Developing instrumentation and software for rapid follow-up of near-Earth asteroids

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.

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 steerable telescopes in Sutherland. In the case of asteroids, many of the newly discovered small asteroids (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 but an agile and dedicated robotic follow-up system needs to be developed to realise this.

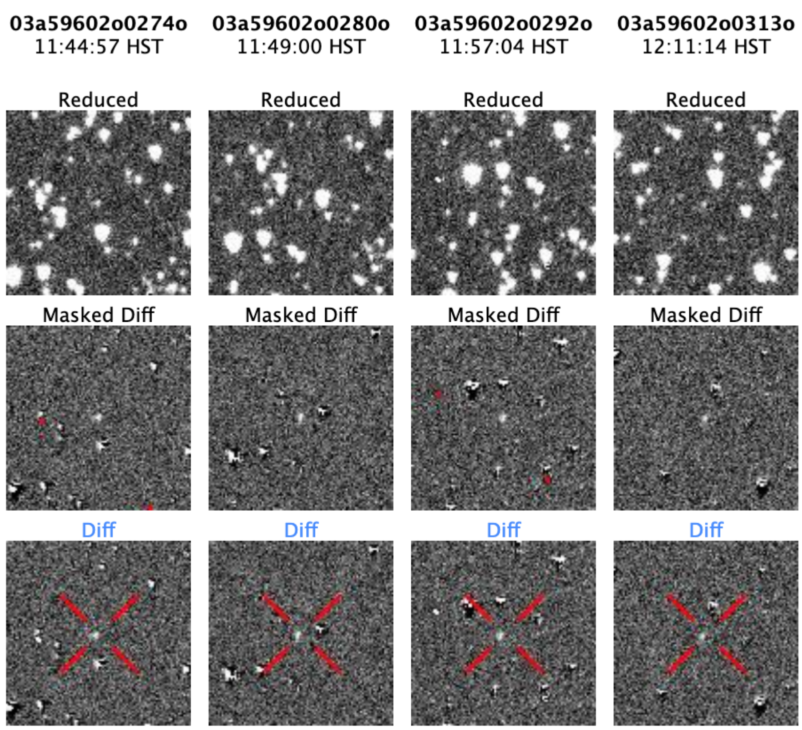

Figure 1: Discovery images from ATLAS-STH of near-Earth asteroid 2022 BK, a 100-200m in diameter object that made a close approach to Earth of approximately 22 Lunar distances on 2022-Jan-28 at 21:35 UTC. More details on the asteroid can be found here: https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=2022%20BK&view=VOPC

This MSc project would contribute to this goal and the ultimate completion of the project could potentially flow into a PhD project. The MSc part of the project will include activities related to:

1. Setting up and testing newly acquired Andor and/or QHY sCMOS camera(s) in an optical laboratory.
2. Simulation in Zemax and optical laboratory testing of a novel ultra low-resolution spectrophotometry technique to do simultaneous multi-band photometry with wedge prisms.
3. Designing and 3D printing prototype mounting interface for the instrument to existing Sutherland telescopes.
4. Installing developed instrumentation on a telescope and performing manual test observations.
5. Developing new or expanding the capability of existing photometry data reduction pipelines to cater for moving sources in an automated fashion.
6. Involvement in the refurbishment and robotisation of the 0.75-m Alan Cousins Telescope (ACT), previously known as the Automatic Photometric Telescope (APT, P. Martinez et. al. 2002), in Sutherland.

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. 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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