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The LOSSy laboratory for spectro-photometric characterization of cometary and planetary analogues at University of Bern

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Abstract

We have built the Laboratory for Outflow Studies of Sublimating Materials (LOSSy) at the University of Bern to simulate and characterize the spectro-photometric properties of ice-bearing cometary and planetary analogues under various temperature and pressure conditions. This includes a radio-goniometer to measure the bidirectional reflectance in the visible spectral range at sub-zero temperatures and atmospheric pressure and a thermal-vacuum chamber to perform hyperspectral imaging in the VIS-NIR range. It focuses on the characterization of the temporal evolution of morphological and spectro-photometric properties of analogues.

1. Introduction

Understanding the interaction of insolation with planetary surfaces is crucial for the interpretation of passive remote-sensing data. Determining the dependence of observed spectro-photometric properties to quantitative properties of the surface, such as composition, grain size or roughness, is very challenging.

In addition to numerical models and simulations, laboratory experiments with well-characterized analogues are necessary to link remote-sensing datasets to physical processes.

The photometric analysis of water ice, as a major constituent of the outer solar system bodies, either in its pure form or mixed with minerals and organics is very delicate, because of the dependence of physical processes to environmental conditions.

The Laboratory for Outflow Studies of Sublimating Materials (LOSSy, previously called “Planetary Ice Laboratory”) at the University of Bern was designed to perform bidirectional visible reflectance measurements and hyperspectral imaging in the VIS-NIR range under different pressure and temperature conditions.

2. Laboratory facilities

The LOSSy laboratory mainly consists of two different experiments: the PHIRE-2 (PHysikalisches Institut Reflectance Experiment-2) radio-goniometer and the SCITEAS (Simulation Chamber for Imaging the Temporal Evolution of Analog Samples) thermal-vacuum chamber equipped with a hyperspectral imaging system.

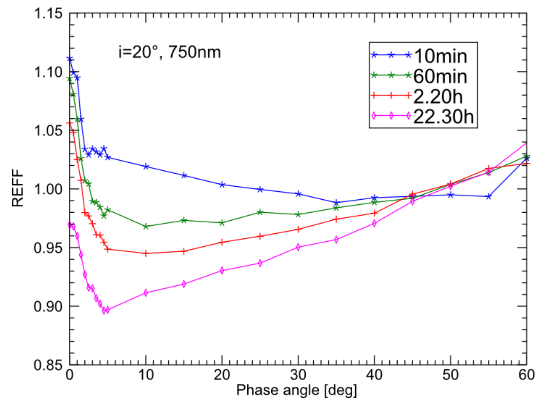

Figure 1: Time sequence of phase curves of pure micrometer-sized water ice particles, prepared with liquid nitrogen.

PHIRE-2 [1,2] is designed to measure the bidirectional reflectance of cm-size samples (Fig. 1) at ambient or subzero temperatures (238 K) and atmospheric pressure over a wide range of geometries including opposition. It is equipped with a collimated light source and six different bandpass filters over the 450-1064nm spectral range. The light scattered from the sample is measured with a silicon-photovoltaic sensor. The instrument is fully automatized and optimized for fast acquisitions to characterize the potential temporal evolutions of icy samples.

The SCITEAS simulation chamber [4] is used to monitor the evolution of ice-bearing samples subliming under low temperature (170-200 K) and low pressure (<10^{-6} mbar) conditions with a VIS-NIR hyperspectral imaging system (Fig. 2). Our main interest here is related to the microphysics of the sublimation process, which leads to changes of the surface morphology with time and the resulting changes in spectro-photometric characteristics.

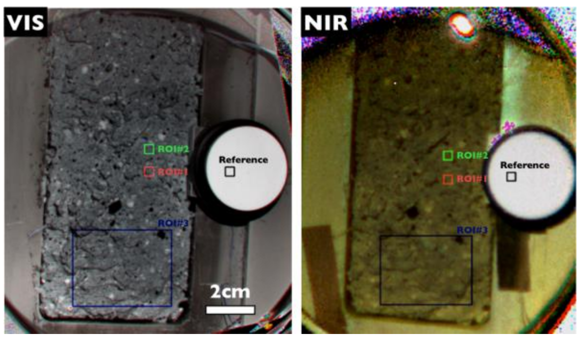

Figure 2: VIS and NIR colour composite images of a cometary analogue in SCITEAS, produced from hyperspectral cubes.

3. Cometary analogues

The constituents of our first cometary analogues are spherical water ice particles of 4-8 µm diameter, produced by spraying a fine nebula into a cold environment [2,3]. As a simple baseline composition, we used carbon black and fine basalt powder to represent the dark organic matter and silicate components of cometary surfaces [4]. Various procedures have been defined to produce different textures of samples.

In the near future we will have to combine systematically different compositions and textures, by varying individual parameters such as mixing ratios or ice particle size to build up a catalog of representative cometary analogs. Furthermore we will replace carbon black and basalt by more realistic mineral and organic compounds.

4. Applications & Outlook

The main purpose of our cometary analog dataset acquired with PHIRE-2 is its use in the analysis of data to be acquired by the OSIRIS and VIRTIS instruments on board Rosetta. The interoperability between PHIRE-2 and SCITEAS allows us to monitor changes in bidirectional reflectance induced by sublimation under simulated space conditions, by regularly exchanging the sample between the two instruments. Further applications of the SCITEAS system are the simulation of HiRISE colour images with icy samples for a better understanding of physical processes on Mars. Furthermore hyperspectral images of Martian analog samples will help to simulate CaSSIS images (a camera still under construction to be launched toward Mars on the ExoMars TGO, Thomas et al., this conf.).

Another field of interest lies in the simulation of surface conditions on Jovian and Saturnian satellites, namely Europa and Enceladus, which are covered by water ice.

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