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Thermal Infrared Multiband Imager TIRI onboard Hera to Investigate S-type Binary Asteroid Didymos and Dimorphos

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ABSTRACT

TIRI - a thermal infrared imager with a multi-band filter, is being developed by JAXA for the ESA Hera mission which will rendezvous with and perform observations at the S-type near-Earth asteroid 65803 Didymos and its small moon Dimorphos. The asteroid binary was visited by the NASA DART spacecraft which made a kinetic impact to Dimorphos in September 2022 to deflect its orbit. Hera will characterize the asteroid binary and validate the efficiency of the asteroid deflection by the DART impact. TIRI will be used to investigate thermophysical properties of Didymos, for the first time as an S-type asteroid, and measure its thermal infrared multi-wavelength feature. These observations will map physical and compositional properties of Didymos which has relatively flat area at the equatorial region and rugged regions at the higher-latitude regions. TIRI will also determine thermophysical properties and spectral feature of Dimorphos, including the excavated artificial crater formed by the DART impact and its sedimented surroundings. From the up-close images taken from the camera on the DART spacecraft, Dimorphos was recognized as a rubble pile body but it still remains unknown how porous or consolidated the surface boulders are, and whether the composition is similar to or different from that of Didymos.
Thermal imaging is a useful tool to map the temperature and the derived thermal inertia of the surface of asteroids, as was proven during the Hayabusa2 mission (Okada et al., 2020; Shimaki et al., 2020; Sakatani et al., 2021). The thermal imager is the successor of the TIR on Hayabusa2 (Okada et al. 2017), and based on an uncooled micro-bolometer array (Lynred PICO1024 Gen2) with 1024 x 768 pixels. Its field of view has 13.3° x 10.0° to cover the whole asteroid binary system from 20 km distance during the asteroid proximity phase. Its spatial resolution is about 4~5 m per pixel from the altitude of 20km. TIRI has six narrow band filters in 7 to 14 μm to characterize spectral profile of thermal emissivity of the surface of the asteroid, informing composition, crystallinity, or degree of thermal alteration of the surface materials, judging from the position and strength of Christiansen Feature (CF) and

Reststrahlen Feature (RF). TIRI engineering model (EM) has been manufactured and the test results show that the temperature detection range covers 150 to 400 K, and the noise equivalent temperature difference (NETD) is below 0.1 K at 300K after onboard image summation to improve its signal to noise ratio. These values are within the range required for TIRI.
TIRI has the internal sequence and macro commands, so that each observation procedure will be freely arranged for each of operation phases. During the early characterization phase (ECP) at 20 to 30 km distance and the solar phase angle of 50° to 70°, the one-rotation thermal images of Didymos and Dimorphos will be taken as well as their multi-band images in mid-infrared range, for the entire binary system for a 2.26-hours rotation of Didymos and for a 11.5-hours rotation of Dimorphos around Didymos. During the detailed characterization phase (DCP) at 10 to 20 km distance, not only at the high solar phase angles but also at the noon (zero solar phase angle), the similar one-rotation thermal images and multi-band images will be taken. During the close flyby operation phase (COP), consecutive thermal images (for example 60 images in two minutes) or some multi-band IR images will be taken from several km distance from the Dimorphos. Using TIRI, the characteristics of the asteroid binary will be investigated, leading the understanding of the origin and evolution of the Solar System bodies..

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Comments:

We request this paper will be included in the Hera session