3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Planetary SAR and NEO tracking using EISCAT 3D

Torbjørn Tveito*(1), Daniel Kastinen(2)(3), and Juha Vierinen(1)
(1) University of Tromsø, Department of Physics and Technology, Norway
(2) Swedish Institute of Space Physics, Sweden
(3) Umeå University, Department of Physics, Sweden

1 Extended Abstract

The upcoming EISCAT 3D facility is a high-power, large aperture 233 MHz phased array radar [2]. We have investigated it's use as a tool for synthetic aperture radar imaging of planetary targets [3] and orbit estimation of near-Earth objects [1]. It was demonstrated that while the facility is not powerful enough to meaningfully map the planets Mars and Venus, it will be well equipped to provide high-resolution maps of the lunar nearside. The interferometric performance of the EISCAT 3D receiver antenna layout was evaluated for disambiguation of range-Doppler maps. The effects of travelling ionospheric disturbances on Doppler broadening was estimated. While ionospheric effects cause significant disturbances, each year will have approximately 100 days where the Moon is observable. A survey of all possible lunar observations between 2022 and 2040 was done, showing that the view of the nearside and direction of the Doppler axis changed significantly year-to-year. The study of NEO observation was done on three separate populations; (1) an estimate based on fireball statistics. (2) Catalogued NEOs from the JPL small-body database. (3) A theoretical population of minimoons. Two observation schemes were evaluated; serendipitous discovery of unknown NEOs passing the radar beam and tracking of NEOs using a-priori estimates of orbital elements. Fireball statistics indicated that 60-1200 objects with diameter $D > 0.01$ m can be discovered per year. It was found that approximately 20 objects per year can be tracked post discovery near their closest approach, indicating that the EISCAT 3D facility can be used for routine NEO tracking. From a theoretical population of minimoons, it was found that approximately 7 objects per year could be discovered using 8% to 16% of the total radar time. It was also shown that the EISCAT 3D radar could be used to discover previously uncatalogued NEOs with sufficient radar time allocated to this purpose. This could be done by arranging time-sharing with ionospheric observations or space debris observing modes.

References

[1] Daniel Kastinen, Torbjørn Tveito, Juha Vierinen, and Mikael Granvik. Radar observability of near-earth objects using eiscat 3d. In *Annales Geophysicae*, volume 38, pages 861–879. Copernicus GmbH, 2020.

[2] Ian McCrea, Anita Aikio, Lucilla Alfonsi, Evgenia Belova, Stephan Buchert, Mark Clilverd, Norbert Engler, Björn Gustavsson, Craig Heinselman, Johan Kero, et al. The science case for the eiscat_3d radar. *Progress in Earth and Planetary Science*, 2(1):1–63, 2015.

[3] Torbjørn Tveito, Juha Vierinen, Björn Gustavsson, and Viswanathan Lakshmi Narayanan. Planetary radar science case for eiscat 3d. In *Annales Geophysicae*, volume 39, pages 427–438. Copernicus GmbH, 2021.