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The ESA Hera mission to the binary asteroid (65803) Didymos: Planetary Defense and Science

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The Hera mission is in development for launch in 2024 within the ESA Space Safety Program. Hera will contribute to the first deflection test of an asteroid, in the framework of the international NASA- and ESA-supported Asteroid Impact and Deflection Assessment (AIDA) collaboration. Hera will also offer a great science return.

1. Introduction

The impact of the NASA DART spacecraft on the 160 m-diameter natural satellite called Dimorphos of the binary asteroid 65803 Didymos in late September 2022 will change its orbital period around Didymos. As Didymos is an eclipsing binary, and close to the Earth on this date, the change can be detected by Earth-based observers. Before impact, DART will deploy the Italian LICIACube that will provide images of the first instants after impact. ESA's Hera spacecraft will rendezvous Didymos four years after the impact. It will perform the measurements necessary to understand the effect of the DART impact on Dimorphos, in particular its mass, its internal structure, the direct determination of the momentum transfer and the detailed characterization of the crater left by DART.

2. Planetary Defense return

Hera will characterize in details the properties of a Near-Earth Asteroid that are fully relevant to planetary defense. Its objectives related to the deflection demonstration are the following:

•Measuring the mass of Dimorphos to determine the momentum transfer efficiency from DART impact.

•Investigating in detail the crater produced by DART to improve our understanding of the cratering process and the mechanisms by which the crater formation drives the momentum transfer efficiency.

•Observing subtle dynamical effects (e.g. libration imposed by the impact, orbital and spin excitation of Dimorphos) that are difficult to detect for remote observers.

•Characterising the surface and interior of Dimorphos to allow scaling of the momentum transfer efficiency to different asteroids.

3. Science return

Even if its requirements are driven by planetary defense, Hera will also provide unique information on many current issues in asteroid science. The reason is that our knowledge of these fascinating objects is still poor, especially for the smallest ones. The recent data obtained by the JAXA Hayabusa2 and NASA OSIRIS-REx missions have revolutionized our understanding of carbonaceous-type Near-Earth Objects. Hera has the the potential to do similar as it will rendezvous for the first time with a binary asteroid. Its secondary has a diameter of only 160 m in diameter. So far, no mission has visited such a small asteroid. Moreover, for the first time, internal and subsurface properties will be directly measured. From small asteroid internal and surface structures, through rubble-pile evolution, impact cratering physics, to the long-term effects of space weathering in the inner Solar System, Hera will have a major impact on many fields. How do binaries form? What does a 160 m-size rock in space look like? What is the surface composition? What are its internal properties? What are the surface structure and regolith mobility on both Didymos and Dimorphos? And what will be the size and the morphology of the crater left by DART, which will provide the first impact experiment at full asteroid scale using an impact speed close to the average speed between asteroids? These questions and many others will be addressed by Hera as a natural outcome of its investigations focused on planetary defense.

4. Instruments

Hera is equipped with the following payload:

- The Asteroid Framing Cameras are both science and navigation cameras. They will provide the target global properties as well as local geomorphology and will investigate the crater. They will also measure the mass of Dimorphos through the "wobble" motion of Didymos.
- The Planetary ALTimeter (PALT) will measure the distance to the target and, from close distance, derive shape and topography information complementary to the shape information in framing camera images.
- A thermal infrared imager (TIRI) will provide information about thermal properties and spectral information in the mid-infrared.
- The Hyperscout-H hyperspectral imager will provide mineralogical information in the spectral range between 450 and 950 nm.
- Milani is a 6 unit cubesat that will carry the ASPECT Fabry-Perot imager to derive mineralogical information, and a thermogravimeter for measuring the abundance and constraining the composition of ambient dust particles.
- Juventas is a 6 unit cubesat that will carry a monostatic low-frequency radar, and a gravimeter to derive interior and surface properties of the asteroids. Its landing on Dimorphos will also allow an estimate of the surface response to a very slow impact.
- The radioscience experiment will measure the gravity field of the Didymos system. It will work in two ways: measurements of the acceleration of the Hera spacecraft by the asteroid pair through the radio link between earth and Hera will be used as well as the intersatellite link between Hera and the two cubesat, which will measure the gravitational parameters from the relative position and velocity of the three spacecraft.

5. NEO-MAPP

NEO-MAPP (Near Earth Object Modelling and Payload for Protection) is a project funded by the H2020 program of the European Commission. Hera is its reference mission, and most of the NEO-MAPP activities are aimed at supporting the preparation of Hera. The main goal of NEO-MAPP is to provide significant advances in our modeling of impact physics, binary dynamics and internal properties, as well as in instrumentations and associated measurements by a spacecraft (including those necessary for the physical and dynamical characterization in general). In particular, innovative and synergetic measurement and data-analysis strategies are developed that combine multiple payloads, to ensure optimal data exploitation for Hera and other NEO missions.

6. Conclusion

The measurements performed by Hera will thus provide unique information on many current issues in asteroid science and therefore, the scientific legacy of the Hera mission will extend far beyond the core aims of planetary defense. Hera is thus an amazing European contribution to the international planetary defense and asteroid exploration era.

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