All you can measure at the Planetary Emissivity Laboratory (PEL): the case of quartz 0-25 µm

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Abstract

The Planetary Emissivity Laboratory (PEL) of DLR in Berlin is equipped with two FT-IR spectrometers to allow measurements from the visible to TIR range using bi-conical reflection, transmission and emission spectroscopy.
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. In this paper we show the capabilities of the facility for emissivity, reflectance and transmission measurements in most of the possible spectral ranges and environmental conditions that we can cover at PEL on a standard quartz sample in the 0-25 µm grain size range.

Figure 1: The various targets made of quartz 0-25µm

1. Introduction

At PEL, using two instruments working in parallel, we can perform the following kind of measurements:
1) emissivity at high T under vacuum conditions,
2) bi-directional reflectance at room T under vacuum,
3) transmission at room T under vacuum,
4) emissivity at low/moderate T under purging,
5) bi-directional reflectance at room T under purging.

2. The PEL Set-up

Figure 2 shows the optical table where the two instruments, the external chambers and the other complementary devices are placed.

Figure 2: The PEL set-up at DLR, Berlin

The high temperature chamber is connected to the VERTEX 80V and can be evacuated to ~.1 mbar. The induction heating system heats the samples to temperatures of up to 700K. Further details can be found in [1]. The second chamber is connected to the older Bruker IFS 88. it's a purged emissivity chamber, developed at DLR. A heater in the chamber heat the sample cups from the bottom, from 20° up to 180° C. A cooling system build in the walls of the chamber allows to set the chamber temperature to typically 10° or 20° C, or even below zero. The chamber and instrument are described in [2, 3].

With the Bruker A513 accessory on Vertex 80V, we get bi-directional reflectance of minerals, with variable incidence and emission angles between 13° and 85°. We measure at room temperature, under purge or vacuum conditions, covering the 1 to 100 µm spectral range. Figure 3 shows the comparison

between emissivity at high T in vacuum and reflectance in vacuum.

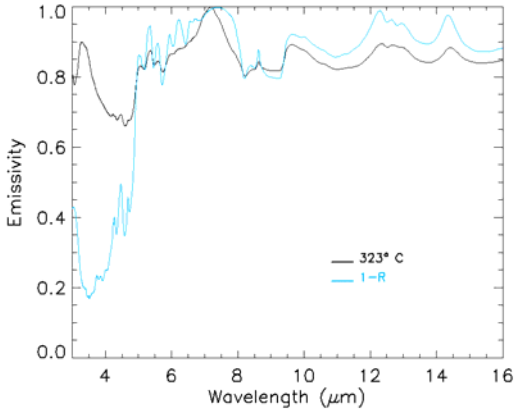

Figure 3: Emissivity vs. reflectance in vacuum

A Harrick Seagull™ variable angle reflection accessory on the Bruker IFS 88 allows to measure bi-directional reflectance of minerals, under purging conditions in the extended spectral range from 0.4 to 16 µm for angles between 5° and 85°. In Figure 4 is shown the comparison between emissivity at low T and reflectance in air.

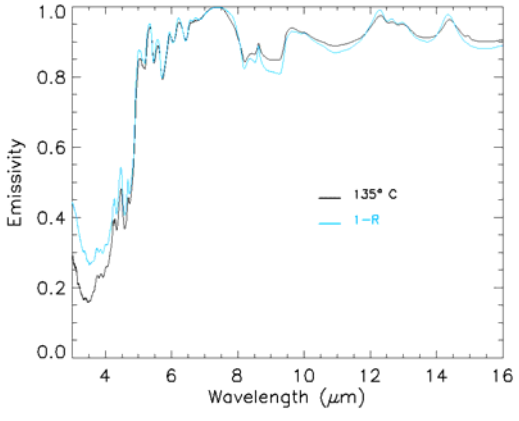

Figure 4: Emissivity vs. reflectance in air

The Bruker A480 parallel beam accessory mounted on the Vertex 80V allows us to measure transmission of thin slabs, optical filters, optical windows, etc, in the complete 1 to 100 µm spectral range avoiding refraction, typical in this kind of measurements. Figure 5 shows the transmission spectra of a pellet made of 0.5% quartz and 99.5% KBr both in the 0-25µm size range.

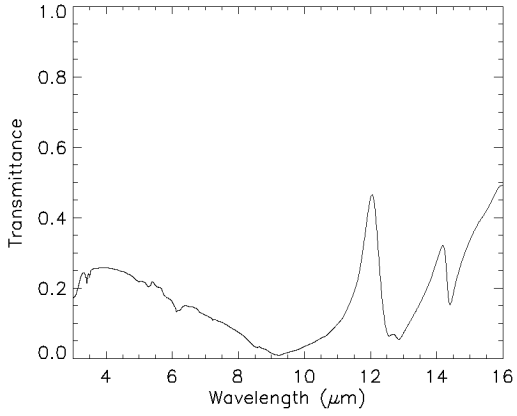

Figure 5: Transmission in vacuum

3. Summary and Conclusions

The PEL provide the planetary community already today with emissivity measurements highly complementary to existing spectral databases. 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

[1] Helbert, J. and Maturilli, A.: The emissivity of a fine-grained labradorite sample at typical Mercury dayside temperatures, EPSL, Vol. 285, pp. 347-354, 2009.

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[3] Maturilli, A., Helbert, J., and Moroz L.: The Berlin Emissivity Database (BED), PSS, Vol. 56, pp. 420-425, 2008.