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Hera – the European contribution to the first Asteroid deflection demonstration

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Abstract

Hera is ESA's contribution to the international Asteroid Impact Deflection Assessment (AIDA) cooperation, targeting the demonstration of deflection of a hazardous near-earth asteroid. Hera will also be the first in-depth investigation of a binary asteroid and make measurements that are relevant for the preparation of asteroid resource utilisation. Hera is foreseen to rendezvous with the binary near-Earth asteroid (65803) Didymos in 2026, four years after the impact of NASA's Double Asteroid Redirection Test (DART) spacecraft. Here we describe the contribution of Hera to the AIDA cooperation.

1. Introduction

Hera is a small mission of opportunity whose primary objective is to observe the outcome of a kinetic impactor test and thus, to provide extremely valuable information for possible future mitigation of the impact of a hazardous asteroid [1]. It is part of the Asteroid Impact & Deflection Assessment (AIDA) mission, in which the second component is the NASA Double Asteroid Redirection Test (DART) mission, which aims to send an artificial projectile to perform an asteroid deflection test [2]. The outcome will be observed by a cubesat provided by the Italian Space Agency (ASI) and carried to the target asteroid by DART, from ground-based observatories and from later observations by Hera during its rendezvous mission with the target asteroid. AIDA will thus be the first test ever to use a kinetic impactor to deflect an asteroid. The AIDA target is the binary Near-Earth Asteroid (NEA) (65803) Didymos (1996 GT), in particular the secondary component and target of the DART mission, called hereafter Didymoon. Here we discuss the Hera mission, an updated version of the Asteroid Impact Mission (AIM), originally proposed to be at Didymos during the DART impact. We show that most of the goals of AIM are still being fulfilled with the investigation of Didymos by the Hera mission.

2. Hera payload

The following instruments form the baseline payload of Hera:

- Asteroid Framing camera. This is a flight spare of the DAWN framing cameras [3] and will be used for science imaging and Guidance, Navigation, and Control. The image scale is ~1m/pixel from a distance of 10 km.

- A 6 U cubesat that will performed very close-proximity observations down to few cm-scale resolution of the crater and its surroundings. Payload options for the cubesat currently include two of the following: a spectral imager from 0.5 µm to 1.6 µm and as a point spectrometer from 1.6 µm to 2.5 µm, a spacecraft relative-radioscience package, a gravimeter, a high-frequency radar and a nephelometer.

- Planetary Altimeter (PALT). This is a lidar that will perform accurate distance measurements. The operating wavelength is 1.5 µm and the beamwidth 0.5 mrad.

- Hyperspectral imager (HYP), an imager with a linear variable filter attached to it, based on the CHIEM instrument developed for earth observations [4]

- Radio Science Experiment (RSE). Radio science makes use of existing hardware on the spacecraft to measure the gravity field of Didymos

It is expected that additional resources will be available onboard Hera. These will be allocated for additional payload should it be supported by ESA Member States. A workshop will be organized in late 2018 to provide an overview of available options. It will be followed by an announcement of opportunity to be expected in mid-2019.

3. Hera relevance for mitigation of an asteroid impact

Although the probability of an asteroid impact on Earth during the coming years is low, the potential consequences to our society could be very severe. Small bodies are continually colliding with Earth, however, the vast majority of these objects are very small (below 10 m in size) and pose no threat to human activity. Larger impacts (1 km or more) occur far less often but, when they do occur, they can lead to a major natural catastrophe. Fortunately more than 90% of the asteroid population with diameter of 1 km or larger is known and poses no risk. On the intermediate size (100-500 m range), damage can still be of regional scale (a country or a continent) and we only know a small fraction of these objects while their impact frequency becomes high enough (centuries to millenia, i.e., within the duration of a civilization) that we must study how to protect ourselves from the threat they pose. Indeed, the impact of an asteroid is the only natural disaster we may be able to accurately predict and prevent. For this we need to (1) improve our knowledge of the geophysical properties of bodies in this size range, (2) test our ability to deflect such a small asteroid, (3) complete the inventory of this population.

AIDA will allow us to address (1) and (2) for the first time. In terms of deflection techniques, we will never know whether we are ready if no test is performed. DART will hit the smallest component, whose size is the most relevant one for mitigation purposes. Groundbased observations will measure the change of the orbial period of Didymoon around Didymos imposed by the impact. However, only Hera can measure the mass of Didymoon, required to estimate the efficiency of the momentum transfer from DART to Didymoon. Furthermore, Hera will accurately measure the dynamical state of the Didymos system after the impact, directly measuring the excentricity imposed by the impact and any libration that may be have been introduced as a consequence of the impact. The investigation of the DART impact crater by Hera, together with the geophysical and surface properties of both asteroids, will allow us to validate/refine our numerical impact models that can then be used with higher confidence at such scales. All those measurements together will allow scaling of the results to other asteroids and therefore to predict the efficiency of the momentum transfer should the deflection of an asteroid be needed in the future.

References

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