EPSC Abstracts
Vol. 7 EPSC2012-50-3 2012
European Planetary Science Congress 2012

The MASCOT Radiometer MARA for the Hayabusa 2 Mission

M. Grott (1), J. Knollenberg (1), F. Hänschke (2), J. Helbert (1), E. Kührt (1),
(1) German Aerospace Center, Berlin, Germany (matthias.grott@dlr.de), (2) Institute of Photonic Technology, Jena, Germany

Abstract

The MASCOT radiometer MARA is a multispectral instrument to radiatively measure the surface temperature of the Hayabusa 2 target asteroid 1999JU3. MARA uses 5 bandpass and one longpass channel to determine the surface temperature, emissivity, and thermal inertia. In addition, surface mineralogy can be constrained.

1. Introduction

The MASCOT radiometer (MARA) is one of the payloads of the MASCOT lander [1] onboard the Hayabusa 2 mission, due to be launched in 2014. Hayabusa 2 is targeted for the C-type near Earth Asteroid 1999JU3 and will arrive after a three years cruise. Following an initial asteroid characterization phase, MASCOT will land and begin in-situ investigations using its four science instruments, which comprise a near infrared spectrometer, a camera, a magnetometer, and the MARA infrared radiometer.

MARA will measure the radiative flux emitted from the asteroid's surface using thermopile sensors in six wavelength bands, and the primary scientific goal of the instrument is the determination of the asteroid's thermal inertia at the landing site. A secondary goal is the characterization of the surface mineralogy by identifying characteristic absorption features of rock forming minerals. In addition, MARA will use a channel which will be identical to that used by the spacecraft thermal mapper [2], thus providing ground truth for measurements at spacecraft altitude.

2. Science Objectives

Remote sensing data indicate that 1999JU3 has an effective diameter of 0.92 ± 0.12 km and a low visual geometric albedo of 0.063, compatible with a C-type taxonomic-type classification. Estimates of the surface averaged thermal inertia range from 200 to 600 J m^{-2} K^{-1} s$^{-1/2}$ [3], and it is likely larger than 500 J m^{-2} K^{-1} s$^{-1/2}$ [4]. Thus, thermal inertia is about a factor of 2 lower than the value for 25143 Itokawa [3], indicating that surface texture lies somewhere between a thick-dust regolith and a gravel-dominated surface.

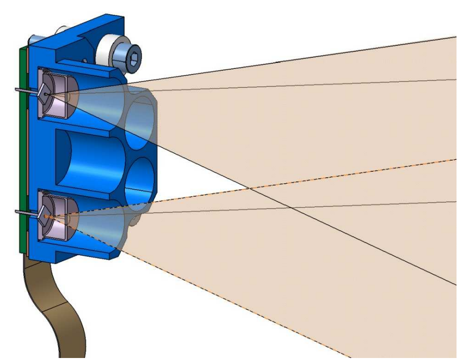

Figure 1: Conceptual view of the MARA sensor head showing two of the six thermopile sensors and the associated field of view.

Remotely determined thermal inertia gives a non-linear average of the surface thermo-physical properties, with hotter surfaces being overrepresented. MARA has a field of view of $\pm 15^\circ$, resulting in a footprint size of 30 cm diameter, and will determine the surface temperature, emissivity, and thermal inertia in this area. In this way, estimates of the local thermo-physical properties of the regolith will be obtained, which can be interpreted in terms of grain sizes. Thus MARA will provide ground truth at small scales in addition to context for the spacecraft measurements.

3. Instrument Description

MARA sensors have significant heritage from the MUPUS thermal mapper onboard the Rosetta Philae lander, and MARA will use the IPHT TS-72-M thermopile sensors as sensing elements [5]. These thermopiles consists of 72 Bismuth-Antimony ($Bi_{0.87}Sb_{0.13}$/Sb) thermopair junctions with a thermoelectric power of 135 μV/K each. A circular absorber of 0.5 mm diameter will measure the radiative temperature, and PT100 sensors will be used to measure the thermopile cold junction temperature. The sensitivity of the sensors is 250 V/W under Krypton fillgas and each thermopile can be fitted with its own individual filter. In addition, three different types of absorber surfaces can be used: One broadband black silver smoke absorber, and two interference absorbers with optical ranges of 3 to 5.0 and 5.5 to 13 μm are available.

Thermopile sensors will be embedded in a temperature controlled aluminum housing to stabilize the cold junction reference temperature, and the instrument will be calibrated at the working temperature setpoint. The instrument electronics employ 24 bit analogue to digital converters, resulting in an expected noise equivalent temperature difference of better than 1 K at a target temperature of 100 K. The instrument sensor head and back-end electronics have a mass of 90 and 50 g, respectively.

MARA sensors can be fitted with six individual filters, and bandpasses between 5.5-7, 8-9.5, 9.5-11.5, and 13.5-15.5 μm have been chosen to derive the surface emissivity and characterize the asteroid's mineralogy. In addition, a longpass filter between 5 and 100 μm will be employed to determine the surface temperature, and a filter between 8 and 14 μm will be used to provide ground truth for spacecraft measurements.

In addition to becoming transparent at around the double wavelength of the optical window, infrared filters usually become transparent at wavelengths above $\sim$50 μm, depending on the filter substrate. As a significant part of the signal is expected to originate at wavelength > 50 μm for the low night time temperatures expected on the asteroid, this signal needs to be blocked. MARA achieves this by using the IPHT interference absorbers, as shown in the top panel of Fig. 2. Filter transmittance for all filter/absorber combinations is shown in the bottom panel of the same figure.

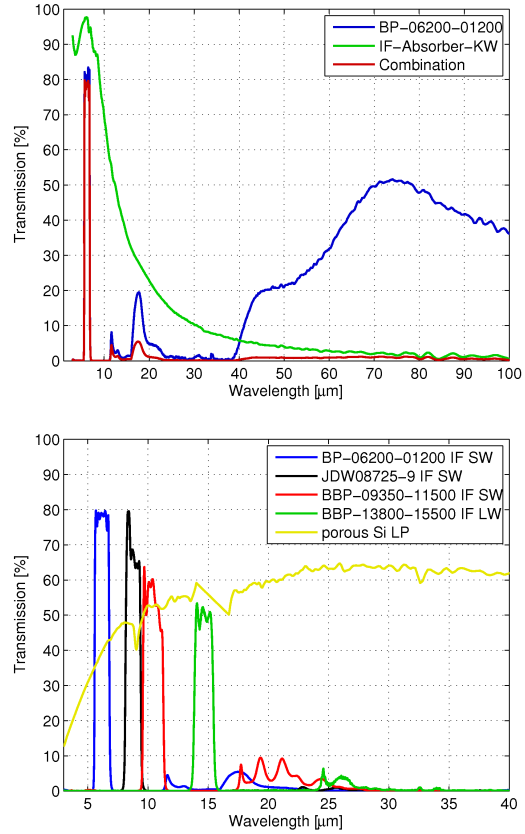

Figure 2: Top: Example of combining a bandpass IR filter with an interference absorber to remove the long-wavelength signal. Bottom: The 4 bandpass and 1 longpass filters currently foreseen to be used. In addition, an 8-14 μm filter identical to that of the Orbiter Thermal Mapper will be employed.

References

[1] Lange, M., C. Hühne, O. Mierheim, et al., MASCOT - A Lightweight Multi-Purpose Lander Platform, European Conference on Spacecraft Structures, Materials and Environmental Testing, 20.-23.Mrch 2012, Noordwijk, Netherlands.

[2] Okada, T., T. Fukuhara, S. Tanaka, et al., Thermal Infrared Imager TIR on Hayabusa 2 to Investigate Physical Properties of C-Class Near-Earth Asteroid 1999JU3, *4*3rd LPSC, abstract 1498, 2012.

[3] T.G. Müller, J. Ďurech, S. Hasegawa, et al., Thermophysical properties of 162173 (1999 JU3), a potential flyby and rendezvous target for interplanetary missions, *A*stron. Astrophys., 525, A145, 2011.

[4] Hasegawa, S., T.G. Müller, K. Kawakami, et al., Size, and Surface Characteristics of Hayabusa-2 Sample-Return Target 162173 1999 JU3 from AKARI and Subaru Observations, *P*ASP, 60, 399-405, 2008.

[5] Kessler, E., V. Baier, U. Dillner, et al., High-temperature resistant infrared sensing head, Proceedings of Sensor 2005, 12th International Conference, Vol. I, Nürnberg, pp 73-78, 2005.