FIRST OBSERVATIONS OF THE MERCURY RADIOMETER AND THERMAL INFRARED SPECTROMETER (MERTIS) OF MERCURY: OVERVIEW OF PRELIMINARY RESULTS FROM FLYBY MSB#5. H. Hiesinger[1], S. Adeli[2], O. Barraud[2], K. E. Bauch[1], M. D'Amore[2], J. Helbert[2], T. Heyer[1], J. Knollenberg[3], A. Maturilli[2], A. Morlok[1], J. H. Pasckert[1], M. P. Reitze[1], N. Schmedemann[1], M. Tenthoff[4], I. Weber[1], K. Wohlfarth[4], C. Wöhler[4], and the MERTIS Team. [1]Institut für Planetologie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (hiesinger@uni-muenster.de); [2]DLR-Institute for Planetary Research, Rutherfordstrasse 2, 12489 Berlin, Germany, [3]DLR-Institute of Optical Sensor Systems, Rutherfordstrasse 2, 12489 Berlin, Germany, [4]Image Analysis Group, TU Dortmund University, Otto-Hahn-Str. 4, 44227 Dortmund, Germany.

Introduction: With only two space missions, Mariner 10 and MESSENGER visiting Mercury, it is probably the least explored terrestrial planet. Hence, Mercury still holds many riddles that await closer inspection. Among the many open questions are the formation of the large iron core, the basically iron-free surface composition, the surprisingly large amounts of volatiles as well as its general geological history and evolution [e.g., 1].

BepiColombo: Launched in October 2018, the ESA/JAXA spacecraft BepiColombo is on its way to become the third mission to observe Mercury from close-up and only the second to enter into orbit around this planet. Consisting of two spacecraft, the ESA-provided Mercury Planetary Orbiter (MPO) and the JAXA contributed Magnetospheric Orbiter (Mio), BepiColombo will help to answer some of the open questions [e.g., 1]. Equipped with a suite of 11 instruments, the MPO will enter a ~460 x 1500 km orbit to explore the surface of Mercury and its interaction with the space environment, while Mio will observe the magnetosphere from a highly elliptical orbit [e.g., 1]. One of the instruments on board the MPO is the Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS), which will observe Mercury in the wavelength region of 7 - 40 microns [2,3]. MERTIS consists of two channels, the TIS spectrometer, operating in the wavelength region of 7 – 14 microns, and the TIR radiometer, covering wavelengths between 7 and 40 microns. The TIS is uniquely suited to identify and map rock-forming minerals, whereas the TIR will provide us with highly accurate surface temperature measurements [e.g., 2,3].

The cruise: Since launch, BepiColombo performed several gravity-assist flyby maneuvers, including one at the Earth/Moon system, two at Venus, and five at Mercury with a sixth flyby coming up on January 8th, 2025. MERTIS was able to observe the Moon in 2020 and Venus in 2020 and 2021. On December 1st, 2024, MERTIS observed Mercury for the very first time during its 5th flyby (MSB#5). For these observations, the operations sequence had to be re-programmed as the Mercury Transfer Module (MTM) obstructs the field of view of many instruments, including MERTIS' planet view. Fortunately, MERTIS has two apertures that allow the nominal observation of the planet through the planet baffle and of cold space through the space baffle. During the cruise until orbital insertion around Mercury in November 2026, only the space baffle can be used for observations. Although BepiColombo previously performed four flybys with altitudes of down to only 165 km, MERTIS could not be operated due to thermal constraints. Hence, MSB#5 is the first time that Mercury is observed at MERTIS wavelengths from spacecraft. Once in orbit, MERTIS will globally map the hermean surface at a pixel scale of ~500 m, significantly improving our understanding of its mineralogy and composition.

The data: In preparation of the flyby, the MERTIS Team executed two rehearsals in November 2024 to ensure flawless operations during the flyby. In addition, we benefitted from our experiences during the Moon [4] and Venus [5] flybys, underlining the importance of these early observations for optimizing our operations and calibration procedures. During MSB#5, MERTIS observed Mercury for about 36 minutes during closest approach at a distance of about 37268 km, which resulted in a ground pixel scale of 26 – 30 km/pixel - high enough to identify several geologic features, including fresh impact craters.

During data acquisition, the temperature of the MERTIS chip was stable mostly within ±0.0025 K, whereas housing and baseplate temperatures increased by about 3 K during operations. During MSB#5, MERTIS acquired a total of 1,410,841 ground spectra. The new data cover a swath of 165 – 210 degrees longitude at the equator, with increasing longitudinal coverage towards both poles. Included in the dataset are the eastern rim and floor of the Caloris basin as well as parts of the Northern Volcanic Plains (NVP) and several impact craters such as Bashō, Nureyev, Liszt, and Tolstoj. With the data on ground for just about one month, the MERTIS Team is working hard on calibrating the data [6], improving the geometric pointing of the instrument (i.e., instrument SPICE kernels) [7], and calculating emissivities. In the calibrated radiance data (Fig. 1), temperature effects are clearly visible from the equator toward the poles. We also see indication for stray light in the data.

Furthermore, due to the low spatial resolution of the data, each individual MERTIS pixel contains many differently oriented and therefore differently hot surfaces. The combination of these effects makes the derivation of emissivities non-trivial [8]. Hence, several techniques of calculating emissivities can be applied and it remains to be seen which technique provides the most accurate results. Detailed thermal modeling and sophisticated spectral investigations in the laboratory are performed in parallel to provide a better understanding of temperature, grain size, ambient conditions, and observation geometry effects, among others [e.g., 9-16]. Hence, the results presented here should be treated as preliminary.

Preliminary results: In a companion abstract we investigated 48 complex craters between 60° and -60° latitude and calculated emissivities for 30 of them [12]. Studying ejecta and central peaks of complex craters provides insight into the composition of a planet's subsurface, as these materials originate from depth [e.g., 17]. Hence by spectrally investigating complex craters of different sizes we might decipher the vertical structure and composition of the crust [18,19]. Our preliminary results indicate that there is a wide range in spectral characteristics, such as possible shifts in the position of the Christiansen Feature (CF). However, so far, we did not observe systematic changes with crater diameters between 46 km to 188 km [12]. We are also combining MESSENGER MASCS data with MERTIS data to investigate the geology of the Tolstoj basin in detail [20, 21].

Surface temperatures were derived from the TIR channels. We found that temperatures are in the expected range for Mercury. Furthermore, both MERTIS TIR channels yield consistent brightness temperatures of 693 K (TIR-A) and 692 K (TIR-B) for the equatorial region [21].

Acknowledgments: This work receives funding from the DLR (50 QW 2201A/B) in the framework of the BepiColombo mission.

References: [1] Benkhoff et al. (2020) Space Sci Rev. 217; [2] Hiesinger et al. (2010) Planet. Space Sci. 58; [3] Hiesinger et al. (2020) Space Sci. Rev. 217; [4] Barraud et al. (2024) SPIE 13144. [5] Helbert et al. (2023) Nature Comm. 14; [6] D'Amore et al. (2019 SPIE 11128; [7] Schmedemann et al. (2025) LPSC 56; [8] Wohlfarth et al. (2023) Astron. Astrophys. 674; [9] Ferrari et al. (2020) EPSL 534; [10] Reitze et al. (2024) J. Geophys. Res. 129; [11] Morlok et al. (2023) Icarus 396; [12] Pasckert et al. (2025) LPSC 56; [13] Tenthoff et al. (2025) LPSC 56; [14] Powell et al. (2025) LPSC 56; [15] Maturilli et al. (2025) LPSC 56; [16] Van den Neucker et al. (2025) LPSC 56 ; [17] Melosh (1989) Impact cratering: A geologic process. Cambridge University Press; [18] D'Incecco et al. (2015) Planet. Space Sci. 119; [19] D'Incecco et al. (2016) Planet. Space Sci. 132; [20] D'Amore et al. (2025) LPSC 56; [21] Adeli et al. (2025) LPSC 56.

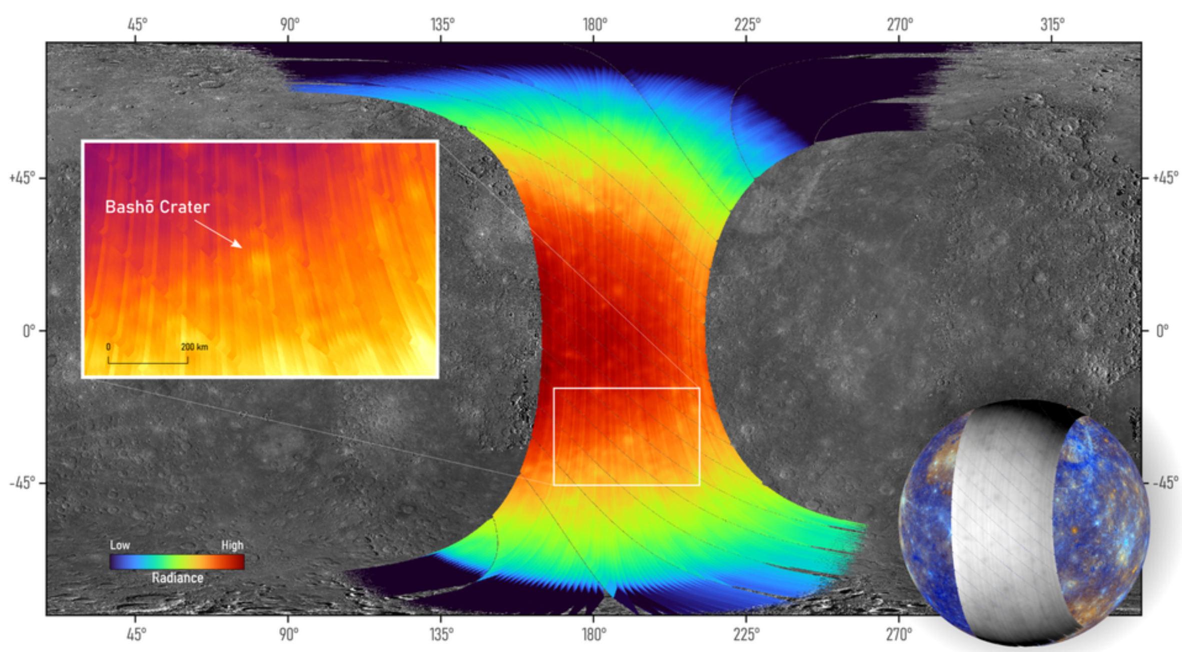

Figure 1: Color-coded radiance map (~8.45 µm) of MERTIS MSB#5 data. Low radiances are shown in blue and high radiances are indicated in red. The white box focuses on Bashō crater, the lower insert shows the MERTIS coverage superposed on the MESSENGER MDIS false color ratio.