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Potential thermal infrared camera for Hera mission

T. Fukuhara (1), T. Okada (2), and S. Tanaka (2)
(1) Rikkyo University, Japan, (2) Institute of Space and Astronautical Science, JAXA, Japan

Abstract

We propose to mount a newly developed thermal infrared camera to the Hera spacecraft which investigates the S-type asteroid called Didymos. It is based on the thermal infrared camera developed for an earth observing satellite to detect wildfire. Preliminary result of the fundamental function test and evaluation of the camera specification in the vacuum environment shows the camera satisfies a requirement for applying to Hera mission. The wavelength of 8-14 μm which the camera detects may be divided for multi spectral observation, by which the spectra of minerals such as plagioclase, orthoclase, and quartz can be distinguished and quantified. It would be more advantageous than the observation of visible to near infrared reflectance from these minerals.

1. Introduction

Thermophysical property of the asteroid surface is a fundamental characteristic for planetary science. It informs us on the physical state such as grain size, porosity, or small-scale roughness, from which planetary formation processes or surface processes in the later stage could be investigated. The Thermal Infrared Imager (TIR) onboard Hayabusa2 has been developed to investigate the thermophysical properties of asteroid 162173 Ryugu by the remote sensing [1]. Thermography obtained by TIR showed the regional distribution of thermophysical properties of Ryugu at a glance. Now, we propose to mount a newly developed thermal infrared camera to the Hera spacecraft which investigates the S-type asteroid called Didymos.

2. Our experience of the camera development

TIR for Hayabusa2 is a thermal infrared camera with the wavelength ranging from 8 to 12 μm and the field of view corresponding to 16° x 12° [2]. The detector is based on a two-dimensional Uncooled Micro Bolometer Array (UMBA) with 328 x 248 pixels. Since the UMBA does not need to be cooled, namely it has light weight without heavy cryogenic system, it is suitable for deep space missions. When the emission from a target strikes the UMBA whose temperature is strictly controlled by the Peltier element device, electrical resistance is slightly changed; the detector measures it for image creating [3]. Image data can be converted to brightness temperature by reference tables acquired beforehand. It has been well calibrated in the laboratory from -40 to 150 °C, which covers the expected temperature of the sunlit surface of the asteroid.

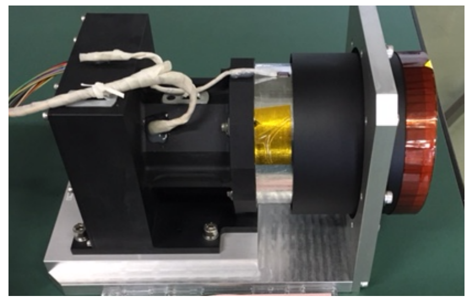

Fig.1. The uncooled microbolometr camera evaluated in this study

The specification of TIR is exactly same as that of LIR which is the thermal infrared camera mounted to Japanese Venus climate orbiter called Akatsuki launched in 2010. It was the first attempt of the UMBA applying to space mission in Japan [4]. The meaningful outcome of LIR accounted for adopting the UMBA to Hayabusa2 mission. However, the UMBA for Akatsuki and Hayabusa2 was too old for future planetary missions to adopt.

3. Instrumentation for Hera

In 2014, a commercial product of the UMBA named "UL04171" provided by ULIS Inc. in France has been applied to the new thermal infrared camera (Fig.1) which has been developed for an earth observing satellite to detect wildfire [5]. It is made of amorphous silicon for detecting wavelength of 8-14 μm with pixel size of 640 x 480, and the noise equivalent temperature difference (NETD) is ~0.12 K at 300 K with F/1.0. The specification of the UMBA has kept the highest at the time of launch. In this study, a prototype of the further newest thermal infrared camera with the UMBA of ULIS has been developed for future planetary mission. Pixel arrays are increased to 1024 x 768 and spatial resolution becomes finer while maintaining FOV. Pixel size of the new detector is smaller than that of old one, while sensitivity has higher; The NETD is kept to less than ~0.1 K at 300 K with F/1.0. Preliminary result of the fundamental function test and the camera specification in the vacuum environment shows the camera satisfies a requirement for applying to Hera mission. Furthermore, the wavelength of 8-14 μm may be divided for multi spectral observation, by which the spectra of minerals such as plagioclase, orthoclase, and quartz can be distinguished and quantified. It would be more advantageous than the observation of visible to near infrared reflectance from these minerals.

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