Discovery and Characterization of Near-Earth Asteroids

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Project Description: Near-Earth Asteroids (NEAs) are thought to be a steady-state population of asteroids that is continuously being replenished by asteroids from the main asteroid belt, through resonant motion with large planets like Jupiter and Saturn (Granvik *et al.* 2017). NEAs have orbits that bring them close to the Earth's orbit and therefore they pose a direct threat to Earth, as some of them potentially have impacting orbits. The most significant recent examples are the Chelyabinsk airburst in 2013, a ~17-m asteroid that impacted Russia without being discovered before atmospheric entry, and a ~2-m object that created a bright fireball over Botswana on 03 June 2018. The Botswana airburst was discovered only a few hours before impact by the Catalina Sky Survey, one of only a handful of dedicated asteroid-discovery programs worldwide. In order to increase the warning time for small impactors and to complete the census of more threatening, larger asteroids, additional discovery programs are needed. The Southern Hemisphere currently has zero discovery programs, and Sutherland, South Africa has been earmarked as an ideal site. The Sutherland node of the Asteroid Terrestrial-impact Last Alert System (ATLAS) will be the third 0.5-m telescope (the other two are located in Hawaii) dedicated to this asteroid discovery program. Construction of the Sutherland ATLAS is expected to start in late 2019, with telescope installation in 2020. **Part of the PhD project entails involvement in the construction and commissioning of the ATLAS telescope in Sutherland.**

On the other hand, the close proximity of NEAs to Earth has its benefits. Being nearby on an astronomical scale makes them convenient, small, solar system objects to characterize using Earth-bound measurements. Coming close to Earth also makes NEAs attractive objects to visit and investigate with spacecraft. This is evident with the numerous ongoing and proposed space exploration missions from the scientific community, like JAXA's Hayabusa (Yano *et al.* 2006) and Hayabusa2 (Tsuda *et al.* 2013), and NASA's OSIRIS-REx (Lauretta *et al.* 2017) and DART (Cheng *et al.* 2016). There is also an increasing interest in space mining endeavors from the technology and industrial community (Elvis 2012). Determining the physical properties (e.g. rotation period and shape) and composition (e.g. elemental make-up) of NEAs is critical to all of the above. **In parallel to involvement in ATLAS, the project involves observing on several of the steerable telescopes located in Sutherland, and obtaining data from other telescopes (e.g. SALT, KMTNet, Las Cumbres, MeerLICHT). The telescope time will be used for characterizing newly-discovered and known NEAs through spectrophotometry, photometric light-curve derivations, and/or spectra.** Note that the collaborator and runs a research group that specializes in asteroid observations: there should be an opportunity for the student to visit NAU and work directly with that group.

Depending on the interest of the student, additional or complementary work could include characterization of main-belt asteroids (e.g. studying super-fast rotators) and Jupiter Trojans (e.g. targets for the upcoming NASA Lucy mission, which launches in 2021).

Within the 3-year period of the project, we expect that ATLAS will be installed and commissioned and many NEAs will be characterized. The focus can either be quantity, with a small amount of information on up to thousands of objects, or quality, with more detailed studies of specific groupings of objects. These projects will play a key role in detecting possible Earth impactors and will contribute directly to an increased understanding of the formation and evolution of the Solar System.