Project proposal for the SAAO Prize PhD Scholarship

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Optical and radio transient sources

We know that different types of astrophysical objects display a range of extremely energetic events, including nova eruptions, supernova explosions, stellar mergers, and compact object mergers. Observing these transient events allow us to study the laws of physics operating in conditions unachievable in a laboratory. Many transient sources originate in interacting binary stars. The interest in these objects revolve around accretion and relativistic jets, the neutron star equation of state, strong-field gravity, the Galactic and extra-galactic X-ray and gamma-ray source populations, and the progenitors of type Ia supernovae.

Transient astronomy is already a rapidly growing field, thanks to all-sky X-ray and γ-ray monitors, as well as several optical surveys. During the coming months and years several important surveys will be offering an opportunity to do science that was previously impossible, and to prepare for future larger surveys. Follow-up observations with with large telescopes such as SALT will be key in many cases.

MeerKAT and MeerLICHT The Karoo Array Telescope, MeerKAT, combines a wide field of view, wide frequency coverage, and excellent sensitivity to provide one of the most powerful southern hemisphere facilities for radio transient studies. The capabilities of MeerKAT will be exploited via a collaboration with Rob Fender (Oxford) and Patrick Woudt (UCT). They are co-PIs of an approved Large Survey Project, ThunderKATs, aiming to observe all transient synchrotron sources in the southern sky. Besides an allocation of dedicated time, all data taken by MeerKAT will be checked by a transient detection pipeline. These commensal observations are expected to yield the majority of transient discoveries.

MeerLICHT is a planned 0.6-m robotic optical telescope with a wide-field imager. This is a small project, but will greatly enhance the scientific output of MeerKAT. It will be slaved to the MeerKAT array, thereby obtaining immediate optical coverage at a sensitivity that will not only reach most of the known objects we plan to observe, but will also serve to distinguish less interesting transient sources (e.g. flare stars), so that they can be excluded from further follow-up. Early observations will repeatedly cover several nearby galaxies, enabling the discovery of transient events such as stellar mergers and novae in environments of differing metallicity and stellar population age.

These two telescopes together will provide a unique dataset, and we expect it to be the most valuable survey for radio transients.

The SKA and LSST Although the SKA and LSST are some years off, both facilities will open up new parameter space and will soon be of great importance in transient science, as well as time-domain astronomy in general. The co-supervisors of this project will be involved in transient science with data from these telescopes, and part of our aim with this PhD project is to lay the groundwork for the LSST and SKA era.

This project The student will be expected to drive a project involving the study of radio and optical transients, and will be free to define it. The work may focus on characterization via optical follow-up, or automated classification based on MeerKAT/MeerLICHT imaging data, or on modelling the transient populations. Depending on the rate of MeerKAT transients, the student may also choose to focus on transients from other optical surveys, or from X-ray or gamma-ray facilities.

Figure 1. Optical image of V838 Mon and its light echo. The red central object is likely the product of a stellar merger, and the bright emission from this event is sweeping through surrounding interstellar dust, illuminating it and creating the appearance of a shell.