

Thermal infrared and multiband imaging experiment for S-type potentially hazardous asteroid binary Didymos

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Introduction: TIRI is a thermal infrared imager with multi-band filters to be onboard the ESA Hera spacecraft [1] and will investigate thermophysical properties and material constituents of an S-type near-Earth binary asteroid 65803 Didymos and its moon Dimorphos. We present here the specifications of TIRI and its science objectives.

Hera Mission and Objectives: Hera is an asteroid mission to explore the binary asteroid system as a part of the first international planetary defense mission AIDA (Asteroid Impact and Deflection Assessment) with the NASA DART (Double-Asteroid Redirection Test) mission [2], which was launched on 24 Nov 2021 and will conduct a kinetic impact to Dimorphos in late September 2022. The asteroid deflection by the impact will be detected by ground-based observations. Hera will be launched in 2024 and arrive at the binary system in 2027 to characterize them in their surface physical properties, composition, geologic features, and dynamical motions, we well as characterize the crater excavated by the DART impact.

Hera Instruments: TIRI is among the remote sensing instruments onboard Hera, together with two visible imagers AFCs, an altimeter PALT, a 25-color visible to near-infrared hyperspectral imager HyperScout, and two 6U CubeSats Milani and Juventas. All these instruments will be mounted on the top panel of the spacecraft and point in the same direction, to observe the asteroid simultaneously.

TIRI Instrument: TIRI consists of the sensor unit BOL on the electronics unit SHU. Its total mass is 4.0 ± 0.4 kg, the power is 17 ± 3 W, and the envelope size is 190 x 230 x 263 mm. 28 V unregulated power is supplied from the spacecraft. Thermal control both for survival and operational is conducted by the spacecraft using 2 channels of heaters and thermistors. SpaceWire is used for telemetry and command communication. BOL are inherited from the thermal imager developed for UNIFORM2 [3], while the logics of SHU are inherited from Hayabusa2 TIR [4]. BOL is based on an uncooled micro-bolometer array (Lynred PICO1024 Gen2) of 1024 x 768 pixels. It covers the wavelength of 8 to 14 μm , and has the FOV of $13.3^\circ \times 10.0^\circ$, with the IFOV of $0.013^\circ/\text{pixel}$ (0.23 mrad). Detectable temperature range is 150 to 400 K. It has an 8-point filter wheel, one for close, one for 8-14 μm wide band, and other 6 narrow bands. SHU is an FPGA based electronics to control the BOL with the interface for telemetry and command via SpaceWire, the power supply, and thermal control with the spacecraft.

TIRI Operations: After arrival in 2027, TIRI will start observations of the binary asteroid system. During the Early Characterization Phase (ECP, 20-30 km from Didymos), TIRI will observe the entire binary system as one-rotation images of Didymos (2.26 hours) and one-revolution images of Dimorphos around Didymos (11.9 hours) from the dawn and dusk directions and from the north-pole and south-pole directions. During the Detailed Characterization phase (DCP, 8-20 km from Didymos), TIRI will observe Didymos and Dimorphos at higher spatial resolution for their one-rotation and one-revolution images from the noon direction. During the Close-up Operation Phase (COP, 4-22 km from Didymos), TIRI will observe the DART

crater at a spatial resolution of < 1 m/pixel (from 4 km distance). During the Extended Phase (EXP, close to 1 km from Didymos), TIRI will take consecutive thermal images of local areas of Didymos and Dimorphos, especially for the DART crater at the spatial resolution of < 0.25 m/pixel. All the observed data using TIRI and the other instruments will bring a new insight of planetary science and also planetary defense in Hera mission.

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