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APOPHIS CRATERING EXPERIMENT

Abstract

Apophis is an exciting asteroid worthy of scientific attention due in part to its close encounter with Earth in 2029. More generally, due to the long visit by a highly capable space mission, OSIRIS-APEX, Apophis will be one of the best studied of all asteroids [1]. Here, we define a mission concept to leverage the capabilities OSIRIS-APEX as an observer and perform a cratering experiment at Apophis with an independent impactor spacecraft.

A 65kg impactor impacting Apophis at 7km/s will make a crater between 20-50m in diameter based on best knowledge of crater formation derived from the findings of SCI [2]. This would result in an excavation of 2-8m deep – well below the depths previously explored and into the depths where crater morphology suggested increased strength at Bennu and Ryugu.

For the nominal mass of Apophis, with simple momentum transfer (Beta=1), the resulting Delta-V would be 0.01mm/s. While incredibly small, it is 2.5x larger than the formal 1-sigma tracking uncertainties for OSIRIS-REx at Bennu, owing to its long baseline of study and highly capable radio science package [3]. The momentum enhancement expected in the cratering process should increase the Delta-V.

Owing to the importance of OSIRIS-APEX mapping and orbiting of Apophis for the interpretation of a cratering experiment [14], an impact after the completion of those studies would be ideal. Thus, an ideal impact time is after November 2030. This allows for a wide range of launch opportunities even well after the Apophis Earth flyby in April 2029.

Notably, this experiment leverages the science instruments from OSIRIS-APEX entirely, requiring only key instrumentation for the impactor spacecraft survival and navigation. The large desired mass for the spacecraft, and the interplanetary trajectory provide for a rare opportunity for small spacecraft technology maturation in the deep space environment. Further, several so-called new space launch providers have proven or upcoming vehicles that can provide cost effective launch opportunities with the required C3.

1 DellaGiustina D. N. et al. (2023) PSJ, 4, 198.

2 Arakawa M. et al., (2020) Science, 368, 67-71.

3 Farnocchia D. et al. (2021) Icarus 369 114594.