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X Apophis: T-4 Years

The Caltech Mission to Characterize Apophis

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The close flyby of asteroid (99942) Apophis on April 13, 2029 presents a unique opportunity to achieve scientific and planetary defense goals. A multi-spacecraft mission concept to exploit this opportunity has been developed in a collaboration between Caltech, JPL and CNES. The Caltech-led mission is being pursued as a privately funded venture with commercial partners. Its architecture employs a high delta-V Mothership and two 12U CubeSats that would rendezvous with Apophis prior to Earth closest approach and escort it through the encounter. Its measurements can determine: the body's shape and density; the size, distribution, and arrangement of blocks and voids in the interior; surface movements or reshaping during the Earth flyby; as well as spin state changes. Its goals are to understand the interior structure of a (presumed) rubble pile asteroid and implications for its formation, evolution and response to deflection, and to understand how close planetary encounters affect asteroids. The Caltech mission would provide unique high fidelity in situ data to complement and enhance Earth-based optical and radar observations of Apophis, as well as data from NASA's OSIRIS-APEX mission. Low-frequency (≤60 MHz) bistatic radar observations are performed to probe Apophis's interior, revealing the distribution of monolithic objects and voids within. These data would complement low-frequency monostatic radar data from ESA's RAMSES mission should it fly a radar. The Mothership would carry the CubeSats to Apophis, achieve the rendezvous cruise trajectory, perform high resolution imaging, and act as a Direct-to-Earth node for the constellation. A narrow-angle multi-band camera on the Mothership performs imaging for shape, morphology and geology. After deployment, the CubeSats insert themselves into coordinated low orbits to perform monostatic and bistatic radar observations to probe internal structure. Radar data products include 3D volumetric backscatter via monostatic/bistatic tomographic SAR, and average dielectric constant along interior bistatic ray paths to assess internal heterogeneity. Inter-Spacecraft Link S-band transponders on all spacecraft perform intra-constellation data transfer, synchronize the CubeSat clocks for accurate bistatic radar measurements, and aid in recovering Apophis's gravity field. The mission is currently in Phase A, with partnerships and funding to be finalized early next year.

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