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Thermal Infared Imager TIR on Hayabusa2: Initial Check and Future Operation Plan

OKADA, Tatsuaki[1*] ; TANAKA, Satoshi[1] ; FUKUHARA, Tetsuya[2] ; TAGUCHI, Makoto[3] ; IMAMURA, Takeshi[1] ; ARAI, Takehiko[1] ; SENSHU, Hiroki[4] ; DEMURA, Hirohide[5] ; OGAWA, Yoshiko[5] ; KITAZATO, Kohei[5] ; SEKIGUCHI, Tomohiko[6] ; NAKAMURA, Ryosuke[7] ; KOUYAMA, Toru[7] ; HASEGAWA, Sunao[1] ; MATSUNAGA, Tsuneo[8] ; WADA, Takehiko[1] ; TAKITA, Jun[9] ; SAKATANI, Naoya[10] ; HORIKAWA, Yamato[10] ; HELBERT, Jorn[11] ; MUELLER, Thomas[12] ; HAGERMANN, Axel[13]

[1]ISAS/JAXA, [2]Hokkaido University, [3]Rikkyo University, [4]Chiba Institute of Technology, [5]University of Aizu, [6]Hokkaido University of Education, [7]National Institute of Advanced Industrial Science and Technology, [8]National Institute of Environmental Studies, [9]University of Tokyo, [10]Sokendai, [11]German Aerospace Center, [12]Max-Planck Institute for Extraterrestrial Physics, [13]The Open University

TIR is a thermal infrared imager on Hayabusa2, based on two dimensional uncooled micro-bolometer array. It aims at mapping the thermos-physical properties of the surface of asteroid (162173) 1999JU3 to investigate and constrain its formation and evolution processes, which will be applied for a study of physical properties of small solar system bodies such as asteroids, comets, or planetesimals in the ancient solar nebula. TIR is also to give information for sampling site selection, such as the thermal environment and the distribution of hazardous boulders for assessment of safe touchdown operation, as well as the typical particle size of surface regolith for better sample collection.

Thermal radiometry is among the typical methods in planetary missions. It determined what the surface condition is like such as fine regolith, full of pebbles, many boulders, or rocky basement rock. Multi-filtered thermal mapper has been used for mapping from orbiters (i.e., Viking, Mars Odyssey, and Mars Reconnaissance Orbiter). Recently small bodies such as 9P Tempel-1, 103P Hartley-2, or 4 Vesta was mapped with near-infrared spectroscopy at 3 to 5 micrometer range. These method is only applicable for hot surface regions (the sub-solar points).

In Hayabsua2, TIR images the asteroid surface in 10 micrometer band, with relatively high spatial resolution (0.05deg/pixel, 17m/pixel from 20km altitude). This method has an advantage to image the colder surface, meaning that the dawn-dusk regions (even the night side if thermal inertia is high enough) are also imaged. TIR will take images of asteroid every several minute from the Home Position, 20km Earthward from the asteroid surface, with Sun angle from 0deg to 40deg to the surface normal. The whole asteroid surface is imaged by asteroid rotation in 7.6 hours. The temperature profile of each site is traced, and the thermal inertia of each site is determined by the peak temperature and its delay from the sub-solar time.

We conducted the initial check of TIR after the launch of Hayabsua2 on 3 December 2014. Functionality and performance has been checked on 11 and 17 December, respectively, and we found no uncomfortable problems compared to those of pre-flight tests. After that the monthly health and performance checks are planned for TIR. Attitude control of spacecraft is not requested so that TIR points to the deep sky. Readout value varies from pixel to pixel so that a couple of images taken during the shutter open and close must be subtracted to derive a thermal image by reducing the offsets. During the Cruise Phase of Hayabsua2, a long-term trend of damage or degradation of the imager is investigated by the monthly operation. The performance of TIR is highly influenced by temperature, so the temperatures of TIR optics and mounting panel are controlled by spacecraft the thermal control system of spacecraft. The on/off setting temperature as well as the percentage of heater on can be set by commands, and we are searching for the best settings during the in-flight monthly operation. Currently the temperature can be controlled within 0.2 ℃. In addition, TIR will image the Earth and the Moon 10 to 2 days just before the Earth swing by for gravity assist of trajectory change. The geometry of Sun-Earth-Spacecraft angle is almost 50deg, and the observation time is limited but this may be the only chance for TIR to image the bodies of known thermal radiation. The Earth and the Moon will be seen as more than 10 or 3-4 pixels of diameter, respectively, which is a good opportunity before asteroid arrival.

Keywords: Hayabusa2, thermal inertia, thermo-physical property, mid-infrared, asteroid, thermograph