Thermal-infrared imager TIR on Hayabusa2: Result of ground calibration

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Thermal-infrared imager TIR on Hayabusa2 will image C-class NEA (162173)1999JU3 in 8-12 micrometer band. TIR observation is not only for scientific investigation of asteroid thermo-physical properties, but also for assessment of landing site selection and safety descent operation.

Hayabusa2 is the follow-on mission after Hayabusa that accomplished the first asteroid sample-return in 2010. Hayabusa2 is primarily an asteroid sample-return mission, but remote sensing of the asteroid is also essential to understand the global nature of asteroid, complementary to returned samples. Active impact experiment using SCI (Small Carry-on Impactor) and surface measurements using MASCOT lander which carries camera, NIR imaging microscope, radiator, and magnetometer, as well as hopping rover MINERVA are also planned in this mission.

A thermal-infrared imager is to image the surface temperature profile and its temporal variation by asteroid rotation. TIR adopts a non- cooled bolometer array NEC 320A with 328×248 effective pixels. Its fields of view covers 16°×12° with 0.05° per pixel. The image can be taken at 60 Hz, and summation onboard can be set from 1 to 128 to improve signal-to-background ratio. The imaging is interlaced with the shutter open and close. The subtraction of shutter-close image (bias data) from shutter-open image (biased image) produces the realistic thermal images. To improve more accurate data in radiation intensity, those realistic thermal images can be summed by onboard software. Data compression is also conducted by onboard software[1]. TIR is based on LIR on Akatsuki Venus climate orbiter [2].

We know something about C-type meteorites but little about C-class asteroids. We know little about asteroid 1999JU3 but it is considered as something like low-dense and huge-cratered as asteroid 253 Mathilde, or like rubble-piled, sedimented small asteroid 25143 Itokawa. To investigate the nature of asteroid and its formation processes, thermo-physical properties of boulders or materials inside huge crates are important targets to observe. Evident thermal measurements are conducted to compare them with thermal model for ground observation, and to investigate Yarkovsky or YORP effects. If the orbiting satellites or dust clouds exist at the surroundings, asteroid mass or dust properties will be determined. Cooperative observation with radiometer on MASCOT is also important to determine the thermo-physical properties precisely.

We conducted radiometric and geometric calibration for TIR. We use the cavity black-body and oil-bath based black-body plates for calibration at higher temperature from 25 to 150 °C. We also use the black-body plate inside the vacuum chamber for lower temperature from -40 to +50 °C. Both of appratuses share the temperature region from 25 to 50 °C. For geometrical correction, collimator is used measure the square-shaped target. For cross-calibration, the same targets are used for other instruments: 30 cm diameter serpentine target plate with heater is shared with MARA radiometer on MASCOT, and the same meteorite samples (Murchison CM2 meteorites, Murray CM2 meteorites) are shared with NIRS3 spectrometer and ONC camera. The landscape and the walls of test sites were imaged for demonstration. TIR is able to measure the surface temperature from -40 to 150 °C at the central region of images (a little wider range but less resolution at non-central region). The absolute temperature is less than 2 °C, and the resolution (NETD) is less than 0.3 °C for most of conditions. TIR is well calibrated thermal-infrared imager to take thermal images of asteroid and investigate its thermo-physical properties. This type of instruments will be used in other future missions for scientific and operational purposes.

References: [1] H. Hiara et al., The SpaceWire-based thermal infrared imager system for asteroid sample return mission HAYABUSA2, Journal of Applied Remote Sensing, in print. [2] T. Fukuhara et al., LIR: Longwave Infrared Camera onboard the Venus orbiter Akatsuki, Earth Planets Space, 63, 1009–1018, 2011.