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The Planetary Emissivity Laboratory - high temperature spectroscopy of planetary analogs

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The Planetary Emissivity Laboratory (PEL) at DLR in Berlin has a long-standing expertise in providing spectral data of planetary analog materials. Based on this experience we decided 5 years ago to extend our laboratory capabilities to support specifically missions to Venus and Mercury. Both planets exhibit surface temperatures up to 500C and this extreme temperature range affects the spectral characteristics of the surface minerals. First test data obtained in support of the NASA MESSENGER mission to Mercury highlighted the need for high temperature measurements. While the focus is on high temperature measurements the setup can be used to study also analogs for asteroids or the Moon. The measurements obtain so far helped the meaningful interpretation of the remote sensing data not only from MESSENGER but also from VenusExpress, and Spitzer observations. PEL is supporting the development of the JAXA mission Hayabusa 2 as well as the NASA mission Osiris-REX. The laboratory will play a key role in supporting the ESA-JAXA BepiColombo mission to Mercury.

The core instrument is a Bruker Vertex 80V, coupled to an evacuable high temperatures emissivity. This fourier-transform spectrometer has a very high spectral resolution (better than 0.2 cm^{-1}), and can be operated under vacuum conditions to remove atmospheric features from the spectra. To cover the entire from 1 to 100 micron spectral range, two detectors, a liquid nitrogen cooled MTC (1-16 micron) and a room temperature DTGS (15-300 micron) and two beamsplitter, a KBr and a Mylar Multilayer, are used. The spectrometer is coupled to a custom build planetary simulation chamber, which 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 allowing maintaining the vacuum while changing the samples. PEL uses an innovative approach for heating the samples to temperatures of 500C. The samples are placed in a stainless steel sample cup, which is heated by a 1.5kW induction system. The induction heating system installed in the new chamber allows heating the samples to temperatures of 700K and more permitting measurements under realistic conditions for the surface of Mercury. The chamber can also be used independently as a vacuum-oven, to thermally process minerals and minerals which are afterwards measured in reflectance. Reflectance measurements are obtained with the Bruker A513 accessory. It allows bi-directional reflectance of minerals, with variable incoming and outgoing angles (between 13^o and 85^o). Samples are measured at room temperature, under purged air or under vacuum conditions, covering the 1 to 100 micron spectral range.

The second instrument currently available in the laboratory is a Bruker IFS 88 with an attached emissivity chamber, both purged with dry air to remove particulates, water vapor and CO_2. The chamber, which has been developed at DLR, consists of a double-walled water-cooled box with an attached blackbody unit. A heater in the chamber is used to heat the cup with samples from the bottom, for temperature from 20 up to 180 C. The chamber temperature can be set and maintained constant at typical working temperatures of 10 to 20 C. If necessary it can be cooled down to below zero. In addition a Harrick Seagull^{TM} variable angle reflection accessory mounted in the Bruker IFS 88 allows us to measure bi-conical reflectance of minerals at room temperature, under purging conditions in the extended spectral range from 0.4 to 55 micron.

The third instrument newly available in the laboratory is a Bruker IFS66v spectrometer. It allows measurements of the biconical reflectance at variable emergence and incidence angles as well as transmittance measurements between 1 and 25 micron. The reflectance measurements are comparable to the IFS88 but the instrument can be evacuated and has a significantly higher signal-to-noise ratio.

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