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Thermal Infrared Imager TIR on Hayabusa2: Instrumentation and Ground Calibration

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Thermal Infrared Imager TIR onboard Hayabusa2 is to map thermo-physical properties of Near-Earth C-class asteroid (162173) 1999JU3 through thermal imaging. Scientific significance must be placed on physical properties of asteroids as well that imply the planetesimal formation in solar nebula and its mechanical evolution to current small bodies, although planetary material science is often more focused in small body missions.

In the typical solar system evolution scenario, very fluffy porous bodies are formed in solar nebula and then become denser due to high-speed collision and thermal metamorphism. Some C-class asteroids are less dense, implying a highly porous assembly of densely compacted rocks or a loosely bound rubble-pile of porous rocks and soils. Those features will be identified by thermo-physical properties derived with TIR. Some C-class asteroids must have experienced dehydrated process whose clues might be found as veins or grooves on the asteroid. Those features are expected to be investigated by TIR. Granular flows which were found on asteroid Itokawa and ejecta sediments around impact craters will be measured by TIR as different thermal inertia zones because they have smaller particle size or higher porosity. Floating boulders (or moons), surrounding dust or vapor clouds ejected from asteroid surface could be detected by TIR if they exist sufficiently. Furthermore, on-site TIR observation will contribute to more confident and accurate determination of asteroid thermo-physical properties by ground observation.

TIR is a thermal infrared imager using two-dimensional micro-bolometer array, which has 328 x 248 effective pixels, 16 x 12 degrees field of view, and 0.05 degree per pixel, so that pixel resolution is 20m when observed from 20km altitude Home Position (HP), and less than 1m from 1km altitude covering 280m x 210m. The imaging feature is suitable for obtaining asteroid global feature from HP and investigating local geological context before and after sample collection. Hayabusa2 will observe asteroid 1999JU3 at the heliocentric distance from 0.96 to 1.42 AU and the dayside surface temperature is estimated -40 to 150 ℃ assuming the albedo is 0.05 and emissivity is 0.90 to 0.95. Detection range of TIR is 8 to 12 μm, which is best for observing thermal radiation from asteroid.

We have calibrated TIR performance for the target temperature ranging from -40 to 150 ℃. Goal is to construct the calibration curves for each pixel by 3 ℃ absolute temperature as well as 0.3 ℃ NETD. The apparatus for TIR calibration are the vacuum chamber for cold target and the clean-booth for hot target, with adjusting the optics and mounted panel temperatures. It is ideal that a single OFPN (Onboard Flat Pattern Noise) data is applicable for all the temperature range. Now efforts have been taken to improve its performance by interrelation between cold and hot calibration cases, adjusting bias levels due to different thermal energy input to detector, as well as geometric calibration. Instrumentation and results of calibration for TIR will be reported in detail.

Keywords: asteroid, Hayabusa2, thermo-physical property, Thermal Infrared, bolometer, planetary exploration