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Registration: Student will be expected to register at the University of Cape Town (UCT)
Project Title: **Fast Transients in the Local Universe**
Type: PhD, within the UCT/SAAO-based SARChI group of Paul Groot

Project Description

1 Problem Statement

Transients are stars that become unstable and flare up for shorter or longer periods of time. Well-known examples are supernovae, gamma-ray bursts and gravitational wave mergers. Observationally we can detect these systems better and better, at all electromagnetic wavelengths (e.g. optical or radio) and beyond (gravitational waves). While we are pushing the technical boundaries towards ever faster detections and responses (no within a day), *there is a severe lack of understanding on how to fit all types of fast transients within the framework of binary evolution.*

At the same time we can also use fast transients to illuminate short-lived and rare phases of stellar and binary evolution, such as the common-envelope or an actual merger or explosion of stars. As these occurrences are rare, we need to study stellar populations that stretch beyond our Milky Way Galaxy: towards the Local Universe ($d < 100$ Mpc) where stellar populations can be resolved.

2 Aims and Objectives

The project aims to discover and characterise fast transients within the Local Universe with the objective to place them within the framework of binary evolution and to use them to better understand binary stellar evolution.

The project will use data from the combined MeerLICHT+MeerKAT optical-radio studies and the BlackGEM optical data, within the SARChI group of Paul Groot and the ThunderKAT LSP project to identify new (fast) transients. Newly identified systems will be studied using the SAAO/SALT telescopes, the MeerKAT radio array, as well as the telescopes of the European Southern Observatory (VLT, NTT, ALMA) to

- a) understand their physical nature
- b) understand their host environment (what kind of galaxy, in clusters, in star forming regions, etc.)?
- c) constrain the myriad of pathways in binary stellar evolution.

The project will study the nearest stellar concentrations most intensely. These include the Milky Way, the Magellanic Clouds, the Local Group galaxies and the nearest galaxy clusters, such as the Fornax and Virgo clusters. It is out to these distances that with ground-based or space-based telescopes we can resolve individual stars. This will be of immense value as it may even lead to the detection of a progenitor system as well as allow for a deep long-duration study of the event and any late-time changes in their appearance. A prime example of such early detections and late-time behaviour is seen in supernovae where nearby ones allow the detection of any pre-explosion mass ejection and late-time interactions with circum-stellar material.

Full advantage will be made of the unique time and colour-baseline of the MeerLICHT and BlackGEM telescopes, and the access South Africa has to cutting-edge astronomical facilities.

3. Potential Impact

The impact of this study is manifold:

- a) a better understanding of the population of fast transients within a galactic population of stars
- b) the use of fast transients to constrain binary evolution.
- c) the possible detection of absolutely unique transients, such as gravitational wave counterparts.
- d) Identification of the nature of transients that can normally only be seen at large distances.

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 (MeerLICHT, SALT, SAAO telescopes) as well as globally (e.g. the telescope of the European Southern Observatory)
- 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, SALT, MeerLICHT, MeerKAT, IDIA/Ilifu