The shape and rotation of the tumbling asteroid (99942) Apophis

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Photometric observations of the asteroid (99942) Apophis taken from December 2012 to April 2013 revealed that it is in a non-principal axis rotation state. We constructed a numerical model of the asteroid's shape and rotation. The asteroid is in a short-axis mode (SAM) of excited rotation. The precession and rotation periods are $P_\phi = 27.38 \pm 0.07$ h and $P_\psi = 263 \pm 6$ h, respectively. The rotation is retrograde with the angular momentum vector's ecliptic longitude and latitude of 250° and -75° (the uncertainty area is approximately an ellipse with the major and minor semiaxes of 27° and 14°, respectively).

The shape of the asteroid is dynamically close to a prolate ellipsoid, with the lengths of largest and intermediate axes of 1.64 ± 0.09 and $1.14^{+0.04}_{-0.08}$, respectively (the shortest axis is normalized to unity); the largest and intermediate moments of inertia differ by 3–4 % only.

The asteroid is close to the lowest-energy rotation state, the rotational kinetic energy is greater than the minimum kinetic energy (for rotation around the principal axis with the largest moment of inertia) by only 2–3 %. Despite this low-energy level of excitation, the figure with the two principal moments of inertia nearly equal results in the wobbling angle reaching substantial values of 50–60°.

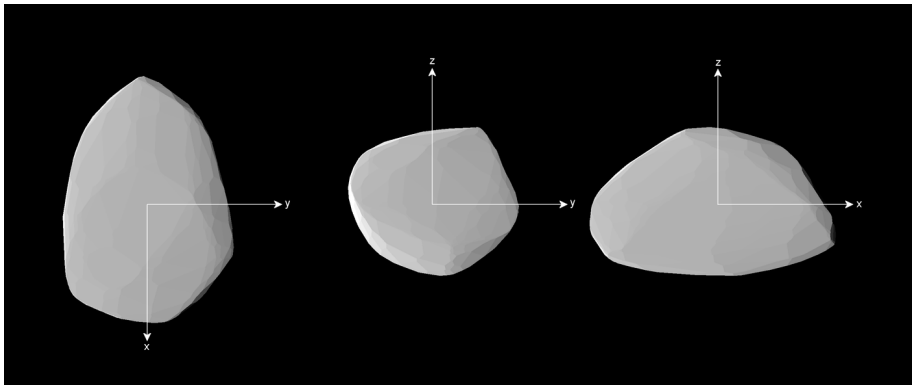

Figure: The convex shape model of the nominal solution shown in three viewing geometries; x and z are the principal axes with the smallest and largest moments of inertia, respectively.

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References: Pravec, P. Scheirich, P., Durech, J. et al. 2014, Icarus, 233, 48.