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The ESA RAMSES mission: A rendezvous with the asteroid Apophis during its close encounter with Earth in 2029

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On April 13, 2029, (99942) Apophis with a diameter of about 340 meters will approach Earth's surface at about 31,000 km. Significant tidal torques will be exerted on Apophis, with possible alterations of its rotation state and internal structure, measurable seismic waves and real-time surface disturbances. This very close Earth flyby presents an unprecedented planetary defense and science opportunity.

A rendezvous space mission to Apophis will allow transforming our understanding of the response of small asteroids to external forces and of the internal structure of potentially dangerous asteroids.

The European Space Agency mission called RAMSES (Rapid Apophis Mission for SpacE Safety) is based on an adaptation of the Hera spacecraft [1], to fit to the updated mission profile, while minimizing any new developments given the short timescale until launch in April/May 2028 for a direct 10-months transfer and a rendezvous in February 2029.

RAMSES embarks two visible cameras, Opportunity payloads and two 6U-XL CubeSats with payloads belonging to the Opportunity category. Opportunity payloads further contribute to the planetary defense objectives and increase the overall scientific return of the mission, without blocking the launch date in case of delay. Preliminary opportunity payloads are based on maximisation of the Hera mission heritage: a JAXA-led Thermal Infra-Red Imager based on the one onboard Hera, another camera,

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possibly provided by a partner agency (e.g., refly of the multispectral imager, MAPCAM, from OSIRIS-APEX), a laser altimeter, a refly of the JuRa low-frequency radar and of the GRASS gravimeter onboard the Hera Juventas Cubesat, a refly of the dust detector and analyzer VISTA onboard the Hera Milani Cubesat, a compact seismometer (geophone), and other potential payloads. The final payload suite will be fixed in mid-2025.

At Apophis arrival, high-resolution imaging at decreasing distances from Apophis down to 1 km at 10cm/pixel will be achieved. During the close Earth encounter, the spacecraft will hover at 5 km, a safe distance where the full asteroid figure will be visible by the Asteroid Framing Cameras. A similar set of characterizations will be performed after Earth encounter, to identify the expected changes in physical properties of the asteroid.

The two CubeSats will be released in proximity of Apophis before the close encounter and will operate independently, using RAMSES as relay. One CubeSat will land on Apophis before the close encounter, carrying a seismometer and a gravimeter. The other CubeSat will embark the low-frequency radar to probe the subsurface properties of the asteroid and their possible modifications resulting from the Earth close approach.



Figure 1: The ESA RAMSES mission logo.

In addition, in the late phase NASA OSIRIS-APEX [2] will have reached Apophis so additional combined synergetic observations might be planned, emphasizing the international cooperation that is at the heart of planetary defense.

RAMSES is the second ESA mission to characterize a near-Earth asteroid, which is part of the planetary defense roadmap while offering a great science return. Its development started during a pre-funding phase including an ongoing Preliminary Design Review (PDR) at the time of writing this abstract and a Critical Design Review (CDR) around the time of its formal approval at ESA Council at Ministerial Level in 2025.

Comments:

Oral

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