A research study analyzes the characteristics of Apophis, the asteroid that will approach Earth in 2029

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The study, in which the Universidad Carlos III de Madrid (UC3M) and the Universidad Estatal Paulista Júlio de Mesquita Filho (Júlio de Mesquita Filho Paulista State University) (UNESP) of Brazil are participating, analyzes the surface and dynamics of Apophis, an asteroid

that will pass close to Earth in 2029.

The Apophis asteroid was discovered in 2004 and has been monitored since then due to its classification as a potentially hazardous asteroid (PHA), as it was estimated that it would have a 2% chance of hitting Earth. This possibility has already been ruled out and, according to the latest measurements, Apophis will reach its closest trajectory to Earth (38,000 kilometers) on the 13th of April, 2029.

This study analyzes the physical characteristics of this celestial body and the possible effects that its approach to Earth may have. Gabriel Borderes-Motta, a researcher at UC3M's Department of Bioengineering and Aerospace Engineering, explains that "collision is not the only possibility in approach events like this one. The gravitational interaction between a planet and a body such as Apophis can change the shape of the body, break the body into pieces, disintegrate possible loose stones on the asteroid's surface, or even remove other bodies orbiting the asteroid (such as rocks, satellites, or rings)... Our study focuses on the last two possibilities: what happens to the possible stones on the surface and the asteroid's orbit."

How to experiment with an asteroid

Research in the space sector presents the challenge that, in most cases, it is impossible to directly experiment with space materials. For this reason, numerous investigations are approached from the field of mathematics and physics, taking the greatest possible number of variables into account.

The research team responsible for this study has analyzed both the physical aspects of the asteroid—among them, its shape and the characteristics of its gravitational field—as well as the factors that can influence its trajectory and its slope angle, such as the radiation pressure

or disturbance inflicted due to its proximity to Earth.

To carry out this piece of research, the team has carried out a set of numerical simulations—two simulation environments with three experimental cases each—using a disk of 15,000 particles of different sizes in the close environment of Apophis as a sample. The objective has been to try to predict how the particles orbiting the asteroid will react to different situations and how these assumptions may influence the behavior of Apophis.

The first set of simulations was designed considering only the gravitational disturbance of Apophis in 24-hour periods over 30 years. The second set of simulations included disturbance caused by solar radiation pressure. Three cases were proposed in both sets, in which the asteroid had different densities. "We evaluated a 340-meter polyhedron with a uniform density in three different cases. In each case, the starting point was a different particle density, from highest to lowest," says Gabriel Borderes-Motta.

From these simulations, it was concluded that the asteroid's slope angle was greater at low densities (4°) than at high densities (2°); in addition, the lower the particle density and the higher the solar radiation pressure, the fewer particles remained intact. In other words, in a scenario where Apophis has a low density, approximately 90% of the loose stones would be removed from its surface during the approach to Earth. In addition, the results have shown that Apophis's approach could slightly affect the tides and cause some landslides on the asteroid's surface.

The team hopes that the asteroid's approach to Earth in 2029 will be an opportunity to improve the 3D model used to run space simulations, as well as to allow them to more accurately investigate and predict the effects on Apophis's surface. All of this would mean an increase in knowledge about asteroids, which would allow us to be better prepared

in the event that new celestial bodies pass close to Earth.

The research was published in *Monthly Notices of the Royal Astronomical Society*.

More information: G Valvano et al, APOPHIS – effects of the 2029 Earth's encounter on the surface and nearby dynamics, *Monthly Notices of the Royal Astronomical Society* (2021). DOI: 10.1093/mnras/stab3299

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