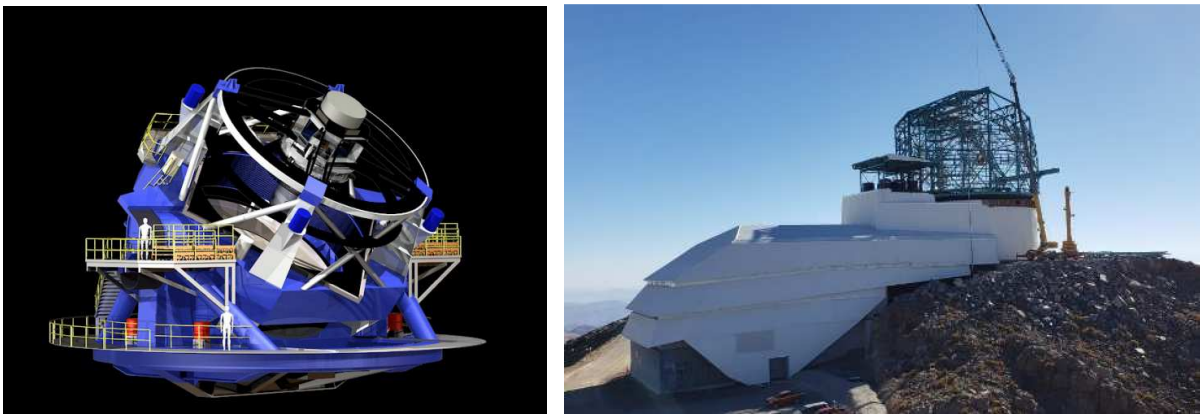
SAAO PhD project

Transients in the LSST Era

6 June 2019

Supervisor:
Dr David Buckley (DB), SAAO (dibnob@saao.ac.za)

Potential Co-supervisors:
Professor Patrick Woudt (PW), UCT (pwoudt@ast.uct.ac.za)
Dr Brian van Soelen (BvS), UFS (VanSoelenB@ufs.ac.za)
Dr Magaretha Pretorius (MP), UCT/SAAO (retha@saao.ac.za)
Dr Stephen Potter (SP), SAAO (sbp@saao.ac.za)
Dr Enrico Kotze (EK), SAAO (ejk@saao.ac.za)



Schematic (left) of the LSST, currently under construction in Chile (right), with expected completion in 2022.

Overview

The activities proposed for this programme involve the planning for supporting followup studies of optical transients discovered by the Large Synoptic Survey Telescope (LSST). When completed in 2022, LSST, with its 10 square degree field and 3.2 gigapixel camera, will embark on its 10 year mission to continuously survey the southern skies, in multiple filters. This will be a game-changer in terms of the number discoveries of transient or variable objects, expected to be millions per night! South Africa will be heavily involved in followup of these LSST-discovered transient. The South African LSST transient project will leverage the experience of the on-going SALT Large Science Programme on transients, which has been running since 2016 and involves studies of astrophysical transients across a broad range of object class, including high energy (X-ray, γ-ray) and multi-messenger (gravitational waves, neutrinos) sources. Since late 2018 the study of transients in South Africa has expanded further, with the start of the ThunderKAT programme to discover and study radio transients, including Fast Radio Bursts (FRBs), discovered by the MeerKAT radio telescope arry. The future South African LSST transient followup programme will involve all of the major facilities accessible to South African astronomers, including SALT, MeerKAT and H.E.S.S., plus the future SAAO Intelligent Observatory, which aims to link many of the existing smaller optical telescopes at SAAO into an automated transient followup machine. In addition, the development of Big Data infrastructure in South Africa, aimed to support MeerKAT, SKA and LSST science, will have a big role in transient followup science in the LSST era.

Recently the opportunity was opened to South African astronomers to participate in the LSST project, with the appointment of 3 South African Principal Investigator Affiliates, each with a team of up to 8 members, including 4 graduate students. DB was recently (Feb 2019) appointed as PI Affiliate for LSST transient science, with the other members of the team, including some potential co-supervisors, being EK, MP, SP & PW. Two graduate students (one Masters, one PhD) have already been appointed in 2019 (D. Hewitt and H. Marais) and we expect to recruit the remaining two students within ~12 months. Our proposed programme will focus primarily on the various object classes, science drivers and task force activities within the LSST *Transients and Variable Stars (TVS)* science collaboration, plus related projects within the *Stars, Milky Way and Local Volume (SMWLV)* collaboration.

Planned Activities

Some of the activities within this programme, for which students could potentially become involved, will include the following:

- developing automatic followup systems at SAAO/SALT to react to triggers from LSST observing brokers,
- developing more optimal cadencing strategies for Galactic transient from simulations of various compact binaries populations in the Galaxy and Magellanic Clouds,
- motivating for various high cadence and deep-drilling programmes, developing and testing simulations and undertaking test observations in support of these,
- using data from shallower wide-field transient alert facilities (e.g. MASTER) to test automated classification software (e.g. from their light curves),
- undertaking mini-surveys with facilities like MeerLICHT (e.g. in twilight), MONET-South or KMTNet to test detection algorithms and automated light curve classifications.
- Assisting with various task force activities within the TVS and SMWLV collaborations, some of which were recently (Nov 2018) discussed in a series of science White Papers.
- Participation in existing transient science projects within the scope of the SALT and MeerKAT (i.e. ThunderKAT) transient programmes, focusing on specific object classes.

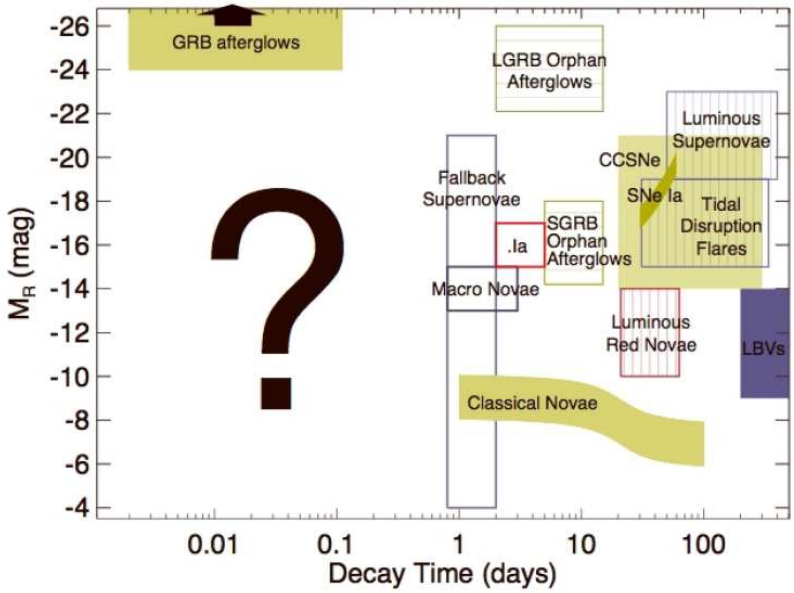
There is plenty of scope for a student at PhD level to become involved in different aspects of the proposed programme, depending on their interests and background. These range from developing software tools to aid in simulations and triggering followup observations, to testing of machine learning classification systems based on real data. South Africa is also proposing to develop an event broker to filter LSST transient alerts, specifically for followup with our own facilities (e.g. SALT/SAAO & MeerKAT). Hence there may also be opportunities for involvement in this development and the wider aspects of South African Big Data infrastructure pertaining to LSST.

Project tasks

Some of these tasks (some can be conducted in parallel) are briefly outlined here, although they are likely to expand and develop over time as the nature of the science collaboration requirements become clearer. These are illustrative of the various activities that a PhD could become involved, but they certainly would not be expected to address all of these.

- Help review the current science drivers, roadmaps and taskforce activities within the LSST *Transients and Variable Stars* science collaboration (and possibly others) to identify areas where South African astronomers can contribute, particularly in regard to optical support with SALT & SAAO facilities, but also possibly other facilities (e.g. MeerKAT or H.E.S.S.).
- Look into the cadencing strategies for various classes of Galactic compact object binaries using simulation tools and population models.
- Become familiar with the reduction and analysis of transient observations from SALT, MeerKAT and other facilities, as appropriate.
- Consider what deep-drilling/high-cadence programmes might be worth exploring with LSST and supporting pilot programmes that might be undertaken with South African facilities.
- Undertake supporting observations, data reduction and analysis for the above.
- Development of a South Africa-specific LSST event broker tailored to local followup facilities and science interests and potential integration with software scheduling systems being developed for the SAAO's Intelligent Observatory.
- Provide some inputs into the Big Data requirements for LSST data specific to South African interests.

- Experiment with automatic light curve analysis algorithms of real (i.e. from observations obtained with local facilities) and simulated data sets.
- Undertake LSST transient followup simulations of different object classes based on expectations regarding frequency of occurrence and, where applicable, population models for their distribution (e.g. for Milky Way or Local Group).
- Consider what followup strategies are appropriate to extend our knowledge to hitherto relatively unstudied transient parameter space (e.g. as in the following figure in the region denoted by "?"), where there are opportunities to discover new classes of objects and astrophysical phenomena.



Discovery space for cosmic transients