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Reflectance spectroscopy under planetary conditions: the Cold Surface Spectroscopy Facility at IPAG

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1. Context

Planetary surfaces can be subjected to extreme thermal and pressure conditions. These environmental conditions can impact the optical properties of surface material, and should be taken into account for valid compositional interpretation of remote sensing observations. Here, we present the capabilities of the cold surface spectroscopy laboratory, a trans-national access (TNA) facility accessible though the Europlanet 2020-RI framework, as well as some scientific results obtained so far.

2. Facility overview

The facility is constructed around two instruments that are dedicated to the high precision spectro-gonio radiometry of rocks, organics and ices over most of the solar spectrum range (0.35 – 5 µm). These two instruments are roughly similar, but dedicated to two different types of samples: i) SHINE, for large (> 10 g) and translucent samples (> 5 cm) [1] ii) SHADOWS, for precious (< 1g) and dark samples [2]. Both instruments are located in a cold room in order to minimize the atmospheric water vapor and to decrease the thermal background.

Each instrument is constituted of two arms (illumination arm and detection arm) that can rotate in order to sample a range of incidence and emergence angles (up to 80°). Also, measurements outside of the principal plane are possible since the azimuth can vary of 180° in order to sample the full bi-directional distribution reflectance function. The incident light is modulated before being sent on the sample, and two lock-in amplifiers, synchronized with the modulation frequency, isolate the reflected light signal from the thermal infrared background. The measured reflected light is analyzed by two detectors (Si, 0.35-1.1 µm and InSb, 1.1-5 µm). The polarization of the reflected light can also be measured.

Each instrument is equipped with a home-made control software enabling automated sampling of the spectral bi-directional reflectance distribution function (BRDF). A sample preparation laboratory is connected to the facility, where grinding (manual or automated) and sieving (manual or automated) can be performed.

3. Environmental chambers

Two different environmental chambers can be coupled to SHINE and SHADOWS. The first one, SERAC (Pommerol et al., 2009 [3]) enables to expose a particular sample to a controlled relative humidity, and to quantify the amount of water that is adsorbed on the sample [3] or absorbed by the sample [4]. A second cell, named CARBONIR, enables to maintain a sample under cryogenic temperature (down to 50 K) while maintaining a given total gas pressure of controlled composition. This cell can also be used to directly condense volatiles on a given surfaces. Also using a specific sample holder, this cell can be used to measure reflectance spectra of minerals (or meteorites) under low temperature. Because of the cells geometry, spectra can only be measured under restricted observation geometries when using them. Because both instruments are located in a cold room (down to -20°C), it is possible to study the spectro-photometry of water-ice and its mixture with dust without using an environmental chamber [5].

4. Some examples of applications

Low-temperature spectra of minerals: Some absorption features can be strongly dependent on temperature. This is the case of transition from excited states (see for instance the case of brucite 3.06 µm feature, [6]) or absorption features related to OH/H_2O in hydrated minerals (Fig. 1; see [7]).

Mars seasonal condensates: The seasonal evolution of Martian atmospheric CO_2 is intimately related to deposition and sublimation processes of CO_2 ices. With the CARBONIR environmental chamber we were able to simulate deposition, metamorphism and sublimation of Mars seasonal CO_2 deposits, pure (Fig.2, [8]) or mixed with water ice or martian dust simulant [9].

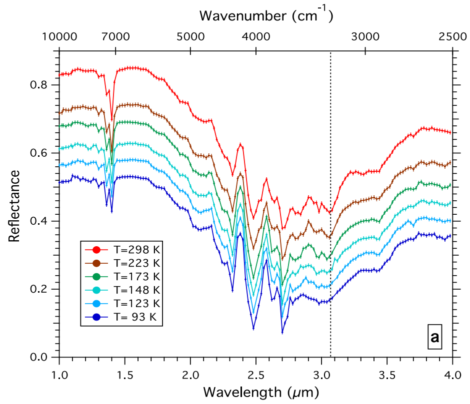

Figure 1: Temperature evolution of the reflectance spectrum of brucite. From [5].

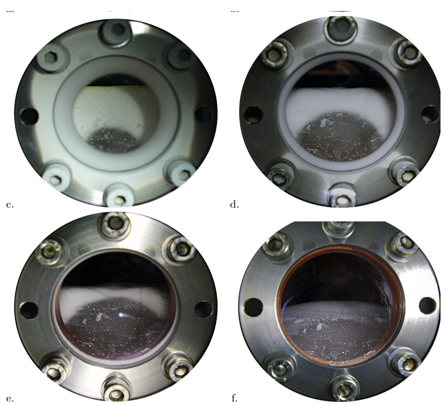

Fig. 2: Progressive metamorphism of CO_2 snow into CO_2 ice [7].

Reflectance of cometary analogues: The high signal to noise ratio of the SHADOWS instrument, even for low reflectance values (< 3 %) is particularly well suited for studies of cometary analogues. These have been undertaken in the framework of VIRTIS observation of comet 67P surface material.

References

[1] Brissaud, O., Schmitt, B., Bonnefoy, N., Douté, S., Rabou, P., Grundy, W., Fily, M., 2004. Spectrogonio Radiometer for the Study of the Bidirectional Reflectance and Polarization Functions of Planetary Surfaces. 1. Design and Tests. Applied Optics 43, 1926–1937.

[2] Potin S., Beck P., Schmitt B., Brissaud O.,SHADOWS: spectro-gonio radiometer for bidirectional reflectance studies of dark meteorites and terrestrial analogues, EPSC 2017.

[3] Pommerol, A., Schmitt, B., Beck, P., Brissaud, O., 2009. Water sorption on martian regolith analogs: Thermodynamics and near-infrared reflectance spectroscopy. Icarus 204, 114–136. doi:10.1016/j.icarus.2009.06.013

[4] Massé, M., Beck, P., Schmitt, B., Pommerol, A., McEwen, A., Chevrier, V., Brissaud, O., Sejourne, A., 2014. Spectroscopy and detectability of liquid brines on mars. Planetary and Space Science 92, 136–149. doi:10.1016/j.pss.2014.01.018

[5] Dumont, M., O. Brissaud, G. Picard, B. Schmitt, J.C.Gallet, and Y. Arnaud, 2010. High-accuracy measurements of snow Bidirectional Reflectance Distribution Function at visible and NIR wavelengths; comparison with modelling results. *Atm. Chem. Phys* **10,** 2507-2520.

[6] Beck, P., Schmitt, B., Cloutis, E.A., Vernazza, P., 2015. Low-temperature reflectance spectra of brucite and the primitive surface of 1-Ceres? Icarus 257, 471–476.[7] De Angelis, S., Carli, C., Tosi, F., Beck, P., Schmitt, B., Piccioni, G., De Sanctis, M.C., Capaccioni, F., Di Iorio, T., Philippe, S., 2017. Temperature-dependent VNIR spectroscopy of hydrated Mg-sulfates. Icarus 281, 444–458. doi:10.1016/j.icarus.2016.07.022

[8] F. Grisolle, PhD. 2013. Les condensats saisonniers de Mars : étude expérimentale de la formation et du métamorphisme de glaces de CO2. Université Joseph Fourier, Grenoble, France.

[9] S. Philippe, PhD, 2016. Microphysique des processus saisonniers des glaces de Mars et Pluton : suivi par télédétection hyperspectrale et étude expérimentale. Université Grenoble Alpes, Grenoble, France.

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