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STATIONKEEPING ABOUT APOPHIS THROUGH ITS 2029 EARTH FLYBY

Abstract

The 2029 flyby of Earth by the asteroid (99942) Apophis will be a spectacle for all humanity to observe. The asteroid will be close enough to the Earth to be visible during its close approach, at approximately 37,200 km from the center of the Earth (under 6 Earth radii). A number of proposed missions are in development for taking advantage of its close Earth passage in order to measure what effects the strong Earth tidal forces may have as it passes through closest approach. These concepts include having both landed and orbital elements about this small asteroid. Previous analyses have shown that the surface forces and changes will be modest, even though the rotation state will change significantly, and thus that landed elements may be feasible. This paper will instead consider the relative dynamics of any co-orbiting vehicles about Apophis during its close approach to Earth, in order to evaluate if it will be feasible to both stay in close proximity to the asteroid during the Earth closest approach, and what level of control effort may be required to enable spacecraft relative observations through the entire close approach passage. Previous analysis has looked at the feasibility of orbiting about Apophis, however they have not considered the feasibility of maintaining orbit or proximity through the closest approach to Earth. This analysis uses the recently measured Apophis shape and spin state based on radar measurements.

This analysis will look at a number of different approaches for maintaining proximity through the Earth flyby. These include having a spacecraft in the vicinity of the asteroid (but not in orbit about it), a spacecraft in orbit about the asteroid, and a spacecraft actively hovering in close proximity to the asteroid. For some of the proposed scientific investigations it will be crucial that a spacecraft in proximity observe the asteroid throughout the entire closest approach phase. The challenge is that the spacecraft will be perturbed by the relative dynamics induced by the flyby, which has a closest approach to Earth of 37,200 km and a hyperbolic eccentricity of 4.232. Thus there may be challenges to maintaining a useful relative orientation to the body. By studying the effects of the flyby on different relative orbits it will be possible to better design any candidate mission to this body.