# Thermophysical Properties of Aseroid Bolders in Hayabusa2, Hera, and Future Missions

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Thermal imaging is a powerful tool to investigate thermophysical properties indicate physical state of materials such as porosity, grain size, and crystallinity, and also compositional information if spectral information is obtained. Thermal imaging of C-type asteroid Ryugu has been conducted in JAXA Hayabusa2 mission using a thermal imager TIR [1], which successfully imaged the entire surface of an asteroid for the first time, to study the surface thermal inertia, especially the surface boulders. We found most of boulders has lower thermal inerita of 200-400 J $kg^{-1}$ $m^{-2}$ $s^{-0.5}$ (tiu, hereafter) than that of typical carbonaceous chondrites [2]. On the other hand, the thermal diffusivity measurements of returned sample from Ryugu indicate that the samples show the thermal inertia almost the same as typical carbonaceous chondrites of ~1000 tiu, but much lower value in the direction where cracks exist [3]. It seems likely that the materials on Ryugu originally is basically a typical chondrite-like material but with more cracks and pores. TIR will observe the other S-type asteroid Torifune (2001 CC21) during its flyby in 2026, and unknown type (probably L- or D-type) small asteroid 1998 KY26.

In ESA Hera mission, which is going to be launched in Oct 2024, a thermal infrared imager TIRI [4] is developed to investigate thermophysical properties and conposition of the constituent materials of surface boulders of S-type asteroid Didymos and Dimorphos. TIRI is capable of thermographoc imaging using a mid infrared wide band and of compositional imaging using six narrow bands. TIRI will inform thermophysical properties and composition of Didymos, which has the rough surface and a relatively smoother equatorial region, as well as those of Dimorphos, which is entirely covered with boulders. In this mission, the surface properties will be also measured by small CubeSats and the results will be compared between multiple measurements. The instrument will be possibly used for ESA-led RAMSES mission to investigate the S-type Earth-approaching asteroid Apophis.

In the next generation small body sample return (NGSR) mission under study in Japan, a similar but probably improved thermal imager will be developed to investigate a comet (currently the target is 289P/Branpain) with a wide band therma imaging and multi-bands compositional imaging. We present here the instrumentation and concept of operation in Hayabusa2, Hera, Ramses, and the future missions.

**References**

[1] Okada. T. et al. 2017. Space Sci. Rev. 208, 255-286. [2] Okda, T. et al. Nature 579, 518-522. [3] Ishizaki T. et al., 2023, Intl. J. Thermophys. 43, 51., [4] Okada, T. et al., Space Sci, Rev., *in prep.*