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Emissivity Measurements and Laboratory Intercalibration at PSF of Oxford University and PEL of DLR

A. Maturilli(1), N. E. Bowles(2), I. R. Thomas(2), J. Helbert(1)
(1)Institute for Planetary Research, German Aerospace Center DLR, (Rutherfordstr. 2, 12489 Berlin-Adlershof, Germany, alessandro.maturilli@dlr.de), (2)Atmospheric, Oceanic and Planetary Physics, Clarendon Laboratory, University of Oxford, Oxford, UK.

Abstract

Emissivity spectra of analogue materials are needed for the analysis of remote sensing emission spectra of airless surfaces. The increasing number of planetary missions to the Moon, Mercury, asteroids, and other minor bodies require appropriate laboratory set-ups to fulfill those requirements. Two independent groups, one at Oxford University and the other at the German Aerospace Center (DLR) in Berlin provide suitable chambers for emissivity measurements in vacuum. The Planetary Spectroscopy Facility (PSF) of the Oxford University favored a high vacuum, low to average sample temperatures, and a limited spectral range for measurements, mostly inspired from lunar and asteroids environment. At the Planetary Emissivity Laboratory (PEL) of DLR, the set-up allows measuring in low-moderate vacuum, for sample temperatures from low to very high (> 1000 K) and in an extended spectral range (1 to over 100µm), with Mercury being the principal driver of chamber design. To understand the influence of environment parameters on emissivity spectra, we measured a fine (0-25 µm) sample of volcanic dust from Iceland (PEL ID 00000240) under several environmental conditions at PSF, and for comparison under standard conditions at PEL.

1. The PSF Set-up

At the Planetary Spectroscopy Facility (PSF) of the Oxford University, an evacuable chamber for simulation of lunar environment, the Lunar Environment Chamber (LEC) has been developed [1].

Typically, the lunar environment is simulated: this involves evacuating the chamber to ~10-5 mbar, cooling the high-emissivity radiation shield to <150K while simultaneously heating the sample from below (to 350-390K by heaters in the cup) and from above (using a solar-like lamp). On the lunar surface, a sample would be heated by the Sun while the top few hundred microns radiate to cold space in the infrared. This creates a thermal gradient in the sample, which alters the measured emissivity, as radiation from hotter deeper layers is emitted from regions of the spectrum with increased transparency. On the Moon, the Sun heats the sample to a depth of a few centimetres. However, due to space and sample mass limitations, the cup is only 3mm deep, therefore the cup must be heated to a temperature similar to that of 3mm depth on the Moon. The lamp intensity is set so that the brightness temperature of the sample is equal to that for the Moon, around 390K. The low pressure environment is required to remove any convective heat transport within the sample, which would reduce the thermal gradient.

2. The PEL Set-up

The PEL is equipped with a Bruker Vertex 80V instrument, coupled to an evacuable high temperature emissivity chamber and an older Bruker IFS 88 attached to a purged low/moderate temperature emissivity chamber. The two instruments can work independently and in parallel as they do not share any crucial device [2, 3].

The Bruker Vertex 80V FTIR spectrometer itself can be operated under vacuum conditions to remove atmospheric features from the spectra. To cover the spectral range from 1 to 100 µm, a liquid-nitrogen cooled MCT (1-16 µm) and a room temperature DTGS (16-100 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 coupled to a 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, and an heating system, based on the principle of electromegnetic induction, allowing to heat up the samples to temperatures above 1000 K in minutes [4].

4. Experimental measurements

At the PSF the samples can be heated from below (by thermoresistors) or/and from above (with an halogen lamp). The emissivity chamber can be evacuated or purged with nitrogen, while a cold shield can be cooled with liquid nitrogen. To assess the influence of these parameters on the measured emissivity, we managed to combine together different configurations for them.

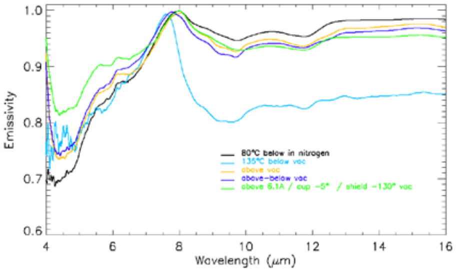

Figure 1. Emissivity spectra of sample 00000240 at PSF.

Figure 1 shows a first set of measurements we took varying the environmental conditions for the sample. The spectrum taken with heating from below in vacuum (light blue) strongly differs from the others: in this case a strong thermal gradient develops in the emitting skin of the sample. The black curve, is again a cup heated from below, but under nitrogen purging, thus minimizing thermal gradients thanks to convection. However, the variable shift in emissivity maxima that we observe is witness to small gradients in all the configurations. It seems that heating from above minimize the thermal gradient in the cups, at least under the PSF configuration. To note the departure from average measurements for the case of measurements taken with a cooled shield (green), that presumably bring another possible effect of thermal gradient in the sample.
Figure 2 shows another series of measurements taken at PSF, compared with a spectra at PEL.

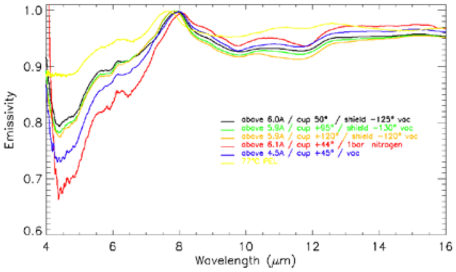

Figure 2. Emissivity spectra of sample 00000240 at PSF and PEL.

Varying the power of bottom heating changes the temperature distribution in the sample, hence the emissivity, while the effect of the cold shield is minor. PEL measurement confirms that a larger shift in the emissivity maxima derives from a larger thermal gradient.

4. Summary and Conclusions

Measurements at PSF and PEL show that emissivity spectra of a sample are strongly influenced from thermal gradients, that are driven from a combination of heating procedure with pressure level in the chamber, and less from the effect of a cold shield. Large differences may however arise from the different procedures used to calibrate the data in the two laboratories. We are currently investigating all the possible causes of differences we see in the spectra, even though some deviations are impossible to avoid, since the two setups are different and operate following different rules. For this exercise we chose the worst possible example: a rock (a pure mineral would be much easier to get very similar results) in a very small grain size range, being aware that the spectral shape for fine particulate samples is very sensitive to the local thermal environment. The differences between measurements highlight the need for inter comparisons such as the one we are presenting, and this joint effort is going to continue.

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References

[1] Thomas, I.R., Greenhagen, B.T., Bowles, N.E., Donaldson Hanna, K.L., Temple, J., Calcutt, S.B.: Rev. Sci. Instrum., 83(12), 124502, 2012.

[2] Maturilli, A. and Helbert, J.: Emissivity measurements of analogue materials for the interpretation of data from PFS on Mars Express and MERTIS on Bepi-Colombo, PSS, Vol. 54, pp. 1057-1064, 2006.

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

[4] 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.