MERTIS – MErcury Radiometer and Thermal infrared Imaging Spectrometer

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Abstract

The MErcury Radiometer and Thermal infrared Imaging Spectrometer (MERTIS) [1] is part of the payload of the Mercury Planetary Orbiter spacecraft of the ESA-JAXA BepiColombo mission that will be launched in October 2018. MERTIS combines an imaging spectrometer covering the wavelength range from 7-14 µm with a radiometer covering the wavelength range from 7 to 40 µm. The instrument will map the whole surface of Mercury with a spatial resolution of 500m for the spectrometer channel and 2km for the radiometer channel. The compositional map of Mercury provided by MERTIS will allow unique insights into the evolution of the least explored terrestrial planet. MERTIS will also address directly questions raised by the NASA MESSENGER mission. For example we will be able to provide spatially re-solved compositional information on the hollows and pyroclastic deposits and answer the question whether hollows are actually predominately sulfide deposits.

1. Introduction

The availability of uncooled microbolometer arrays allowed a new generation of thermal infrared instruments [2, 3]. Based on this technology we MERTIS in 2003 for the ESA-JAXA BepiColombo mission.

1.1 The MERTIS instrument

MERTIS combines IR grating spectrometer (TIS) with a radiometer (TIR), both operating in a push-broom mode. It represents a modular concept of the sensor head, electronic units and power/calibration systems within a mass budget of only 3.0 kg and power consumption of less than 12 W nominal.

MERTIS features more than 10 miniaturized, highly integrated subsystems, including mirror optics, two IR detectors (bolometer and radiometer) with read-out electronics, two actuators (pointing unit and shutter), two on-board blackbody calibration targets at 300 and 700 K, two baffles (planet, space), heater, temperature sensors, and two cold redundant instrument controllers and power supplies (Fig. 1).

The optical design of MERTIS combines a three mirrors anastigmatic (TMA) with a modified Offner grating spectrometer [3]. A pointing device allows viewing the planet (planet-baffle), deep space (space-baffle), and two black bodies at 300 K and 700 K temperature, respectively. The combination of spectrometer and a radiometer channel using the same optics and calibration sources allows retrieving emissivity, surface temperature and thermal inertia independently [4,5].

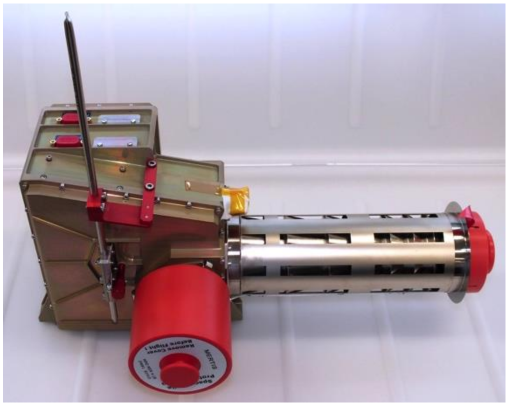

Figure 1: MERTIS flight model before delivery to ESA for integration on the spacecraft

1.2 MERTIS TIS

TIS operates between 7 and 14 µm with a 200nm spectral resolution and will record the day-side emissivity spectra from Mercury at a spatial resolution up to 280m. The instrument uses an uncooled microbolometer, developed under ESA contract at LETI and ULIS in France. This is the first space-qualified microbolometer developed and built in European. It is based on the commercial detector with 160 x 120 pixels with a pixel size of 35 µm. A part of the development the detector was not only space qualified but also the sensitivity was significantly increased and the cut-on wavelength was reduced from 8 to 7 µm. The detectivity (NEP) of the detector is in the range of 10-15 pW.

1.3 MERTIS TIR

Sharing the same optical path a pushbroom radiometer (TIR) is implemented by an in-plane separation arrangement, effectively acting as the slit of the spectrometer. The TIR uses a thermopile line detector arrays of 7 10^8 cm $Hz^{1/2}$ W^{-1} detectivity. TIR is going to measure the surface temperature at day- and night side at a spatial resolution of 2km with two broadband channels. The 7-14 µm channels facilitates cross calibration with the spectrometer, while the 7-40µm channel allows to accurately measure the night-side temperatures of Mercury with a noise equivalent temperatures difference (NETD) of 1K at 80K

2. Getting ready for the journey to Mercury

BepiColombo is a dual spacecraft mission to Mercury to be launched in October 2018 and carried out jointly between the European Space Agency (ESA) and the Japanese Aerospace Exploration Agency (JAXA). BepiColombo uses a solar electric propulsion system. The trajectory is a combination of low-thrust arcs and flybys at Earth (1), Venus (2), and Mercury (5) and will be used to reach Mercury with low relative velocity. Before arriving at Mercury BepiColombo will perform Venus flybys in 2019 and 2020. The launch will be performed by an Ariane 5 from the ESA launch facility in Kourou (French Guyana). The ESA Mercury Planetary Orbiter (MPO) and the JAXA Mercury Magnetospheric orbiter will be launched in a composite with a propulsion element - the Mercury Transfer Module (MTM) and a sunshade cone (MOSIF) to protect the MMO.

2.1 Operation planning

We are currently preparing for launch and the Near-Earth commissioning phase, as well as planning for Venus flybys, and the first year of Mercury observations. For the Mercury observations, we are developing a Science Activity Plan (SAP), which will be verified with our Science Traceability Matrix. This requires a definition of hierarchic observation sequences and the implementation of our operations concept into ESA planning tools.

2.2 Ground Reference Model:

The MERTIS FS is setup at the Planetary Spectroscopy Laboratory at DLR in Berlin and serves as ground reference model for testing software procedures and instrument performance. For this purpose, we developed and built a nitrogen-purged chamber with two black bodies (high and low T) that allow us to simulate observations at Mercury. The set-up is fully functional and will support our launch and Near-Earth commissioning activities (Fig. 2).

Figure 2: MERTIS ground reference model

References

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