<u>Low-resolution spectroscopy of close-approaching near-Earth Asteroids</u>

Near-Earth Asteroids (NEAs) are a population of asteroids in stable orbits around the Sun that escaped from the main asteroid belt due to resonant motion with large planets like Jupiter (Granvik et al. 2017). As of May 2022, the IAU Minor Planet Center's (MPC's) database shows that almost 30 000 NEAs have been discovered in total. This number is increasing, on average, by four per day with many of these NEAs potentially posing a threat to life on Earth via possible impact with Earth.

Obtaining photometric colours from observation in several broad-band filters of an asteroid allows us to infer the most likely surface composition of an asteroid which may hint at the bulk composition. The bulk composition would be a key property in determining the potential impact damage. 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 photometric method of taxonomic classification and only actual spectra can truly reveal the taxonomic type and hence the possible bulk composition of an asteroid. Spectra are also required to differentiate between sub-types within a taxonomic type (e.g S-type vs. Sq-type). Mookodi is a new low-resolution spectrograph installed on the 1-m Lesedi 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. Many small close approaching near-Earth asteroids (NEAs) are discovered with brightnesses in the 16-22 astronomical magnitude range and Mookodi's estimated limiting magnitude means that many of these discoveries can be followed-up for taxonomic type characterisation.

The remaining challenge for the instrument would be to position and maintain a moving source in the entrance slit of the spectrograph for a sensible exposure duration (up to several minutes). The excellent non-sidereal tracking capability of the modern Lesedi telescope should be good enough to maintain a reasonably fast moving NEA in the relatively large 4-arcsecond slit for several minutes. But careful timing (in the order of a fraction of a minute) of the observation will be critical to start the science exposure when the asteroid's predicted sky-position is maneuvered into the slit and the non-sidereal tracking is activated.

The aim of this project would be to commission Mookodi for this non-sidereal spectroscopy mode and to provide instructions to other observers on how to perform such observations. Determining limitations (magnitudes, maximum exposure times vs. sky-rates etc.) of this mode would also be part of the project. A second part of the project would be an attempt to roboticise this mode for fully automated rapid follow-up observations.

If these tasks are completed and time allows the last part of the project could be to use this newly commissioned mode to perform time-resolved low-resolution spectroscopy of several large and slow-moving NEAs to determine if surface composition heterogeneity is observable from ground based spectroscopy observations. Space-craft missions to several asteroids, e.g. the OSIRIS-REx spacecraft to asteroid Bennu (Lauretta et al. 2019, see Figure 1), have shown through much higher spatial resolution than what ground based astronomy can achieve, that surface heterogeneity exists in some asteroids which can have implications for an asteroid’s origin (D. DellaGiustina et al. 2019). While it should be technically possible to resolve dramatic surface composition differences as a function of rotation phase (i.e. time), for example as the result of a large impact crater with “fresh” material exposed dominating one side of an asteroid, this would be challenging to achieve via ground based observations. This latter part of the project could be a segway into a PhD project.

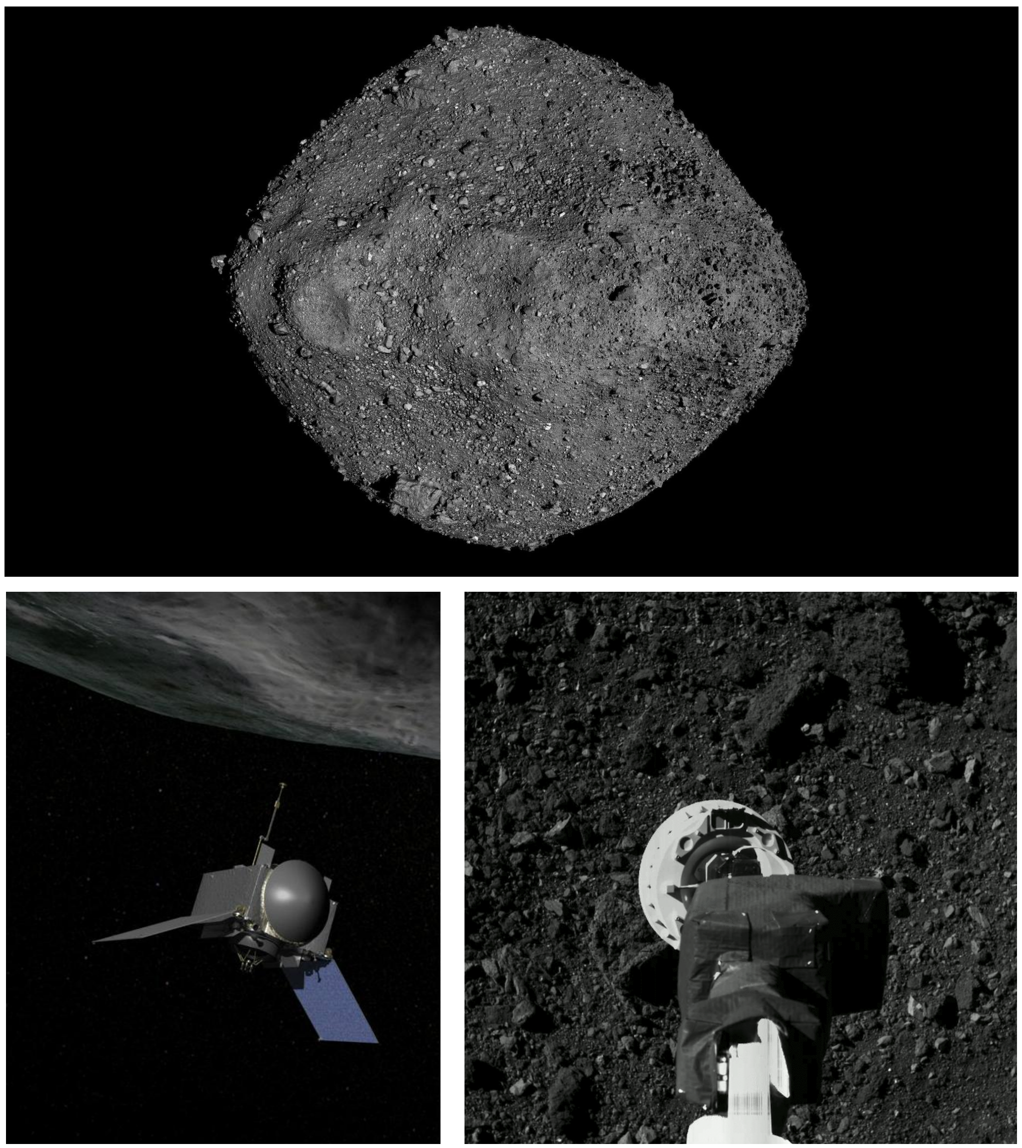

Figure 1: (top) Mosaic of Bennu created using observations made by NASA’s OSIRIS-REx spacecraft. (bottom-left) Artist concept of OSIRIS-REx. (bottom-right) OSIRIS-REx mission’s sample collection event. Image taken with SamCam imager as the spacecraft approached asteroid Bennu’s surface.
Credits: NASA's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

The 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 week-long trips to Sutherland will also be required to perform observations (remote observing from SAAO campus in Cape Town will be possible after sufficient Sutherland observing experience is achieved). 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 is a required skill.

Contact details:

Dr. Nicolas Erasmus
Instrumentation Scientist and Astronomer
South African Astronomical Observatory
n.erasmus@saao.nrf.ac.za