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Thermal inertia of asteroid Ryugu using dawn-side thermal images by TIR on Hayabusa2

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Abstract

A thermal inertia map of the C-type Near-Earth asteroid 162173 Ryugu has been derived using the one-rotation global thermal image sets observed from the Home Position at 20 km altitude [1]. This time the thermal images of the night side areas of the surface just before sunrise were taken during observations from the dawn side. The coldest brightness temperature of the surface indicates another information on the thermal inertia of the surface. The thermal inertia is preliminary estimated at 250 [J m^{-2} K^{-1} $s^{-0.5}$] or lower, which is consistent with other than those derived from the daytime observations [2].

1. Introduction

The thermal infrared imager TIR on Hayabusa2 is a light-weighted bolometer based thermal imager to take high resolution thermal images of the C-type Near-Earth asteroid 16273 Ryugu, the target of the mission. After arrival at the asteroid, thermal images have been continually observed with the TIR, mainly at the Home Position of 20 km altitude from the asteroid surface, but sometimes at lower altitude of 5 km for better spatial resolution, and during several opportunities to take close-up thermal images below the altitude of 100 m for touchdown or lander release operations. Thermal inertia has been estimated from the data of each observation campaign and basically show in common a lower value (typically 200 to 400 [J m^{-2} K^{-1} $s^{-0.5}$]) compared to stony materials like meteorites [3]. This is consistent with the thermal inertia by *in situ* measurement for a single boulder by a MARA, a radiometer on MASCOT [4]. This indicates the surface is very porous with more than 30 % porosity. The surface features imaged by MasCAM on MASCOT indicated the very fluffy surface [5]. This time the temperature at the night side area observed by TIR was applied improve the estimate of the global thermal inertia of Ryugu.

2. TIR observations at the dawn side

At the time of arrival, the Hayabusa2 spacecraft has basically stayed at the dusk side because of its SPE (Sun-Probe(=asteroid)-Earth) angle. But after the solar conjunction, the spacecraft moved to the dawn side and the surface areas just before sunrise have been more and more suitable for observations even from the Home Position, especially after April 2019, with the SPE angle of 20° or larger. There are a few times to observe these areas, so that a preliminary estimate of the thermal inertia from the coldest temperature during one-ration almost all the areas.

3. Thermal inertia from the coldest temperature in a day

At the distance of 1.30 to 1.35 au from the sun, the surface temperature can be calculated for a simple surface thermal model. It is already shown that the simple one-layer thermal model without considering the small-scale roughness does not match the diurnal temperature profile. The surface geologic feature and the surface small-scale roughness in a node of thermal model will strongly affect the temperature profile due to its effects by shadowing and shading of sunlight, self-heating between the sites facing each other, a variety and biased direction of thermal emission. But in the nighttime, the solar effect can be neglected and as the rough estimate the thermal inertia is estimated with the simple model.

The observations by TIR show that the lowest brightness temperatures typically become lower than 200 K at the coldest area but still enough high compared with the background level. The thermal inertia should be 250 [J m^{-2} K^{-1} $s^{-0.5}$] or lower to account for the brightness temperatures.

4. Concluding remarks

Thermal inertia derived from the coldest temperature in a day shows a very low value as stony materials like meteorites, which is consistent with the thermal inertia by the other methods like ground observations [6], *in situ* measurements of a single boulder by MARA [4], and the daytime observations by TIR with or without considering the surface roughness [2,3]. This strongly suggests that the boulders and rocks on the surface should be made of materials with high porosity. If this is the same as other small asteroids, and even the planetesimals in the early solar system, the high porosity might affect on their formation process.

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