High-temperature Emission Spectroscopy – The Planetary Emissivity Laboratory (PEL) at DLR Berlin.

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Introduction: Analyzing the surface composition of Mercury's regolith from remote-sensing measurements is a challenging task. In support of the National Aeronautics and Space Agency's MErcury Surface, Space ENvironment, GEochemistry and Ranging (MESSENGER) mission and especially in preparation for the Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS) instrument on the BepiColombo mission of the European Space Agency and the Japan Aerospace Exploration Agency, we have completely refurbished the Planetary Emissivity Laboratory (PEL) at Deutsches Zentrum für Luft- und Raumfahrt (DLR) in Berlin. The upgraded PEL allows measurement of the emissivity of Mercury-analogue materials at grain sizes smaller than 25 µm and at temperatures of more than 400°C, typical for Mercury's low-latitude dayside. The PEL development follows a multi-step approach. We have already obtained emissivity data at mid-infrared wavelengths that show significant changes in spectral behavior with temperature indicative of changes in the crystal structure of the samples. We have tested new calibration targets that will allow the acquisition of emissivity data over the full wavelength range from 1 to 50 micrometer with good signal-to-noise ratio. Currently we are in the final verification steps of the whole setup.

The PEL: The Institute for Planetary Research has an expertise in spectroscopy of minerals, rocks, meteorites, and organic matter, build up in more than two decades. The available equipment allows spectroscopy from the visible to TIR range using bi-conical reflection and emission spectroscopy. The institute has an outstanding heritage in designing and building infrared remote-sensing instruments for planetary missions.

The PEL has been operating in various configurations for the last 10 years. The laboratory experimental facilities consist of the main emissivity spectrometer laboratory, a supporting spectrometer laboratory for reflectance measurements [1,2,3], sample preparation facilities and an extensive collection of rocks and minerals.

The heart of the spectroscopic facilities is the Planetary Emissivity Laboratory (PEL) which has been completely refurbished in the last three years. The PEL allows currently to measure the emissivity of planetary analogue materials from 3-50 µm for very fine grained samples.

Figure 1: View of the main facility in the PEL

The emissivity spectrometer laboratory has been upgraded in 2006 with a new Bruker VERTEX 80V FTIR spectrometer. This spectrometer has a very high spectral resolution (better then 0.2 cm-1), and a resolving power of better than 300,000:1, and can be operated under vacuum conditions to remove atmospheric features from the spectra. To cover the entire from 1 to 50 µm spectral range, two detectors, a liquid nitrogen cooled MTC (1-16 µm) and a room temperature DTGS (15-50 µm) and two beamsplitter, a KBr and a Multilayer, are used.

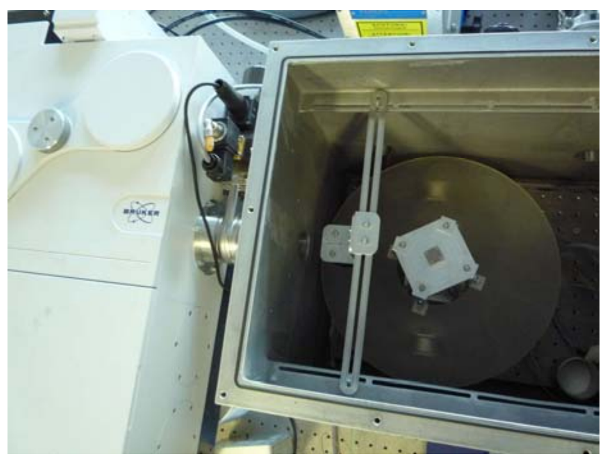

Figure 2: The planetary simulation chamber (top cover removed)

The spectrometer is currently coupled to a newly completed planetary simulation chamber. This chamber can be evacuated so that the full optical path from the sample to the detector is free of any influence by atmospheric gases. The chamber has an automatic sample transport system which allows to maintain the vacuum while changing the samples.

The main highlight however is the new induction heating system that is permanently installed in the new chamber. It allows to heat the samples to temperatures of up to 700K permitting measurements under realistic conditions for the surface of Mercury.

Verification: We are currently in the final steps of verifiying the complete new setup.

The induction system has been verified independently and we already obtained first measurements at high temperatures for Mercury relevant materials using a test setup [4,5]

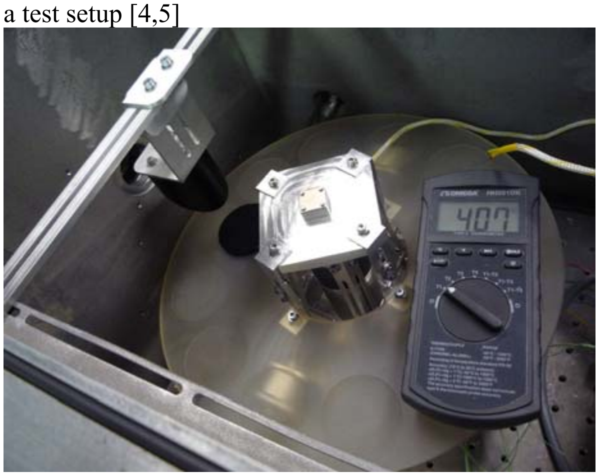

Figure 3: Evaluation of a new calibration target with the induction heating system

For the radiometric calibration we are evaluating a new high temperature calibration source (Fig 3). Instead of using an external blackbody this source is a steel disc with high emissivity paint and an embedded temperature sensor. The steel material allows to heat the source directly with the induction system and the source can therefore reach temperatures up to 500°C. The stability of the paint and its longterm behaviour is currently under investigation.

For the geometric alignment we have developed a laser calibration system (Fig 4). The system uses two sets of 4 laser diodes. It allows to align all components and by switching between the two sets of lasers allows verifying the effective field-of.view of the setup.

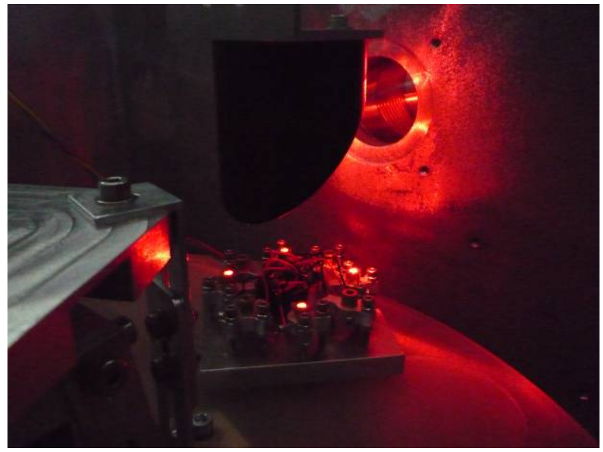

Figure 4: Geometric alignment test with laser calibration system

Summary: After 3 years of intensive planning and a setup period of more than one year the PEL is close to completion. It will allow unique measurements with a strong focus on airless bodies and extreme conditions as for example BepiColombo and MESSENGER [6] will encounter at Mercury. This will be especially benefical for MERTIS the thermal infrared imaging spectrometer on BepiColombo [5,7]. The PEL will routinely obtain emissivity measurements over the extremely wide spectral range from 1-50 µm for fine grained samples. The measurements at 1 µm will for example allow for the first time a direct interpretation of the surface observations obtained by VIRTIS on VenusExpress through the atmospheric windows.

References: [1] A. Maturilli, J. Helbert (2010) this meeting [2] A. Maturilli, J. Helbert et al. (2006), *PSS 54*. [3] A. Maturilli, J. Helbert, et al. (2007), *PSS*. [4] Helbert, J. and Maturilli, A. (2009) *EPSL, 285,* 347-354; [5] Helbert, J. et al. (2007), *ASR 40*, DOI:10.1016/j.asr.2006.11.004 [6] J. Helbert, M. D'Amore, A. Maturilli (2010) this meeting [7] J. Benkhoff, J. Helbert, et al. (2006) ASR, 38, 4