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# Simulation chamber for the characterization of the bi-directional reflectance of cold planetary surfaces environments.

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## Abstract

In order to carryout surface experiments for planetary researches such as small bodies, cometary and Asteroidal, it is essential to reach high vacuum and cryogenic temperature. The Planetary Spectroscopy Laboratories (PSL) at the German Aerospace Center (DLR) will expand its capabilities to a low temperature range with the simulation chamber described here.

## 1. Research question

What are the spectral signatures of water ice that might affect the remotely detected spectral features on the icy Solar System surfaces?

### 1.1 Temperature Range

The Visible, IR, and Thermal Imaging Spectrometer (VIRTIS) on Rosetta obtained hyperspectral images, spectral reflectance maps, and temperature maps of the asteroid 21 Lutetia. No absorption features, of either silicates or hydrated minerals, have been detected across the observed area in the spectral range from 0.4 to 3.5 µm. The surface temperature reaches a maximum value of 245 Kelvin while the minimum retrievable temperature is 170 K [1].

### 1.2 Optical Range

Beck et al., 2015 [2] analyze a low-temperature reflectance spectra dependence of brucite. A strong evolution in the optical properties between 0.50 and 4.00 µm is discussed. This study discusses the likehood of brucite and the feature at 3.06 µm observed on Ceres.

Chabrillat et al., 2013 [3] present soil applications of reflectance spectroscopy, illustrating state-of-the-art methods in quantitative soil spectroscopy. The spectral range that shows good potential for retrieving information on soil attributes was discussed. The Near infrared (Near-IR) region from 1 to 5 µm contains primarily information on overtones and combinations for phylloslicates, most sorosilicates, hydroxides, some sulfates, amphiboles, carbonates, soil water and organic matter; the thermal-IR region from 5 to 100 µm contains mostly information on Si-O lattice vibrations for silicates (quartz, feldspars, clay) other than mafic, carbonate mineral group and organic compounds. To fully understand the mineralogical composition of SSSB and the implications to solar system formation and nature of water in the universe, it is necessary to investigate the whole spectral range from 1 to 100 µm, as previously proposed by Maturilli et al., 2016. [4]

## 2. Laboratory set-up

The simulation chamber is composed by the two external chambers, the redesigned bi-directional reflectance unit, the cryogenic sample cooling system and the vacuum pump.

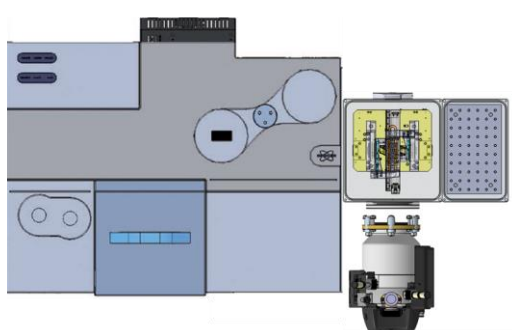

Figure 1: Top view, two external chambers attached.

## 3. Cooling samples

At PSL, there are currently two instruments equipped with external chambers to measure emissivity. One of them is a vacuum chamber built to measure at very high temperatures and the second chamber (that can be cooled down to 270 K) is for measurements at low to moderate temperatures. In the latter samples can be heated from room temperature to 420 K in a purging environment. The sample compartment on the spectrometer has been used to simulate the low-T chamber and a cooling sample container has been designed and adapted to the reflectance unit. The icy-samples have been cooled down to 190 K using a full controlled freezer and they have been kept cool using liquid nitrogen. Figure 2 shows the redesigned reflectance unite.

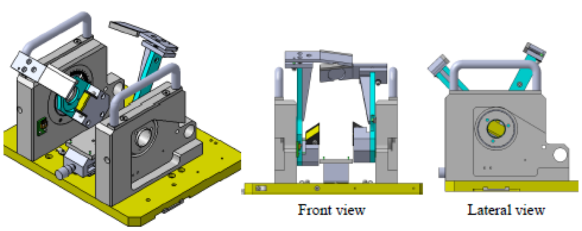


Figure 2: The redesigned reflectance unit can perform bi-directional reflectance measurements with independent incident and emission angles from 13 to 85°.

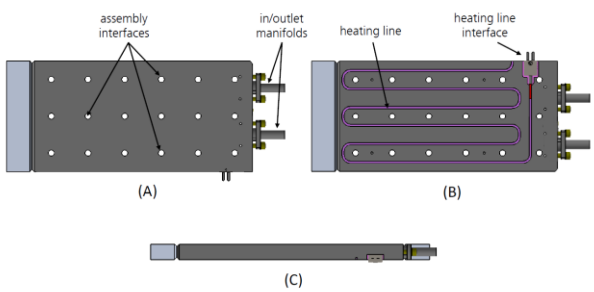


Figure 3: Concept design cooling plate. (A) Top view showing different contact points for the assembly interface with the sample plate; fitting also standard hardware. (B) Bottom view showing the thermocouple as a heating line for the temperature control system, the cooling line inlet and output manifolds are shown. (C) Left view.

A concept design is shown on Figure 3 where the cooling line is fully immersed in the material, the interface area is on the top side having only one cooling system loop, this concept is widely proof as a stable low temperature closed-cycle cryostat. Utilizing thermal conductivity material, temperature control system, and easy-to-use system. The table 1 summarizes its features.

Table 1: This is the example of an included table

| | |
|---|---|
| Material | Copper Or Aluminum |
| Bolt arrange | 3 x 6 |
| Dimensions | 55 x 120 $mm^2$ |
| Thickness | 5 mm |
| Cooling loop system | Liquid Cooled, LN2 |
| Cooling line | 2 lines, LN2 Immersed |
| Temp. range | 100 - 350 K |
| Temp. stability | 1 K or less |
| Control connections | 1 heater, LN2 in/outlet |
| Orientation | Any position |
| Cooldown Consumption | 0.4 liters LN2 |
| Operational Consumption | 0.6 L/hr at 5 K w/LN2 |

## Summary and Conclusions

In summary, laboratory spectroscopy investigations of minerals are key to support the interpretation of remote sensing data returned by the interplanetary missions. A simulation chamber for FT-spectroscopy experiments at the PSL is currently under development. The expected cryogenic temperature to reach is approximately within the range of 70K – 100K. The potential experiments are promising. The current and future missions (e.g., NASA/DAWN and ESA/ExoMars 2020, NASA/EUROPA Multiple Flyby Mission, ESA/JUICE respectively) indicate the high potential usage of this development, which may result in many scientific or even commercial applications.

## References


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