The heat is on – in the Planetary Emissivity Laboratory (PEL) at DLR Berlin. J. Helbert[1], A. Maturilli[1]
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Introduction: 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 biconical reflection and emission spectroscopy. The institute has an outstanding heritage in designing and building infrared remote-sensing instruments for planetary missions.

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

We will report here on the next development step of the PEL which is the addition of a planetary simulation chamber. This chamber will allow to measure samples under vacuum and at temperatures up to 500°C. After this upgrade the PEL will be the first lab that can routinely measure the emissivity of fine grained samples from 1 to 50 µm over an extremely wide range of temperatures.

The PEL: 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, sample preparation facilities and an extensive collection of rocks and minerals.

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). two beamsplitter, a KBr and a Multilayer, and two entrance windows, KBr and CsI are used to measure the same target.

The spectrometer is coupled to an emissivity chamber which has been developed at DLR. It is a double-walled box with three apertures: a 15 cm squared door used to insert the cup in the box, a 5 cm rounded opening through which the beam is directed to the spectrometer and a 5 cm opening facing the attached blackbody unit. A heater is placed in the chamber and is used to heat the cup with samples from the bottom. The thermal radiation emitted normal to the surface by the sample or the blackbody is collected by an Au-coated parabolic off-axis mirror and reflected to the entrance port of the spectrometer. Figure 2 shows the emissivity device attached to the spectrometer external port: the cover of the sample chamber is removed to show the parabolic mirror mounted on a mechanical arm and oriented toward the reference blackbody, the sample heater and the purging system.

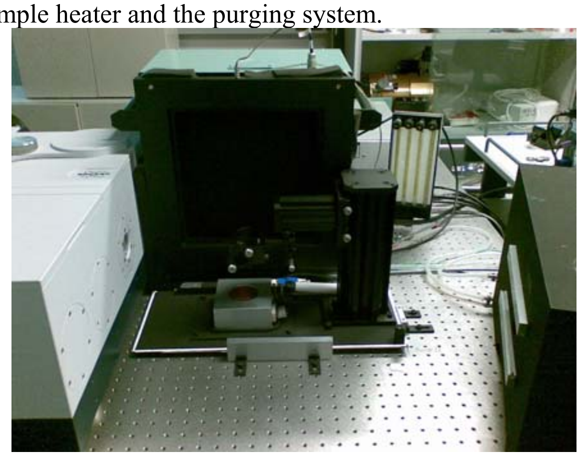

Figure 2: Open emissivity chamber (top cover removed)

A pump circulates water at a constant temperature in the volume between the inner and outer walls of the chamber. The surfaces of the box are painted with black high emissivity paint. The chamber is purged with dry air to remove particulates, water vapour and CO2. Further details can be found in [1, 2].

The PEL is with this setup since late summer 2007 in routine operation. In Figure 2 an example of quartz measurements for two extreme grain sizes is shown, together with analogue measurements extracted from the ASU and ASTER spectral libraries. Complementary to the existing datasets (ASU and ASTER), the BED library sensibly extend both the investigated spectral range and the grain size ranges. The enormous difference between the spectra of the small and large fractions witness the need for such a complete dataset for a correct interpretation of remote sensing data.

The Berlin Emissivity Database (BED): One of the main tasks of the PEL is the creation of the Berlin Emissivity Database (BED) - a spectral library containing the emissivity measurements of several planetary analogues. It contains currently entries for more than 25 minerals including plagioclase and potassium feldspars, low Ca and high Ca pyroxenes, olivine, elemental sulphur, common martian analogues (JSC Mars-1, Salten Skov, palagonites, montmorillonite) and a lunar highland soil sample all measured in the wavelength range from 3 to 50 µm as a function of particle size. For each sample, the spectra of four well defined particle size separates (<25 µm , 25-63 µm, 63-125 µm, 125-250 µm) are measured with a 4 cm^{-1} spectral resolution. These size separates have been selected as typical representations for most of the planetary surfaces [3].

The next step: For 2008 a major upgrade of the PEL is planned. A planetary simulation chamber will be replace the currently used chamber for most measurements. This chamber can be evacuated so that the complete optical path from the sample to the detector is free of any influence by atmospheric gases. The chamber will have an automatic sample transport system which allows to maintain the vacuum while changing the samples.

The main highlight however will be the new heating system. It will allow to heat the samples to temperatures of up to 700K allowing measurements under realistic conditions for the surface of Mercury. Furthermore the heating system will allow to force thermal gradients in the samples which is a much more realistic representation of the thermal conditions on planetary surface.

Summary: The PEL can provide the planetary community already today with emissivity measurements highly complementary to exisiting spectral databases. With the 2008 upgrade the PEL will allow unique measurements with a strong focus on airless bodies and extreme conditions as for example BepiColombo and MESSENGER will encounter at Mercury. This will be especially benefical for MERTIS the thermal infrared imaging spectrometer on BepiColombo [1,2,4]. 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 et al. (2006), *PSS 54*. [2] A. Maturilli, J. Helbert, et al. (2007), *in press on PSS*. [3] Helbert, J. et al. (2007), *ASR 40*, DOI:10.1016/j.asr.2006.11.004 [4] J. Benkhoff, J. Helbert, et al. (2006) ASR, 38, 4

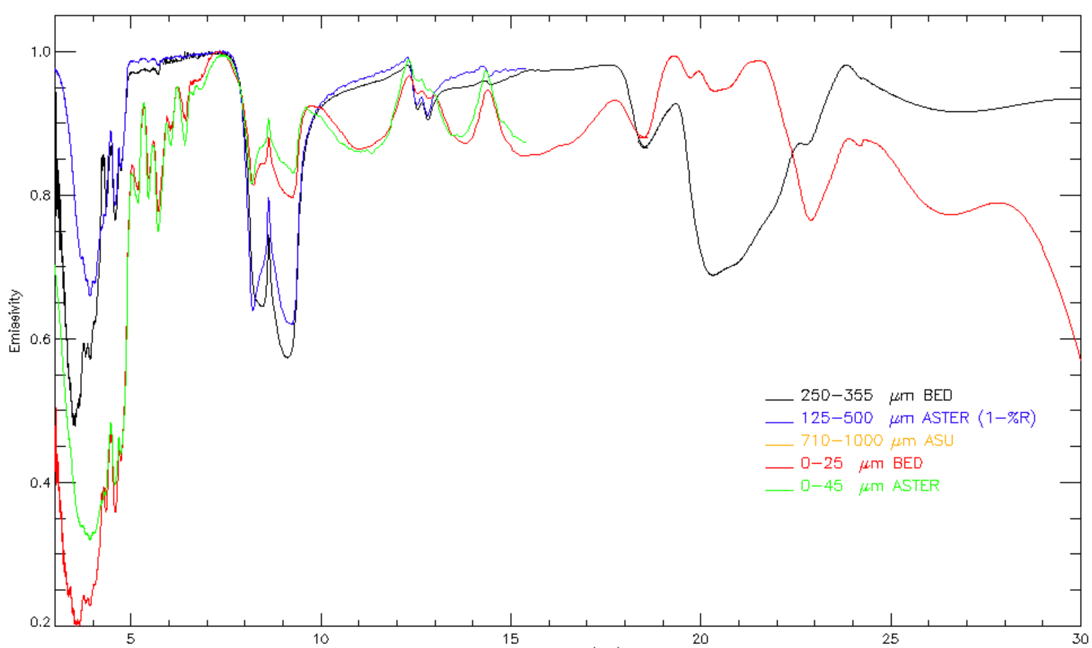

Figure 3 Comparison of quartz emissivity spectra from the BED, ASU, ASTER spectral libraries