Photometric and spectroscopic observations of asteroids using Sutherland telescopes

The name "asteroid" is the colloquial term used for any small, airless, rocky object revolving around the Sun that is too small to be called a planet. Objects that fit this description are essentially left-over material after the condensing dust in the protoplanetary disk became planets and our Solar System developed into what we know it as today. There are many types of objects termed "asteroids" (e.g main-belt asteroids, near-Earth asteroids, Jupiter Trojans, Kuiper-belt objects etc.) and they occur throughout our Solar System. After discovery of an asteroid (currently > 1 million main-belt asteroids and >30 000 near-Earth asteroids[1]), usually nothing more than the location within the Solar System is known (i.e. the most likely type of asteroid) so follow-up characterisation is required for any further studies.

Space-craft missions to several asteroids, e.g. the OSIRIS-REx spacecraft to asteroid Bennu (Lauretta et al. 2019, see Figure 1), is one way to do detailed follow-up characterisation. Sending spacecraft to asteroids is however simply not technically or financially feasible for more than a handful of asteroids. Obtaining photometric colours from ground-based observation in several broad-band filters is one type of follow-up characterisation technique that allows us to infer the most likely surface composition of an asteroid without a physical sample collection. This is because the photometric colours are a proxy to the spectral slope of an asteroid's reflectivity spectrum and asteroids are divided into several taxonomies (e.g. S-types, C-types) based on broad-featured spectral signatures that have varying spectral slopes (DeMeo et al. 2009). However, some ambiguity exists in this method of taxonomic classification and only actual spectra can truly reveal the taxonomic type of an asteroid. Spectra are also required to differentiate between sub-types within a taxonomic type (e.g S-type vs. Sq-type).

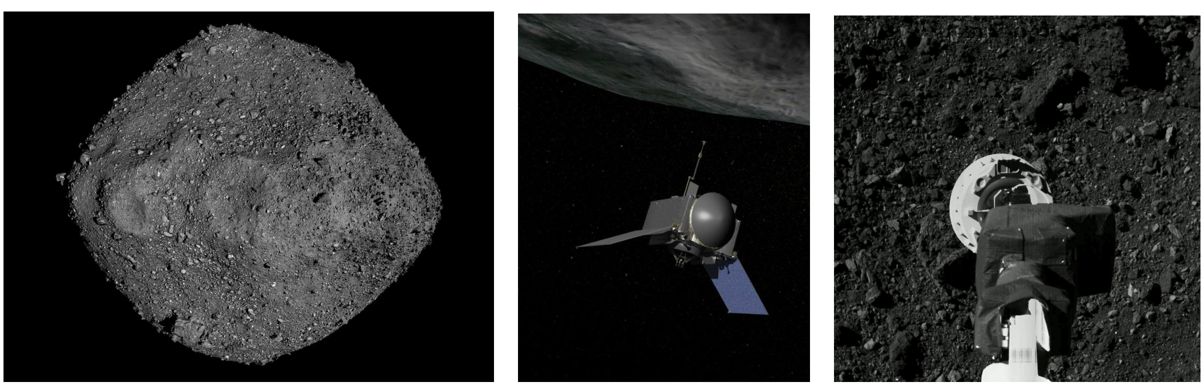

Figure 1: (left) Mosaic of Bennu created using observations made by NASA's OSIRIS-REx spacecraft. (middle) Artist concept of OSIRIS-REx. (right) OSIRIS-REx mission's sample collection event. Image taken with SamCam imager as the spacecraft approached asteroid Bennu's surface.
Credits: NASA's Goddard Space Flight Center, University of Arizona

The SAAO owns several telescopes and instruments that are capable of doing photometric and spectroscopic follow-up observations of asteroids. One example is Mookodi, a new low-resolution spectrograph (with photometric imaging capabilities) installed on the 1-m Lesedi

[1] https://www.minorplanetcenter.net/

telescope in Sutherland. The low resolution nature of the instrument is perfectly suited to resolve the broad-featured spectral signatures of asteroids but still maintain a favorable limiting magnitude capability.

Another exciting development on the asteroid-front for the SAAO is that the third node of the Asteroid Terrestrial-impact Last Alert System (ATLAS, Tonry et al. 2018) is now fully operational in Sutherland. Each ATLAS node discovers one new near-Earth asteroid every couple of days (see example in Figure 1) and several other transient events every night. Unlike LSST, ATLAS has a fairly modest primary mirror of only 0.5m and therefore all discoveries made by ATLAS-STH are easily within the limiting magnitude of many of the smaller telescopes in Sutherland like Lesedi. In the case of near-Earth asteroids, many of the newly discovered small ones (and under-studied population) rapidly fade in brightness as they move away from Earth after discovery. Often there is only a small window of a day or two that follow-up characterisation with 1-m class telescopes is possible and therefore rapid reaction to do follow-up observations is critical. The potential for rapid same-night follow-up of any transient (asteroid or non-asteroid) that ATLAS-STH discovers, with telescopes in Sutherland, now exists.

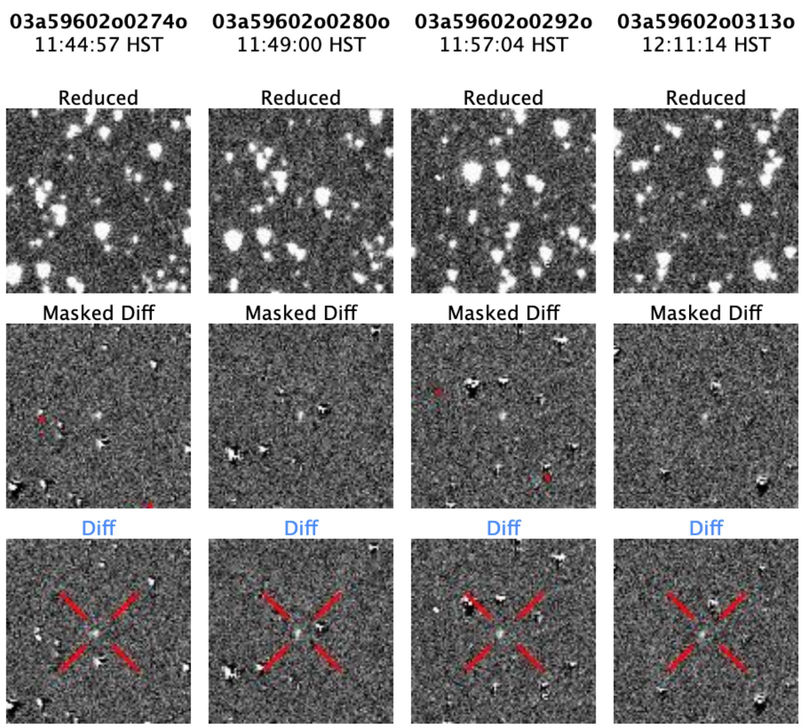

Figure 1: Discovery images from ATLAS-STH of near-Earth asteroid 2022 BK, a 100-200m in diameter object that made a close approach to Earth of approximately 22 Lunar distances on 2022-Jan-28 at 21:35 UTC. More details on the asteroid can be found here: https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=2022%20BK&view=VOPC

This MSc project would contribute to the goal of follow-up characterization and further studies of asteroids using SAAO telescopes. The project could also involve instrumentation development to enhance this capability.

The project is open to students registered at any South African University but requires full-time presence during work hours at the SAAO campus in Cape Town for a minimum of 12 months of the MSc project. Co-supervision will be arranged depending on the preferred university. During the project several trips to Sutherland may be required. All expenses, including travel, accommodation and food will be provided during the Sutherland trips. The student will be expected to work in a team environment with other astronomers, software developers, and electronic/mechanical engineers. Programming experience in Python and attention to the careful handling of sensitive and expensive electronic/optical components are required skills.

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