims and Objectives
The aim is to understand the dearth of known white dwarf – black hole systems. The starting point is to trace their evolution in binary population synthesis codes such as SeBa. In these codes an initial population of stellar binaries is numerically evolved forward in time. In a Galactic context the star formation history of the Milky Way Galaxy can be taken into account as well as the finite lifetime of the Universe. The evolutionary codes keep track of all systems being produced, including the white dwarf – black holes systems. We will explore the expected population as a function of the input parameters of the population synthesis code, as well as a function of other 'final' populations, such as binary white dwarfs and white dwarf – neutron star systems. From the codes, the expected characteristics of the white dwarf – black hole population will be extracted. In the second phase of the project these expected population characteristics (orbital period distribution, masses and mass ratios, location within the Galaxy) will be compared to observational data sets and limitations. This will provide an answer to the question whether they do not exist or if we have missed them observationally.

3. Potential Impact
The impact of the project is to better understand binary evolution, and in particular the evolution of systems that started out with extreme mass ratios, in order to end up with a black hole and a white dwarf. This will shed light on the expected number of these systems to be seen by the gravitational wave mission LISA, as well as the number of expected systems that can be expected to be seen merging in the LIGO/Virgo experiments. The project may lead to an observational campaign the find and understand this population of stellar remnants.

4. Alignment with National Imperativesf

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, BRICS Time-Domain Initiative and the LSST partnership.