THE PLANETARY SPECTROSCOPY LABORATORY (PSL): SPECTRAL MEASUREMENTS OF PLANETARY ANALOGUES FROM UV TO FIR. A. Maturilli[1], J. Helbert[1], [1]Institute for Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, 12489 Berlin, Germany – alessandro.maturilli@dlr.de

Introduction: In the last decade the Planetary Emissivity Laboratory (PEL) of DLR in Berlin has provided spectral measurements of planetary analogues from the visible to the far-infrared range for comparison with remote sensing spacecraft/telescopic measurements of planetary surfaces [1-5]. Bi-directional reflection, transmission and emission spectroscopy are the techniques we used to acquire spectral data of target materials.

In fall 2015 we started upgrading our laboratory set-up, adding a new spectrometer, three external sources, and new detectors and beamsplitters to further extend the spectral range of measurements that can be performed in the laboratory. The new facility received the name of Planetary Spectroscopy Laboratory (PSL). The purpose of this paper is to illustrate all of the possible measurements that can be done at the Planetary Spectroscopy Laboratory (PSL).

Set-up description: Figure 1 shows the optical table where the two FTIR instruments are operating at PSL, in an air-conditioned room. The spectrometers are two Bruker Vertex 80V that can be evacuated to ~.1 mbar. 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. Because the two instruments are identical apart of the mirrors, they can share the collection of detectors and beamsplitters we have in our equipment to cover a very wide spectral range. The instruments and the accessory units used are fully automatized and the data calibration and reduction are made with homemade DLR developed software. Table 1 list the spectral coverage of detectors we have available at PSL, Table 2 describes the associated beamsplitters we use at PSL.

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)
UV/VIS/NIR CaF_2	0.18 – 2.5
Si on CaF_2	0.66 – 8.3
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.

To allow high precision transmission and reflectance measurements, three external sources have been added to the PSL set-up. A deuterium lamp is used to cover the UV (0.2 to 0.5 µm) spectral range. A 24V, water cooled, Tungsten lamp has been added for measurements in 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) spectral range.

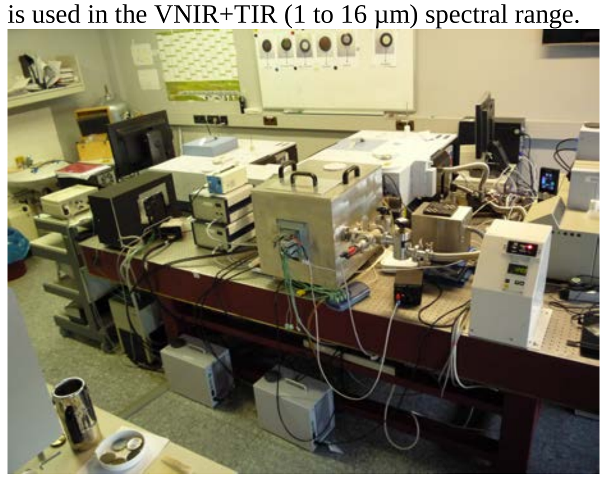

Figure 1. Laboratory set-up at the PSL.

Facility Support Equipment: A number of sample preparation and analysis tools and experiment subsystems are available to the facility: a collection of hundreds of rocks and minerals, synthetic minerals, an Apollo 16 lunar sample, several meteorites, 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, liquidnitrogen tank, an ultrasonic cleaning unit, 2 microscopes, air compressor pistol for cleaning. When enough sample material is available, the typical grain size separates that we produce 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.

Emissivity measurements: An external chamber is attached to one of the FTIR spectrometers to measure the emissivity of solid samples. A shutter allows separating the spectrometer from the external chamber, that can be evacuated to the same pressure as of the spectrometer. If needed, an optical window (vacuum tight) can be mounted at the entrance of the emissivity chamber to operate while keeping the external chamber at ambient pressure under purged air or under inert gases. Sample targets are brought to measuring temperature using an induction heating system. Also, our sample cups and heating surfaces are made of stainless steel and heat the samples from below. Our high efficiency induction system heats the samples to temperatures from 320K up to 900K. A sample caroussel driven by a very precise stepper motor (computer controlled) allows measuring several consecutive samples without breaking the vacuum. A large number of temperature sensors in the emissivity chamber serve to monitoring sample as well as equipment and chamber temperature. A webcam is mounted in the emissivity chamber to monitor the heated sample and its vicinity.

Reflectance measurements: With the Bruker A513 accessory on Vertex 80V, we can obtain bidirectional reflectance of minerals, with variable incidence and emission angles between 13° and 85°. The viewing cone of the A513 has an aperture of 17°, small enough to define our measurements as bi-directional. We measure at room temperature, under purge or vacuum conditions, covering the 0.2 to above 200 µm spectral range.

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.

Facility access: PSL is a Trans-national access (TA) facility supported by the European Union within the EuroPlanet Research Infrastructure framework for the next four years. In this period once per year a call for proposals will be issued for investigations using PSL. Details can be found at:

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

Conclusion: The PEL already provides the planetary community with reflectance, transmission and emissivity measurements highly complementary to existing spectral databases, already in covering a very large spectral range (1-100 µm).

With the recent and still ongoing update of the facility PSL can now provide measurements under vacuum, that cover the whole spectral range from UV (0.2 µm) to the FIR (200 µm and above).

In addition the high temperature spectroscopy capabilities of PSL are currently extended to start at 700nm instead of 1000nm [6].

See more information on the PSL website:
http://www.dlr.de/pf/desktopdefault.aspx/tabid-10866/19013_read-44267/

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