Comprehensive Characterization of Repeating Close-Flyby NEAs to Identify Future Asteroid-Mining Candidates

Near-Earth asteroids (NEAs) originated within the main asteroid belt but have since shifted into orbits that bring them into close vicinity with Earth's orbital path. While their presence poses a risk of potential impacts, they also hold promise for extracting valuable resources in space (e.g. water, precious metals and volatiles). Currently, around 35,000 NEAs have been discovered and catalogued,[1] with approximately 3,000 new discoveries annually.[2] New discoveries are primarily (~85%) of smaller (<300m) asteroids[3], as asteroids have a power law size distribution and most of the larger (>1km) ones have already been detected. Many of these smaller asteroids make singular Earth flybys, fading rapidly in brightness as they recede from view, unlikely to ever be seen again with Earth-based telescopes for thousands of years. However, a subset of these small NEAs shares orbits and orbital periods very similar to Earth's, resulting in multiple close flybys in the forthcoming decades providing multiple chances for characterisation and/or exploitation via orbital capture.

Although the mechanics of capturing such asteroids in orbit around the Earth can be intricate and contingent upon many factors like asteroid mass and relative velocity, several studies (e.g., J.P. Sanchez et al. 2011, J. R. Brophy et al. 2012, S. Gong et al. 2015, Y. Wang et al. 2021, L. Ionescu et al. 2022, Y. Zhang et al. 2022, M. Tan et al. 2023) have theoretically proposed some approaches for feasibly capturing relatively small asteroids using existing spacecraft technology and in some cases with gravity assists. It is reasonable to anticipate that technological advancements will only further enhance the feasibility of capturing sub-100m objects in the next few decades. Once captured in an orbit within the proximity of Earth, subsequent technological advancements may facilitate the deployment of increasingly sophisticated and capable spacecraft for the purpose of extracting or mining valuable materials.

The objective of this project is to identify and thoroughly characterise all sub-300m NEAs observable with a 1.0-meter class telescope from Sutherland during 2024/2025, that are also predicted to undergo multiple close flybys of Earth in the next century. These small multi-flyby asteroids could potentially serve as candidates for future capture missions, making it crucial to ascertain as many of their physical properties (such as rotation period, taxonomic type, and shape) as possible to identify the most suitable candidates for space-mining attempts.

Observations will be conducted utilising the robotic Mookodi instrument on the 1-meter Lesedi telescope where possible and supplemented by manual observations the 74-inch telescope, and potentially the Southern African Large Telescope (SALT) for fainter objects.

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[1] https://www.minorplanetcenter.net/
[2] https://cneos.jpl.nasa.gov/stats/site_all.html
[3] https://cneos.jpl.nasa.gov/stats/size.html

This MSc project would significantly contribute to the overarching goal of the project, potentially paving the way for a subsequent PhD project. The MSc component will encompass several key activities, including:

1. Conducting a comprehensive literature review of proposed approaches for capturing asteroids
2. Utilising the various APIs provided by JPL Horizons and/or CNEOS to determine potential observing candidates for the upcoming 2024/2025 observing seasons
3. Employing both robotic and manual telescopes to gather observational data on selected multiple flyby NEAs
4. Using existing photometric and spectroscopic pipelines to extract crucial data such as photometric colours and spectral signatures from observed NEAs, providing valuable insights into their physical characteristics
5. Augmenting observational data with publicly available datasets, such as those from ATLAS, to enrich the analysis and facilitate the extraction of additional physical properties of the observed NEAs.

The project is open to students from the UCT NASSP node and 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 after discussion with the student. 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 (and software developers, and electronic/mechanical engineers if needed). Programming experience in Python is essential and previous observing experience will be advantageous.

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