Hera Radio Science Investigations through Ground-based and Satellite-to-Satellite Doppler Tracking

Marco Zannoni*(1), Igor Gai(1), Marco Lombardo(1), and Paolo Tortora(1)
(1) University of Bologna, Forli, Italy; e-mail: m.zannoni@unibo.it

The Asteroid Impact and Deflection Assessment (AIDA) is an international collaboration supported by ESA and NASA to assess the feasibility of the kinetic impactor technique to deflect an asteroid, combining data obtained from NASA's DART and ESA's Hera missions [1, 2].
DART will perform a kinetic impact on the secondary of the binary near-Earth asteroid (65,803) Didymos. Hera will follow-up with a detailed post-impact survey of Didymos, to fully characterize this planetary defense technique. Additionally, Hera will deploy two CubeSats around Didymos once the Early Characterization Phase has completed, to complement the observations of the mother spacecraft.
One of the main objectives of Hera is to characterize the mass and mass distribution of both Didymos primary and secondary by means of radio science investigations. The determination of the gravity field of a celestial body provides one of the very few direct measurements of its internal mass distribution, even if the inversion process is not unique. The gravity of Didymos can be estimated precisely reconstructing the trajectory of Hera during a selected number of close encounters (about 10 km at closest approach). The main observables used in the orbit determination are two-way X-band Doppler data, obtained from the standard communication link, and optical navigation images of Didymos taken by the spacecraft.
In addition, Hera will track the two CubeSats by means of a space-to-space inter-satellite link (ISL). This represents an interesting add-on to the gravity investigation as the Doppler effect that affects the inter-satellite link contains the information on the dynamics of the system, i.e. masses and gravity field of Didymos primary and secondary.
We describe here the mission scenario for the gravity science experiments to be jointly carried out by the three mission elements, i.e. Hera, CubeSat-1 and CubeSat-2, via Ground-based and Satellite-to-Satellite Doppler Tracking. Also, our results and achievable accuracy for the estimation of the mass and gravity field of Didymos primary and secondary are presented.

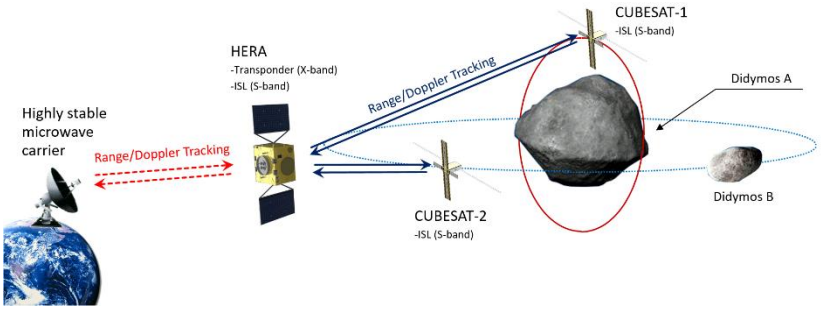

Figure 1. Concept of Hera Radio Science investigations. The figure highlights the main radiometric links between the various elements of the Hera mission that can be exploited to characterize Didymos gravity.

References

[1] A. F. Cheng et al., "AIDA DART asteroid deflection test: Planetary defense and science objectives," Planet. Space Sci., vol. 157, no. February, pp. 104–115, 2018.

[2] P. Michel et al., "European component of the AIDA mission to a binary asteroid: Characterization and interpretation of the impact of the DART mission," Adv. Sp. Res., vol. 62, no. 8, pp. 2261–2272, 2018.