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Near- and mid-infrared spectroscopy of icy planetary/cometary analogue matter

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1. Introduction

The complexity of natural surfaces makes the quantitative inversion of optical remote-sensing data a considerable challenge. Physical and numerical light scattering models such as the one developed by Hapke [1] rapidly show their limitations when confronted to the results of well controlled laboratory experiments. Therefore, libraries of good quality spectra of well characterized samples are crucial to enhance the scientific return from remote-sensing missions. This is problematic in the case of icy materials as the samples are difficult to prepare with good reproducibility and have a tendency to evolve with time as the ice can sublime, sinter, or re-condense. In addition, the laboratory setups needed to hold the samples and perform the spectral measurement must be adapted to work at the very low temperature required to limit the evolution of the samples.

The Planetary Imaging Group (PIG) in Bern has developed a series of Setups for the Preparation of Icy Planetary Analogues (SPIPA) that are used to prepare water ice samples, pure or mixed with contaminants, in a reproducible way [2, 3].

Although difficult, measurements of icy samples are highly desirable at a time when ambitious European missions are operated, about to arrive or currently been designed to study the surfaces of objects containing significant amounts of water ice. Of particular relevance here are the recent Rosetta mission, the Exomars TGO Orbiter –already inserted into Mars orbit, and the JUICE Orbiter which will be launched toward the Jovian system in 2022. These experiments have been performed with the spectro-gonio radiometer [4] of the Europlanet 2020-RI's Cold Surface Spectroscopy Facility (https://cold-spectro.sshade.eu/) at IPAG, Grenoble, France.

2. Samples

We have measured about 30 reflectance spectra from 0.7 to 4 µm of 10 different samples including pure water ice particles of different grain sizes, and their mixtures with anthracite dust. All the measurements have been made at 173K. The geometry of measurement was kept constant at 0° incident angle and 30° emission angle. Three different size distributions for ice have been produced and measured (Figure 1): SPIPA-A [2], with an average grain diameter 4.5±2.5 µm; SPIPA-B [3], with a diameter of 70±30 µm and SPIPA-C, with a diameter distribution between 5 and 100 µm. We have also studied water ice/dust mixtures with different dust-to-water mass ratios (0.01 and 0.1) and using different methods to mix the ice and the dust (intra- and inter- mixtures).

3. Results

We have performed a systematic study showing how the particle sizes, the dust concentration and/or the way the water is mixed with the dust (intra- or inter-particle mixtures) influence the shape/depth of the absorption bands, the level of reflectance of the continuum, and the amplitude of the Fresnel reflection peak. The reflectance spectra of pure water ice particles are shown in Figure 2. These spectra indicate how different size distributions influence the shape/depth of the water absorption bands (at 1.05, 1.28, 1.5, 2 µm), and the shape of the spectrum between 2.5 to 4 µm. In particular, a Fresnel reflection peak centered at 3.1 µm is detected for SPIPA-B, but is absent when micrometer-sized particles (SPIPA-A) are present on the surface. Alternatively, the bump of reflectance centered at 3.7 µm is indicative of the presence of micrometer-sized particles and is absent for particles of 70 µm (SPIPA-B). Figure 3 indicates how the way the water and the dust are mixed together, how the concentration of dust and how the size of the water ice particles, affect the reflectance of the water ice (i.e. the shape/depth of the absorption bands, brightness, amplitude of the Fresnel reflection peak etc.).

All measured data will be made available to the community through publication in our BYPASS database of the SSHADE database infrastructure (under development).

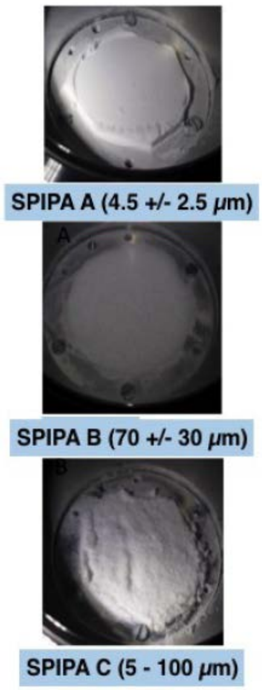

Figure 1: The three different ices produced are shown in their sample holders. For each one, the averaged diameter size or the size distribution is shown.

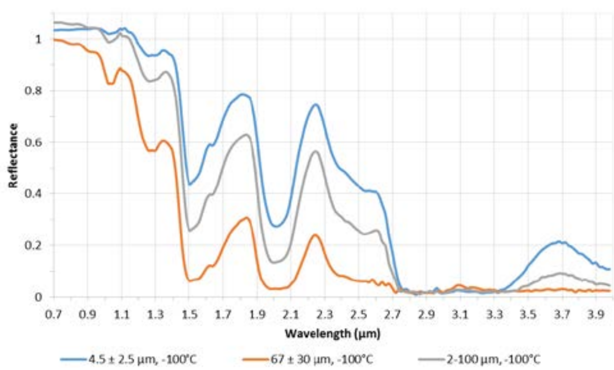

Figure 2: Reflectance spectra of surfaces of pure water ice particles with different sizes. In blue SPIPA-A, in orange SPIPA-B and in grey SPIPA-C.

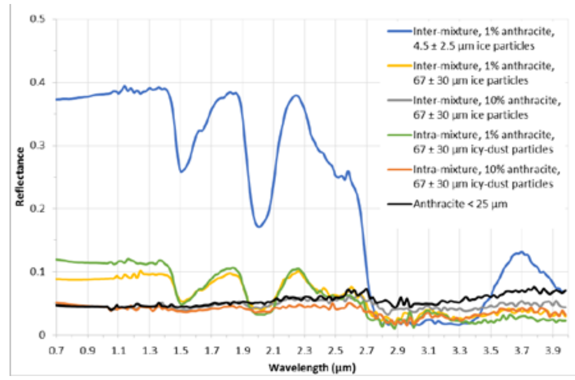

Figure 3: Reflectance spectra of surfaces mixtures of water ice and anthracite particles.

Acknowledgements

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