

OSIRIS-APEX: NASA’S APOPHIS EXPLORER MISSION. D. N. DellaGiustina¹, M. C. Nolan¹, A. T. Polit¹, D. R. Golish¹, M. C. Moreau², A. A. Simon², S. D. Guzewich², and the APEX team. ¹Lunar and Planetary Laboratory, University of Arizona (1629 E. University Blvd, Tucson, AZ 85721, USA, dellagiu@arizona.edu). ²NASA Goddard Space Flight Center (Greenbelt, MD 20771, USA).

Introduction: NASA’s Origins, Spectral Interpretation, Resource Identification, and Security–Regolith Explorer (OSIRIS–REx) mission characterized and collected a sample from asteroid (101955) Bennu [1,2]. Twenty minutes after releasing its sample return capsule to Earth’s surface on September 24, 2023, the spacecraft diverted into an orbit around the Sun that allows for subsequent close Earth flybys. On this trajectory, the spacecraft will approach Earth alongside asteroid (99942) Apophis in 2029, enabling a follow-on mission to another asteroid with the same unique capabilities that led to OSIRIS–REx’s groundbreaking scientific results: OSIRIS–REx’s Apophis Explorer, or “APEX” [3].

Apophis will be well placed for an extensive ground-based telescopic campaign ahead of its Earth encounter on April 13, 2029, but observing conditions degrade just hours after the closest approach as the asteroid passes within 20° of the Sun. Immediate aftereffects of the tidal interaction will be impossible to examine from the ground—but will be distantly witnessed by APEX.

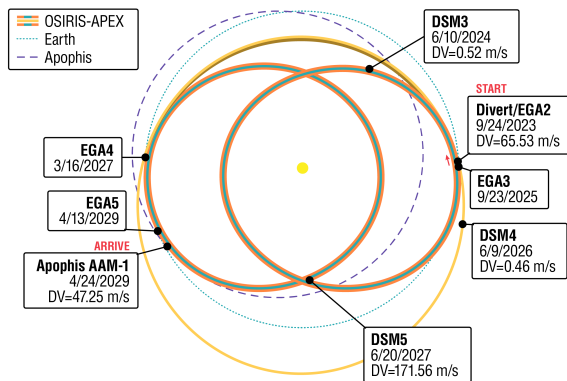


Figure 1. View of the APEX spacecraft, Earth, and Apophis trajectories around the Sun during the cruise phase. APEX will use a series of Earth gravity assists (EGAs) to approach Apophis. APEX will follow the right-hand small ellipse 3 times around the Sun over 2 years. EGA3 alters APEX’s orbit to the larger yellow path, which brings the intersection point with Earth’s orbit to the left side of the figure after 1.5 orbits. EGA4 shifts the orbit to the left-hand small ellipse for 3 orbits over 2 Earth years. About one hour after Apophis’ close approach to Earth, EGA5 puts APEX on a nearly identical trajectory as Apophis.

The Journey to Apophis: The Earth divert maneuver performed just after release of the OSIRIS–REx sample return capsule, and just before the mission’s second Earth gravity assist (EGA2), put the spacecraft on an eccentric orbit that passes to within 0.5 au of the Sun at perihelion (Fig. 1)—much closer to the Sun than the 0.77 au limit analyzed for the OSIRIS–REx mission. To mitigate this, the spacecraft adopts a “fig-leaf” attitude in which the solar arrays shadow critical spacecraft components when the spacecraft is within 0.65 au of the Sun (Fig. 2). As of January 2025, OSIRIS–APEX has successfully completed two of six close perihelion passages, and all instruments and spacecraft systems continue to operate nominally.

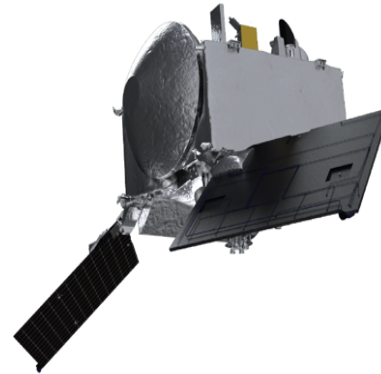


Figure 2. The APEX spacecraft in the fig-leaf attitude as viewed from the Sun. The solar panels shade critical spacecraft components.

Apophis Arrival and Proximity Operations: APEX will begin observing Apophis as a point source by April 2, 2029, at a distance of 5×10^6 km. Orbital mechanics prohibit an earlier rendezvous. APEX will observe Apophis from 50,000 km away during its close Earth encounter on April 13 and capture the evolution of its spin state in real time, revealing the consequences of a near-Earth object undergoing tidal disturbance by a planet (see presentation by Adam et al., this meeting) and continue observing as Apophis grows in its field of view. APEX will arrive at Apophis and begin its detailed study on June 5, 2029. Observations will uncover any signs of mass wasting that the tidal encounter triggered, revealing centimeter-scale topography via lidar and millimeter-scale morphology via images (Fig. 3) (see presentations by Nolan et al.,

Golish et al., and Ballouz et al., this meeting, for details of the data products, observing geometry, and resurfacing).

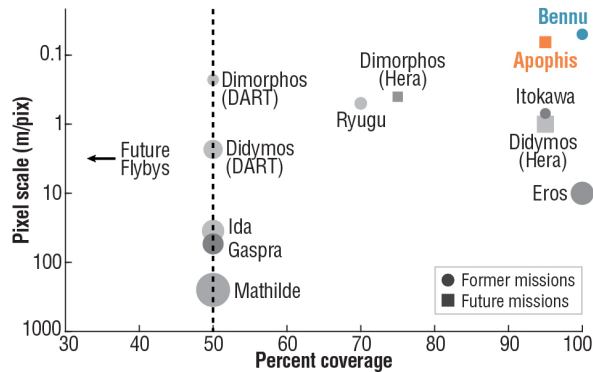


Figure 3. The APEX spacecraft was designed to obtain global high-spatial-resolution imagery of small asteroids.

Chronicling the tidal encounter is only the beginning of APEX's journey with Apophis. Having already challenged our fundamental understanding of carbonaceous (C-complex) asteroids during its exploration of Benu, the spacecraft instrument suite will provide first-of-its-kind high-resolution data of a stony (S-complex) asteroid—dramatically advancing our knowledge of this asteroid class and its connection to the meteorite collection. Global spectral mapping at meter scales and across a wide range of wavelengths (0.4–100 μm) will determine the composition of Apophis and identify any volatiles on its surface. Optical and radiometric tracking data will reveal Apophis' mass and structure. We will also search for signatures of mass shedding, whether due to the tidal encounter or an episodic process like that observed at Benu. After 15 months of orbital operations, APEX will perform the Spacecraft Thruster Investigation of Regolith (STIR), mobilizing surface material by means of its backaway thrusters, as demonstrated at Benu. Observations during and after excavation will provide otherwise inaccessible insight into space weathering and the surface strength of stony asteroids.

Although scientific discovery is APEX's prime motivator, Apophis' bulk structure and surface strength have critical implications for planetary defense. As an S-complex object, Apophis represents the most common class of potentially hazardous asteroids, and knowledge of its properties can inform mitigation strategies. Monitoring Apophis after Earth approach provides the first opportunity to witness any change in an asteroid's Yarkovsky force—a nongravitational effect that influences an asteroid's likelihood of striking

Earth (see presentations by Farnocchia et al., Ryan et al., and Rivera-Valentín et al., this meeting).

Acknowledgement: The OSIRIS-APEX mission is supported by NASA Contract NNM10AA11C.

References:

- [1] Laretta, D.S., DellaGiustina, D.N. et al. (2019). *Nature* 568, 55–60, doi:10.1038/s41586-019-1033-6.
- [2] Laretta, D. S. et al. (2022). *Science* 377, 285–291, doi:10.1126/science.abm1018.
- [3] DellaGiustina, D. N. et al. (2023). *PSJ* 4, 198, doi:10.3847/PSJ/acf75e.