EPSC Abstracts
Vol. 12, EPSC2018-753, 2018
European Planetary Science Congress 2018

The Planetary Spectroscopy Laboratory (PSL)

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Abstract

The Planetary Spectroscopy Laboratory (PSL, formerly known as the Planetary Emissivity Laboratory-PEL) of DLR in Berlin is a well established facility providing spectroscopic measurements of planetary analogue materials. Spectral measurements of planetary analogues from the visible to the far-infrared range are routinely measured for comparison with remote sensing spacecraft/telescopic observations of planetary surfaces [1-5]. Bi-directional and hemispherical reflection, transmission and emission spectroscopy are the techniques we use to acquire spectral data of target materials. This paper describes all of the measurements that can be done at the PSL.

1. Introduction

Two identical FTIR instruments (Bruker VERTEX 80v spectrometer) are operating in an air-conditioned room at PSL. The spectrometers can be evacuated to ~.1 mbar or work under purging with dry air or nitrogen. One spectrometer is equipped with aluminum mirrors optimized for the UV, visible and near-IR, the second features gold-coated mirrors for the near to far IR spectral range. The identical spectrometers share a collection of optical units (fully automated) in our equipment to efficiently cover a very wide spectral range. Table 1 list the spectral coverage of detectors we have available at PSL, Table 2 describes the beamsplitters that we can select to and associate with the desired detector to cover the spectral region of interest. Two detectors can be mounted simultaneously to improve the measured spectral range saving measurement and waiting time. Remotely controlled automatic exchange of up to four different types of beamsplitters under vacuum conditions would become possible. To allow high precision transmission and reflectance measurements, three external sources feature the PSL set-up. A deuterium lamp covers the UV (0.2 to 0.5 µm) spectral range. A 24V, water cooled, Tungsten lamp allows covering the VIS (0.4 to 1.1 µm) spectral range. Another high power Globar lamp (24 V, water cooled) is used in the VNIR+TIR (1 to 16 µm). For emissivity measurements, the source used is the sample itself heated from below and around.

Detector	Spectral Range (µm)	Operating T
GaP Diode	0.2 – 0.55	Room T
Silicon Diode	0.4 – 1.1	Room T
InGaAs Diode	0.7 – 2.5	Room T
InSb	0.78 – 5.4	Liquid N_2
2x MCT	0.8 – 16	Liquid N_2
MCT/InSb SW	1 – 16	Liquid N_2
2x DTGS/KBr	0.8 – 40	Room T
DTGS/CsI	0.8 – 55	Room T
DTGS/PE	14 – 1000	Room T

Table 1. Detectors equipment at the PSL.

Beamsplitter	Spectral Range (µm)
2x UV/VIS/NIR CaF_2	0.18 – 2.5
2x Si on CaF_2	0.66 – 8.3
2x Ge on KBr (Wide)	1 – 25
Ge on KBr substrate	1.2 – 25
Multilayer	14.7 – 333
50 µm Mylar	181 – 666

Table 2. Beamsplitters in use at the PSL.

2. Facility Support Equipment

In addition to sample collection including a collection of hundreds of rocks and minerals, synthetic minerals, an Apollo 16 lunar sample, several meteorites, a full set of sample preparation and analysis tools and experiment sub-systems are available to the facility operated by a dedicated lab technician:, set of sample holders for reflectance (plastic, aluminum or stainless steel), various sets of sieves, grinders, mortars, saw, balances, microscope, an oven (20° to 300°C), ultra-pure water, wet chemistry materials, a second ovens (30° to 3000°C) for sample treatments, a press to produce pellets (10mm or 20mm diameter), a large dry cabinet (moisture < 1%) for sample storage, 3 small exsiccators (moisture < 20%) for sample storage, a rotating device for producing intimate mixtures,

purge gas generator for water and CO_2 free air, liquid-nitrogen tank, an ultrasonic cleaning unit, 2 microscopes, air compressor pistol for cleaning. Typical grain size separates produced for spectral measurements are <25 µm, 25-63 µm, 63-125 µm, 125-250 µm. Larger separates as well as slabs are often measured too.

3. Emissivity Measurements

An external chamber is attached to each one of the FTIR spectrometers to measure the emissivity of solid samples. One chamber (cooled to <4° C) allows measuring the samples under purging conditions for temperature from 290 to 420K. A second chamber (working under vacuum) features high efficiency induction system heating the samples to temperatures from 320K up to 900K. A sample carousel driven by a stepper motor allows measuring several consecutive samples without breaking the vacuum. Large number of temperature sensors serves monitoring sample, equipment, and chamber temperature. A webcam in the emissivity chamber monitor the heated sample and its vicinity.

4. Reflectance Measurements

With the Bruker A513 accessory on Vertex 80V, we obtain bi-directional reflectance of samples, with variable incidence and emission angles between 13° and 85°. We measure from 170K (extension to 70K is under planning) to room temperature, under purge or vacuum conditions, covering the 0.2 to above 200 µm spectral range. Two integrating spheres allow measuring hemispherical reflectance of samples under purging in the entire PSL spectral range.

5. Transmittance Measurements

The Bruker A480 parallel beam accessory mounted on the Vertex 80V allows us to measure transmission of thin slabs, optical filters, optical windows, slabs, etc, in the complete spectral range from UV to FIR avoiding refraction, typical in this kind of measurements.

6. Facility Access

PSL is a Trans-national access (TA) facility supported by the European Union within the EuroPlanet Research Infrastructure framework over a four year period. In this period once per year a call for proposals is issued for investigations using PSL. So far PSL has granted closed to 100 days of access. Details can be found at:

http://www.europlanet-2020-ri.eu/.

7. Conclusion

The PSL provides the planetary community with reflectance, transmission and emissivity measurements highly complementary to existing spectral databases, covering the very large spectral range from UV (0.2 µm) to the FIR (≥ 200 µm).

In addition the high temperature spectroscopy capabilities of PSL are currently extended to start at 700nm instead of 1000nm.

A compact low-temperature reflectance chamber for FT-spectroscopy at the PSL is under development. The expected cryogenic temperature to reach is approximately within the range of 70K – 100K.

8. Acknowledgments:

Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208.

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