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Radar Observation of Asteroids 2005 LW3 and 2006 WB with European Radio Telescopes

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From 2019 to 2022, the ESA funded the "NEO Observation Concepts for Radar Systems" pilot project, aimed at the future development of a European radar system for NEOs, enhancing planetary defense, mission planning, and advancing the scientific study of Near-Earth Objects. Contributions from INAF, SpaceDyS, and the University of Helsinki led to successful radar campaigns, observing asteroids such as 2021 AF8 and (4660) Nereus, conducted in collaboration with NASA's Deep Space Network and the Jet Propulsion Laboratory, California Institute of Technology. The main results of this project are presented in [1].

Additional radar observations were performed to demonstrate the capabilities of radio telescopes and enhance our expertise in this field. We also developed specific software tools for asteroid radar observations that played a critical role in these advancements. This work highlights the results of some of these observations, with a focus on those carried out on the asteroids 2005 LW3 in 2022 and 2006 WB in 2024.

The 2005 LW3 observation involved a multi-static radar configuration formed by the 70-m DSS-63 antenna at the Madrid Deep Space Communications Complex (MDSCC) as the transmitter, and the

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32-m Medicina ”G. Grueff” and the 100-m Effelsberg radio telescopes as receivers, marking one of the first radar observations of a NEO conducted exclusively using facilities in Europe.

The experiment was carried out on November 23, 2022, during the asteroid's close approach to Earth. Both receiving stations successfully detected radar echoes, achieving high-frequency resolution. We derived key physical characteristics of 2005 LW3, such as the rotation period and the polarization ratio, the latter related to the roughness of the asteroid's surface and sub-surface at the wavelength scale. Delay-Doppler imaging conducted by Goldstone revealed that the asteroid measures about 400 meters in diameter and has a satellite approximately 50-100 meters in diameter. A significant achievement of our observations was the independent confirmation of the satellite, detected as a distinct spectral spike superimposed on the primary body's broader radar echo.

Finally, we present the preliminary results from the last radar observation of asteroid 2006 WB, conducted on November 25-26, 2024, during its close approach. This campaign employed the 64-m Sardinia Radio Telescope (SRT/SDSA) as a receiver, using different acquisition systems - some of which are under testing. The Goldstone DSS-14 and Madrid DSS-63 antennas were the involved transmitters, respectively at frequencies of about 8.6 and 7.2 GHz. These observations provided important information on the physical parameters of the target. The 8-GHz portion of the experiment also aimed at allowing us to test, for the first time, the production of Delay-Doppler images. Reduction is still underway.

Collectively, these findings demonstrate the potential of the European radio telescopes for an EU-based radar system, in synergy and collaboration with the US one, to contribute significantly to NEO characterization and planetary defense efforts.

Comments:
(Poster)

References

[1] G. Pupillo, S. Righini, R. Orosei, et al., Toward a European Facility for Ground-Based Radar Observations of Near-Earth Objects, Remote Sensing 16 (2024) 1–38.