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Apophis 2029: Planetary Defense Opportunity Of The Decade

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ABSTRACT

Nature is providing a once-per-thousand year opportunity for Planetary Defense with the 2029 April 13 near-miss passage of the 350m asteroid Apophis within 6 Earth-radii. On this date, Apophis will be visible to the naked eye across the evening sky and will attract world-wide attention, with the world asking: What are the world's experts doing in response? Apophis is estimated to be five times the size and 100 times the mass of the Tunguska impactor and its physical and orbital reaction to Earth's gravitational interactions are a natural experiment that nature is performing for "free." Time is of the essence as we have a decade to plan Earth-based and *in situ* missions whose measurements can deliver unprecedented detailed knowlege on the physical nature of Apophis as the proto-type example ("poster child") of potentially hazardous asteroids.

Knowledge is the first line of planetary defense and the 2029 Apophis encounter is the learning opportunity of the decade. The greatest opportunity is through measurements revealing the strength and internal construction characteristics of a potentially hazardous asteroid. Tidal torques exerted on Apophis and its rotation

axes, have the potential not only to change its rotation state, but also its shape and surface landforms. Any or all of these measured consequences will be diagnostic of the strength and interior structure of Apophis as, for example, a solid monolithic body or loosely held conglomerate "rubble pile." These two vastly different physical regimes highlight the range of our current lack of knowledge of potentially hazardous asteroids, posing particular challenges to planetary defense mitigation planning.

The most exciting measurement opportunity for informing planetary defense is through possibly measureable seismic waves induced inside Apophis in response to tidal interaction with Earth. By instrumenting the surface of Apophis, or devising standoff measurement techniques, mapping the seismic wave propagation provides the first ever opportunity to map in detail the internal structure of a potentially hazardous asteroid. Just like *Insight* is opening an entirely new realm of investigation at Mars, seismic measurements of Apophis will open an entirely new field of asteroid geophysics. Thus the once-per-century encounter of an asteroid this large passing this close to Earth holds the promise of breakthroughs across many disciplines to the benefit of science and planetary defense securing the asteroid future for humanity.

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