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Topic: NEO Characterization

Physical characterization of 99942 Apophis from ground-based radar assets in 2029

Marina Brozović [1], **Lance A.M. Benner**[1], **Shantanu P. Naidu**[1], **Michael W. Busch**[2], **Jon D. Giorgini**[1], **Patrick A. Taylor**[3], **Steven R. Chesley**[1], **Davide Farnocchia**[1], **Daniel J. Scheeres**[4], **Mark S. Haynes**[1], **Joseph Lazio**[1], **Timothy Hall**[5], and **Shinji Horiuchi**[6]

[1]Jet Propulsion Laboratory, California Institute of Technology, *4800 Oak Grove Dr, MC 301-120, Pasadena, CA 91108, USA, 1-818-354-5197,*
marina.brozovic@jpl.nasa.gov

[2]*SETI Institute, Mountain View, CA, USA*

[3]National Radio Astronomy Observatory, Green Bank Observatory, VA, USA

[4]*University of Colorado, CO, USA*

[5]*Lincoln Laboratory, MIT, Lexington, MA, USA*

[6]*Canberra Deep Space Communication Complex, CSIRO, Australia*

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ABSTRACT

In April 2029, (99942) Apophis will encounter Earth within 5 Earth radii from the surface. The proximity of the flyby is expected to alter Apophis's spin state and possibly features on its surface. This once-in-several-millennia encounter of a ~340 m diameter object provides an exceptional science opportunity. Ground-based observations will occur before, during, and after the encounter and NASA's OSIRIS-APEX mission will go into orbit around Apophis a few months after the close approach. The ground-based observations will be important for full dynamical characterization of the flyby.

Apophis will approach from the south at a declination of about -30 deg, rapidly move past Earth, and then recede at a declination of +17 deg. After the closest approach, Apophis will become a daytime object for several weeks but will gradually move away from the Sun until it reaches 17th magnitude near opposition in late November, 2029. Apophis will be observed extensively by optical telescopes before the flyby and post-encounter in November and December. Ground-based radars will be able to detect Apophis from mid-March until mid-May with high resolution imaging up to 1.875 m/pixel at Goldstone lasting ~20 days centered on April 13. Apophis will be observed by the Deep Space Network radars at Goldstone (the 70 m DSS-14 and 34 m DSS-13 antennas) and Canberra (DSS-43, DSS-34, DSS-35, and DSS-36), and possibly with other radar facilities such as HUSIR and MISA at Haystack Observatory in Massachusetts and EISCAT-3D in Norway. It is also possible that the 100-m Green Bank Telescope will have a radar transmitter by 2029 and could observe Apophis.

The principal goals for radar will be full characterization of the spin state change and high-resolution imaging. Because Apophis is a non-principal axis rotator,

estimation of the shape and spin state will provide precise estimates of the moment of inertia ratios that will constrain the internal structure pre- and post- flyby. Modeling of the spin change will provide additional insight into the interior. The images might reveal surface feature changes if localized events occur (e.g., if a boulder moves or if there are landslides). Dual-polarization radar imaging will enable polarimetric investigation of the surface roughness, regolith distributions, and changes that may occur during the flyby. Ground-based long-wavelength radar (wavelengths of decimeters to meters) could map the depth of regolith, reveal features not visible on the surface, and image the interior. The ionospheric HAARP radar in Alaska could be used as a transmitter and the Owens Valley Radio Observatory Long Wavelength Array used as the receiving antennas for a radar tomography experiment (PI. M. Haynes). Radar astrometry obtained in 2029, coupled with significant improvements in estimates of the Yarkovsky effect acting on Apophis, will enable improved orbital predictions and estimates of future close encounters. After 2029, the next opportunities to obtain radar images and precise ranging measurements of Apophis with Goldstone (assuming current sensitivity) will be at 0.080 au in 2044 and 0.041 au in 2051.

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