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THE ESA RAMSES MISSION AND THE 2029 APOPHIS ENCOUNTER: A UNIQUE OPPORTUNITY TO STUDY ASTEROID RESPONSE TO PLANETARY TIDAL FORCES

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The ESA RAMSES (Rapid Apophis Mission for Space Safety) mission has been officially approved at the ESA Council Ministerial Level in November 2025 and represents a cornerstone of ESA's planetary defense programme. RAMSES is designed to rendezvous with the near-Earth asteroid (99942) Apophis prior to its exceptionally close encounter with Earth on 13 April 2029, at a distance of about 30,000 km, well within the orbital distance of geostationary satellites. The mission will characterize Apophis before, during, and after the Earth flyby, with the primary goal of directly observing the dynamical, structural, and geological response of an asteroid to planetary tidal forces for the first time. RAMSES will investigate Apophis' orbit, spin state, shape, surface morphology, internal structure, and physical properties, enabling a comprehensive assessment of possible tidal deformation, surface mass movements, and internal restructuring induced by the encounter. RAMSES builds on the heritage of ESA's Hera mission [1] and will consist of a main spacecraft and two CubeSats. The payload includes high-resolution

optical imaging, radio science, a thermal infrared imager (TIRI, led by JAXA), a newly selected visible–near-infrared hyperspectral camera, a high resolution camera with filters in the visible and near infrared region for compositional and mineralogical mapping and, for the first time, a Plasma Spectrometer to investigate the interaction of Apophis with the solar wind and Earth's magnetosphere. In addition, a lander CubeSat equipped with a seismometer, gravimeter, and magnetometer aims to provide the first in-situ seismic and magnetic measurements on an asteroid, while an orbiter CubeSat will probe the interior with a low-frequency radar and investigate dust activity. The mission is planned for launch in 2028, with Japanese H3 launcher. RAMSES will share the launch with JAXA's DESTINY+ mission, further strengthening the international character of the Apophis exploration campaign. Together with NASA's OSIRIS-APEX mission [2], which will investigate Apophis after the encounter, RAMSES will enable an unprecedented multi-mission, multi-agency temporal coverage of this unique event. Beyond its scientific return, RAMSES will play a key role in advancing planetary defense strategies by improving our understanding of asteroid physical response to close planetary encounters. The 2029 Apophis flyby, visible to the naked eye for billions of people, will also represent a major opportunity for public engagement, in line with the United Nations designation of 2029 as the International Year of Asteroid Awareness and Planetary Defense.

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