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Laboratory studies of light scattering by well-controlled and characterized ice samples

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Abstract

Over the past 8 years, we have developed LOSSy – the Laboratory for Outflow Studies of Sublimating Materials - at the University of Bern. The aim of this lab. is to produce ice and dirty ice samples that are reproducible and that can be characterized with an array of different instruments. This has primarily been for planetary science although application to Earth-orbiting remote sensing and studies of proto-planetary discs have also been looked at.

Ice particles of varying sizes can be produced using different setups. These setups use nebulizers with different characteristics. The surface structure of the resulting material can be investigated using scanning electron microscopy and optical coherence tomography. A spectro-goniometer (PHIRE-2) can then be used to determine the reflectance properties over the full hemisphere. Both the sample and the goniometer can be maintained at low temperature (typically -30C) during these measurements. A thermal vacuum chamber (SCITEAS) is also available for space simulation and VIS-NIR hyperspectral measurements can be made while the sample evolves under different conditions. A system has also been developed to measure the polarization of icy samples at multiple wavelengths in the visible and from 3 to 30° phase angle (with direct application to icy satellite observations). Approaches to determine the properties of the samples at sub-mm wavelengths have also been developed. The presentation will show some of our latest results.

Examples

We have studied a large number of icy samples prepared using our standardised sample preparation systems called SPIPA [1]. The PHIRE-2 spectro-goniometer measurements [2] are now produced in a standardized format (PDS compatible) and many are now free to use through the DACE platform [3] of the National Center for Competence in Research programme, PlanetS. Data at low phase angle can now be acquired easily with high signal to noise [4].

Figure 1 shows the DACE interface with our goniometer measurements. Hapke parameter fits to the data can almost be made.

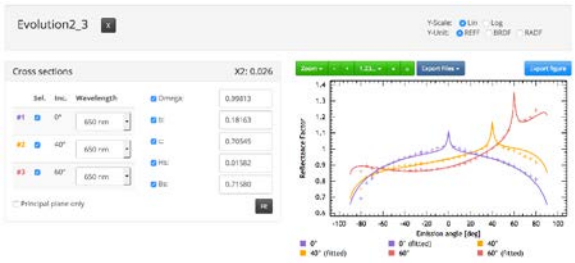

Figure 1 The DACE interface to our database of bidirectional reflectance distribution function.

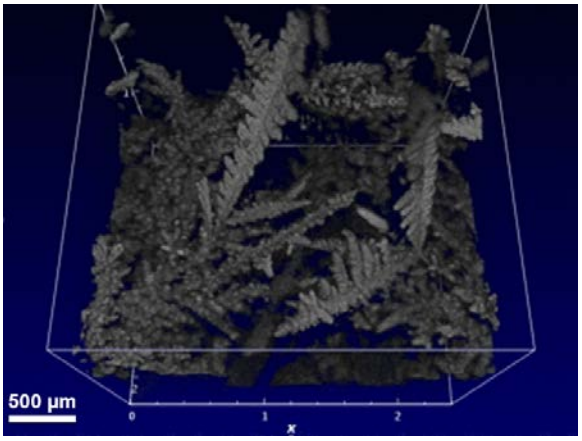

Figure 2 The high precision characterization of surfaces can be performed with the Optical Coherence Tomography equipment. Here an example of water frost is shown.

While preparation is important characterization is also of great significance. In Figure 2 an example from our Optical Coherence Tomography experiment (OCTOPUS) is shown. This provide 6 µm resolution

contactless imagery of surfaces and allows us to characterize surface structure at scales only slightly larger than the wavelength of the light used for goniometric investigations. Our equipment is transportable allowing us to bring samples to a cryo-SEM for further higher resolution characterization [4].

The POLICES equipment is a novel development with the Bern laboratory and is being used to study polarization of many materials including materials of direct relevance for the investigation of comets. An example is shown in Figure 3. Whilst there remains some work to be done to improve aspects of the set-up, this equipment is functional and already producing accurate results.

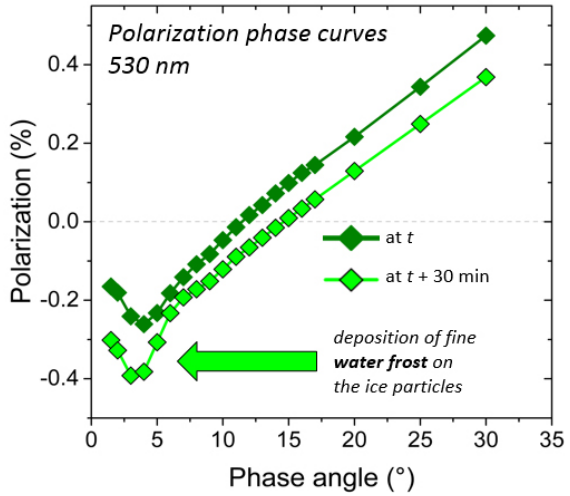

Figure 3 Polarization phase curve of water ice particles using the SPIPA preparation system.

The data can be used for studies of carbon-rich dust/ice mixtures with applications to comets [5]. We are also performing near-infrared hyperspectral monitoring of evolving surfaces within the SCITEAS system [6]. The laboratory is a powerful tool for supporting interpretation of planetary remote-sensing observations. The techniques used are also being used to prepare samples for other experiments [e.g. 7]. We are open to collaboration on a variety of topics.

Acknowledgements

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