All you can measure at the Planetary Emissivity Laboratory (PEL) at DLR, in Berlin

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Abstract

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, transmission 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 and transmission measurements, sample preparation facilities and an extensive collection of rocks and minerals.

1. Introduction

Remote sensing exploration of planetary surfaces remains the most accurate available method for a global characterization of the crust composition and its implication on planetary evolution scenarios. All the principal planets of the solar system are actually (or have been in the last few years) target of planetary exploration missions, all of them having spacecrafts bringing remote sensing instruments, capable to observe the planets in the (among other spectral regions) very significant visible, near-infrared and thermal-infrared spectral ranges.
The analysis of such measured spectra, especially when regarding the surface composition, takes enormous advantage of previous laboratory activity, very often carried on to support such planetary missions.
For such reasons, in the Planetary Emissivity Laboratory (PEL) at German Aerospace Center (DLR) in Berlin we can, using two distinct instrument working in parallel perform the following kind of measurements on planetary analogue materials or any kind of material of interest:
1) emissivity measurements at high temperatures and under vacuum conditions,
2) bi-directional reflectance measurements at room temperature and under vacuum conditions,
3) transmission measurements at room temperature and under vacuum conditions,
4) emissivity measurements at low/moderate temperatures and under purging conditions,
5) bi-directional reflectance measurements at room temperature and under purging conditions.

2. The PEL Set-up

The PEL is equipped with a Bruker Vertex 80V instrument, coupled to an evacuable high temperatures emissivity chamber and an older Bruker IFS 88 attached to a purged low/moderate temperatures emissivity chamber. The two instruments can work independently and in parallel, since they do not share any crucial device. Figure 1 shows the optical table where the two instruments, the external chambers and the other complementary devices are displaced.
The new generation Bruker VERTEX 80V FTIR 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 100 µm spectral range, two detectors, a liquid nitrogen cooled MTC (1-16 µm) and a room temperature DTGS (15-100 µm) and two beamsplitter, a KBr and a Mylar Multilayer, are used. However, the system DTGS+Multilayer is usually operated under its full capability, since it allows to measure spectra until 300 µm. The spectrometer is currently coupled to a newly completed planetary simulation chamber, that 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 maintaining the vacuum while changing the samples.

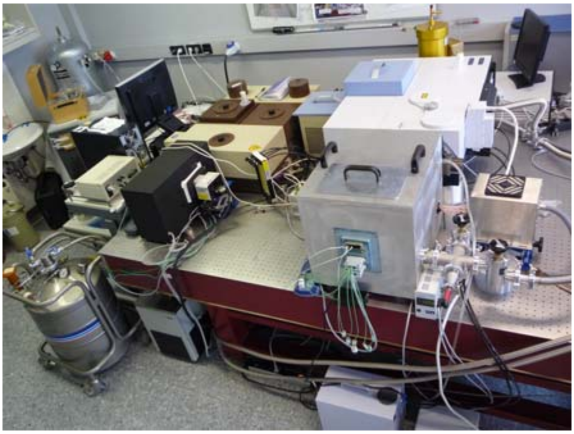
Figure 1: The PEL set-up at DLR, Berlin

The induction heating system that is permanently installed in the new chamber allows heating the samples to temperatures of up to 700K permitting measurements under realistic conditions for the surface of Mercury. Further details on this device can be found in [1]. The other instrument available in the laboratory is an older Bruker IFS 88 with attached an emissivity chamber, which has been developed at DLR. A heater placed in the chamber is used to heat the sample cups from the bottom, from 20° up to 180° C. The thermal radiation emitted normal to the surface by the sample or the calibration blackbody is collected by an Au-coated parabolic off-axis mirror and reflected to the entrance port of the spectrometer. The chamber is purged with dry air to remove particulates, water vapor and CO_2. By means of the cooling mechanism, the chamber temperature can be set and maintained constant, typically at 10° or 20° C, but if needed its temperature can be set to below zero. The chamber and instrument are described in major details in [2, 3].

The VERTEX 80V and its attached simulation chamber allows to measure emissivity of minerals at high temperatures between 1 and 100 µm, under vacuum conditions.
Similar measurements, in a purged/dry atmosphere and at low/moderate temperatures can be obtained with the Bruker IFS 88 and the coupled emissivity chamber.

By means of the Bruker A513 accessory, and VERTEX 80V instrument, we obtain bi-directional reflectance of minerals, with variable incoming and outcoming angles (between 13° and 85°). We can measure room temperature samples, under purged air or under vacuum conditions, covering the 1 to 100 µm spectral range. Such measurements can be used even to complete the emissivity measurements we can perform, especially in the case of a very limited amount of the available material. Similarly, a Harrick Seagull™ variable angle reflection accessory mounted in the Bruker IFS 88 allows to measure bi-directional reflectance of minerals at room temperature, under purging conditions in the extended spectral range from 0.4 to 16 µm.

The Bruker A480 parallel beam accessory mounted in the VERTEX 80V allows us to accurately measure transmission of thin slabs of material, optical filters, optical window materials, etc, in the complete 1 to 100 µm spectral range. Such a device, allows us to avoid refraction (causing focus and lateral beam shifts), typical in this kind of measurements.

3. Summary and Conclusions

The PEL provide the planetary community already today with emissivity measurements highly complementary to existing spectral databases. With the recently completed upgrade the PEL allows unique measurements with a strong focus on airless bodies and extreme conditions as the ones BepiColombo and MESSENGER will encounter at Mercury, over the extremely wide spectral range from 1-100 µm for fine grained samples. Two accessories permit complementary measurements of reflectance and transmission in the same large spectral range, which can be easily extended. A second instrument is used to measure emissivity at low/moderate temperatures, and bi-directional reflectance from VIS to MIR spectra at room temperature of samples, under purged air conditions.

References

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