EPSC Abstracts
Vol. 16, EPSC2022-1159, 2022, updated on 25 Feb 2023
https://doi.org/10.5194/epsc2022-1159
Europlanet Science Congress 2022

Changes in Apophis rotation and surface gravity during its 2029 Earth flyby

Guillaume Noiset, Elisa Tasev, and Özgür Karatekin
Royal Observatory of Belgium, Planetology, Belgium (guillaume.noiset@observatory.be)

Apophis, the Asteroid 2004 MN4 is one of the Near-Earth Object (NEO) with regular and very close Earth encounters. During the next encounter in 2029, Apophis will flyby by about a distance of 36000 km above the surface of Earth. During this close flyby, the orbit and dynamics of Apophis is expected to vary significantly due to gravitational interactions with the Earth (Scheeres et al., 2006; Souchay, Lhotka, et al., 2018; Souchay, Souami, et al., 2014). The surface is not expected to undergo catastrophic disruption, however it may be subject to tidal stresses and localized failures resulting in debris (Scheeres et al., 2006). The variations of orbital parameters, i.e. spin, obliquity, longitudinal and latitudinal librations am increase considerably during the closest-approach epoch which will be observable in real time by groundbased radar and telescopes.

Here we present the numerical simulations using the full-two-body (F2BP), where the rotational and translational dynamics are fully coupled. F2BP can fully capture the system's dynamics taking into account the objects' irregular shapes and the close proximity of the components . The system's dynamical evolution is especially sensitive to the shapes and initial positions and orientations of each component. Here we use the open source F2BP code GUBAS (Davis and Scheeres, 2020). The initial position and speed come from Horizon System from the Jet Propulsion Laboratory, the initial orientations from Pravec et al., 2014 and the system is propagated using a LGVI integrator.
We use a radar based shape model for Apophis (Brozovic et al., 2018) while the Earth is modeled by an ellipsoid of revolution.

Starting from when Apophis enters the sphere of influence of Earth until it leaves it, we propagate the dynamical parameters. The results shows significant changes in the rotational state of Apophis already few

hours before the
closest-approach. In addition to rotational and orbital parameters, we calculate also the changes in surface gravity
and dynamical slopes during the close encounter. The changes in Apophis rotation and surface changes, including
potential localized failures across its surface, are important parameters for planetary defense missions since they
provide information on otherwise inaccessible interior and mechanical properties of the asteroids.

References

Scheeres, D. J., et al. (2006). Dynamical configuration of binary near-earth asteroid (66391) 1999 KW4. *Science, 314* (5803), 1280–1283.

Souchay, J., Lhotka, C., et al. (2018). Changes of spin axis andrate of the asteroid (99942) Apophis during the 2029 close encounter with Earth: A constrained model. *Astronomy and Astrophysics, 617*, 1–11.

Souchay, J., Souami, D., et al. (2014). Rotational changes of the asteroid 99942 Apophis during the 2029 close encounter with Earth. *Astronomy and Astrophysics, 563*, 1–6.

Davis, A. B., & Scheeres, D. J. (2020). Doubly synchronous binary asteroid mass parameter. *Icarus, 341*.

Pravec, P., et al. (2014). The tumbling spin state of (99942) Apophis. *Icarus, 233*, 48–60.

Brozovi´c, M., et al. (2018). Goldstone and Arecibo radar observations of (99942) Apophis in 2012–2013. *Icarus, 300*, 115–128.