PDC2025
Stellenbosch, Cape Town, South Africa

☑ **Apophis: T-4 Years**

Apophis 2029: Advancing Planetary Science and Planetary Defense with the Caltech Mission

Adriana Daca[1], Masatoshi Hirabayashi[2], Yaeji Kim[3], Joseph DeMartini[3], and the Caltech mission team

[1]*California Institute of Technology, M/C 104-44, 1200 E California Blvd, Pasadena, CA 91125, United States, (626) 395-3389, adaca@caltech.edu*
[2]*Georgia Institute of Technology, 270 Ferst Dr., Atlanta, GA 30332, United States, (404) 894-7521, thirabayashi@gatech.edu*
[3]*University of Maryland, 4296 Stadium Dr., College Park, MD 20742, United States, (301) 405-3001, ykim1231@umd.edu, jdema@umd.edu*

Keywords: *Apophis, asteroid, modeling, data, mission*

An understanding of both surface and interior properties of potentially hazardous objects enables accurate characterizations of their geological and geophysical conditions for planetary defense purposes (e.g., risk assessment and impact mitigation), in addition to their formation and evolution mechanisms relevant to planetary science investigations. Asteroid 99942 Apophis will fly by Earth within a distance of ~6 Earth radii on April 13, 2029. This event will be a rare opportunity to observe the reaction of a small, suspected rubble-pile body to planetary tidal forces. Caltech is leading a first-of-its-kind mission that would rendezvous with Apophis before its Earth Closest Approach (ECA) and escort it through the approach. The mission will aim to improve our understanding of the interior structure, surface conditions, and potential dust environment of Apophis, which may be representative of rubble-pile asteroids. The mission would consist of a spacecraft constellation comprised of a mothership and two CubeSats equipped with radar to characterize possible surface and internal changes throughout the ECA.

Here, we compile and summarize Apophis modeling and data, focusing on knowns, unknowns, current science knowledge gaps, and how Caltech's mission would fill those gaps. We discuss current knowledge around the surface dynamics and interior structure of rubble-pile asteroids, implications for asteroid formation and evolution, predicted responses to the Earth encounter via numerical modeling, and how these predictions flow down to mission requirements (e.g. defining imaging resolution based on the scale of predicted resurfacing). We also outline how Caltech's mission fits within the landscape of other Apophis missions such as OSIRIS-APEX and RAMSES, and how its unique bistatic radar dataset complements the data returned by other missions.