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NEO Characterization

DROID: BISTATIC LOW-FREQUENCY RADAR SOUNDING OF 99942 APOPHIS IN 2029

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ABSTRACT

Our knowledge of the internal structure of asteroids entirely relies on inferences from remote sensing observations of the surface combined with theoretical modeling (Herique et al. 2018). Is Apophis a rubble-pile, as expected, or a monolithic rock, and how high is the porosity? What is the typical size of the constituent blocks? Are these blocks homogeneous or heterogeneous? If Apophis is bilobed, how does the material differ between each lobe? Direct measurements of Apophis deep interior are needed to better understand its accretion and dynamical evolution, to improve our ability to study its stability conditions and to model its response to the gravitational constraints induced by Earth close approach. This is also crucial to plan any interaction of a spacecraft with Apophis especially for Planetary Defense purposes.

Radar observation of Apophis from a spacecraft is the most mature technique capable of achieving these objectives, by providing a direct measurement of its interior. This is the goal of the DROID, Distributed Radar Observations of Interior Distributions, a mission concept developed in collaboration between NASA JPL and CNES (Raymond et al, this meeting). The DROID mothership will release two CubeSats each with a low-frequency radar. The radar will be a version of JuRa (60 MHz) (Herique et al, this meeting), modified to operate in a bistatic mode. The mothercraft and daughtercraft will also have cameras for both science and navigation.

Each daughtercraft radar can operate in a monostatic mode, or in a bistatic mode using the two platforms to measure the signal transmitted throughout Apophis, as CONSERT on Rosetta/ESA. Then, the inter satellite link between mothercraft and

daughtercrafts provides the synchronization of the two electronics allowing absolute measurement of the propagation delay in bistatic mode.

The monostatic radar mode offers a larger penetration (up to 100 meters or more) with a limited resolution (≈20 m). It corresponds to the radar under implementation for the Juventas Cubesat on Hera/ESA mission (Herique et al, this meeting). Multipass processing allows us to build a 3D tomographic image of the interior to identify internal structure like layers, voids and sub-aggregates, to bring out the aggregate structure and to characterize its constituent blocks in terms of size distribution and heterogeneity at different scales from submetric to global. Shallow subsurface characterization and radar images to support to shape modeling are also possible in this configuration, but with degraded performance due to a limited resolution.

The bistatic radar mode will firstly measure the signal in transmission, allowing us to achieve a direct measurement of the dielectric permittivity, which is related to composition and microporosity. This mode is less demanding in terms of data volume and operation compared to full bistatic coverage. Partial coverage will provide slices of the body with average characterization and its spatial variability to characterize large scale structures. Dense coverage will provide a larger diversity of observation angles, the bistatic mode will then allow a complete 3D tomography benefiting from angular decorrelation of the size effect and permittivity contrast in the return power.

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Comments: Oral session.