THERMAL INERTIA OF C-TYPE NEAR-EARTH ASTEROID 162173 RYUGU DETERMINED FROM THE DAWN SIDE OBSERVATIONS BY THERMAL INFRARED IMAGER

T. Okada[1,2] , T. Fukuhara[3], S. Tanaka[1], M. Taguchi[3], T. Arai[4], N. Sakatani[1], Y. Shimaki[1], H. Senshu[5], H. Demura[6], Y. Ogawa[6], K. Suko[6], T. Sekiguchi[7], T. Kouyama[8], J. Helbert[9], T. G. Mueller[10], A. Hagermann[11], J. Biele[9], M. Grott[9], M. Hamm[9], M. Delbo[12], and The Hayabusa2 TIR Team[1], [1]AInstitute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, Japan, okada@planeta.sci.isas.jaxa.jp, [2]University of Tokyo, Tokyo, Japan, [3]Rikkyo University, Tokyo, Japan, [4]Ashikaga University, Tochigi, Japan, [5]Chiba Institute of Technology, Narashino, Japan, [6]University of Aizu, Aizu-Wakamatsu, Japan, [7]Hokkaido University of Education, Asahikawa, Japan, [8]National Institute of Advanced Industrial Science and Technology, Tokyo, [9]German Aerospace Center (DLR), Germany, [10]Max Planck Institute for Extraterrestrial Physics, Garching, Germany, [11]University of Stirling, Stirling, UK, [12] Code d'Azur Observatory, Nice, France.

Introduction: Thermal inertia is a fundamental thermophysical property of materials on planetary bodies, which is derived as the response of temperature change in a day-night cycle. It informs on the surface physical state such as grain size, porosity, or small-scale roughness, even if the planetary surface is not observed directly from the near range nor measured by spatially resolved observations. It is already evidently found that the surface of Ryugu, the target asteroid of Hayabusa2, are not covered with fine regolith, but rocks and boulders with several centimeter or larger size [1], [2]. There is a difficulty in determining thermal inertia of such rough surface, since a diurnal temperature profile using a simple thermal model is not well fit to the observations [3].

Ryugu is a C-type Near-Earth asteroid and its average density is 1199 ± 20 kg m^{-3}, with more than 50 % of porosity assuming the typical CI and CM chondrite meteorites [4]. The materials on Ryugu, even those of the large boulders, might have very porous structure under the low gravity condition [5]. The lower thermal inertia should be expected for the surface Ryugu compared with that of the typical value of CI or CM chondrites, and it needs a hard task to derive the quantitative TI value for such a rough surface.

Thermal Inertia Estimate by TIR: There are several ways to derive the thermal inertia of Ryugu: 1) peak temperature, 2) delay of peak temperature , 3) fitting the diurnal temperature curves, 4) cooling rate after sunset, 5) warming rate after sunrise, 6) lowest temperatures just before sunrise. There needs a proper thermal model for the rough surface, considering the self-heating between the facing facets, shadowing and shading the surface structures, and small-scale roughness within a node. Here we take lowest temperature just before sunrise during the dawn side observations, because it is most simple case where no solar radiation inputs to the surface, and the heat exchange is minimum at the low temperature.

A meaningful data of the dawn side becomes available after conjunction and the Sun-Probe-Earth (SPE) angle is larger than 20° so that the several pixels in the nighttime get imaged. TIR has performed to take thermal images during one rotation (~7.63 hours) at the step of every 6° or 3°. On 13 March 2019, for example, a one-rotation set of TIR images was taken at the solar distance of 1.38 au, at the SPE angle of 18.4°, and from the Box-A (20 km from the asteroid) and showed that the temperature just before sunrise is below 200 K almost all the surfaces. This result indicates the thermal inertia of 250 [J m^{-2} K^{-1} $s^{-0.5}$: hereafter, tiu] or lower considering simple thermal model. This value of thermal inertia is consistent with the thermal inertia of 300 ± 100 tiu derived from the daytime data of TIR [6], and with *in situ* measurements of a single boulder by MARA radiometer on MASCOT [7], and also with the prediction by the ground observations of 150 to 300 tiu [8]. This result is still preliminary but concludes that the surface of Ryugu has much lower thermal inertia compared with that of a typical CI or CM chondrite meteorites.

Asteroid thermal model considering the surface roughness should be updated to explain the flat diurnal profiles which were observed on Ryugu, and other comets 9P/Tempel 1 and 103P/Hartley [9], and to explain the dawn and dusk profiles more completely.

References:

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