THE SCIENCE CASE FOR APOPHIS 2029 AT T-7 YEARS TO ENCOUNTER. R. P. Binzel[1], D. DellaGiustina[2], J. de Leon[3], P. Michel[4], H. K. Moon[5], E. Tatsumi[3,6], [1]Massachusetts Institute of Technology, Cambridge, MA 02139 USA rpb@mit.edu, [2]University of Arizona, [3]Instituto de Astrofísica de Canarias, [4]Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France, [5]Korea Astronomy and Space Science Institute, [6]University of Tokyo.

Rationale: The forthcoming April 13, 2029 close Earth encounter by the large 340m asteroid (99942) Apophis presents a once-per-thousand-year natural science opportunity. On that date, nature is performing the "experiment" of subjecting the physical body of Apophis to Earth's tidal torques as it approaches to within 31,000 km of Earth's surface, a distance that is *closer than orbiting geosynchronous satellites.* Because of this event's incredible rarity, knowledge gained through measurements and outcomes of the Apophis 2029 "natural experiment" are clearly an opportunity for planetary science. Most specifically, this knowledge opportunity is for the science supporting planetary defense. Further, on April 13, 2029 all of Earth will be watching: Apophis will be visible to the naked eye speeding across the evening sky for an estimated *2 billion people* spanning western Europe and northern Africa. As orbital calculations show with certainty that Apophis is not an impact threat to the Earth, science knowledge must be widely communicated as the benefit of the encounter.

As written in a white paper prepared for the forthcoming Decadal Survey [1], many advancements in planetary science are achieved by seizing upon the opportunity created by rare natural events (e.g. comet Shoemaker-Levy 9 Jupiter impact; 1994) and by planned physical interactions (e.g. Deep Impact into comet Tempel 1; 2005). With this presentation, and through the Apophis T-7 Workshop, we seek to unravel the best understanding, and uncertainties, for scientific advances in the physical study of potentially hazardous asteroids that may be achievable by measuring physical changes of Apophis' spin, surface structure, and/or shape configuration in response to Earth's tidal torques. If tidal torques themselves, or surface configuration changes induce any measurable seismic vibration signal inside Apophis, a new field of asteroid seismology has the potential to be born. *Over six decades of planetary science*, seismology has been achieved beyond Earth for *only two* planetary worlds: Moon and Mars.

We encourage the international science community to consider broadly the types of investigations capable of achieving the science advances offered by the Apophis 2029 opportunity. Similarly, we encourage international science and space agencies to:

• Recognize the decadal, if not millennial, opportunity for the science of planetary defense presented by the Apophis 2029 once-per-thousand-year "natural experiment."

• Prioritize as a top-level planetary defense science goal modeling and measuring the physical outcome on Apophis exerted by Earth's tidal torques so as to achieve the greatest possible new insights into the physical nature, including the internal structure, of PHAs.

• Recognize that *time is of the essence* for defining and implementing investigations of physical effects on Apophis, particularly if *in situ* measurements are to be considered.

• Recognize that the achievable knowledge of PHAs presented by the Apophis 2029 opportunity could have immeasurable benefits to the future of humanity, in the highly unlikely, but not impossible necessity to mitigate a future impact threat.

[1] Binzel R. P. and 40 co-authors. Apophis 2029: Decadal Opportunity for the Science of Planetary Defense (2021). *DOI*:10.3847/25c2cfeb.f87e0599