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Measuring the degree of polarisation of analogues for icy moons surfaces in the laboratory

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1. Context

The polarimetry of the light scattered by planetary surfaces is a powerful tool to complement observations performed in total light intensity, providing additional constraints to interpret remote sensing observations of bodies in the Solar System and beyond [1]. For atmosphereless bodies, the unpolarized sunlight acquires its polarization when scattered by the first micrometers to millimeters of the surfaces depending on their optical properties. The degree of linear polarization of the scattered light is particularly sensitive to the morphology (e.g. size, shape, structure) and the chemistry (e.g. composition, mixture) of the grains constituting the surface [2].

The fine characterization of the surface of icy bodies such as the Galilean moons (Europa, Ganymede and Callisto) is of major interest for future ESA (JUICE) and NASA (Europa Clipper) missions. Ground-based polarimetric observations of the icy satellites, conducted since many years [3, 4], provide a very precious dataset to prepare and complement the observations of these future missions. It is thus essential to build a database of polarimetric data on well-characterized icy samples measured in the laboratory.
For this purpose, we have developed the POLarimeter for ICE Samples (POLICES) at the University of Bern, described in detail in [2]. This experience was then improved to allow repetitive measurements of the degree of polarization of icy samples, pure or mixed with salts and/or dust.

2. Improvements to POLICES

POLICES is now embedded inside a box which can be purged with neutral gases or dry air to remove water vapor and prevent the formation of frost and fog. Our previous results [2] demonstrated the noticeable effect of water deposition onto icy samples. To be able to prevent this deposition was the main reason for the improvements of the experiment. The sample also remains thermally stable for a longer duration and the adjustable time of measurement (regarding the desired range of phase angles between 1.5 and 60°) allows a great flexibility for monitoring the evolution of the icy analogues.

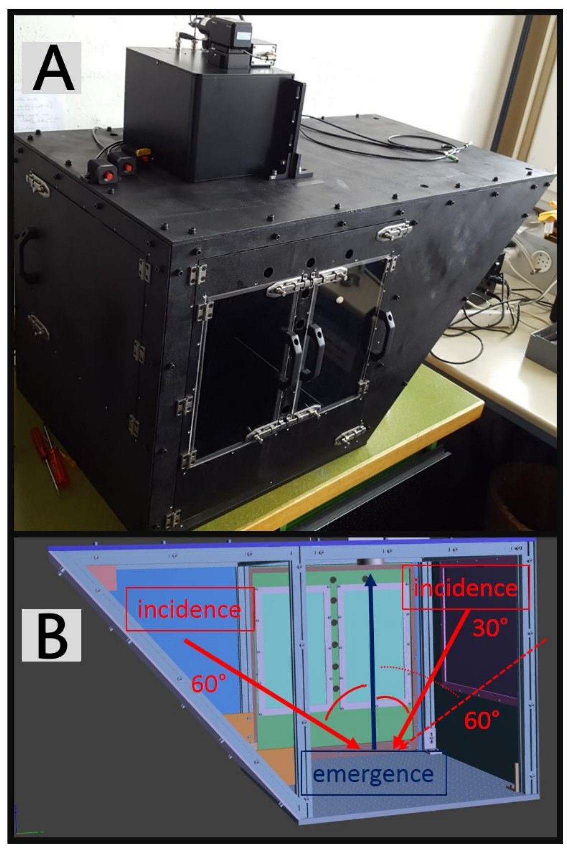

Figure 1: A) Polarimeter for ICE Sample v2. B) 3D back view with geometry of observation.

Figure 1 is composed of a picture (A) and a 3D back view (B, without the rotative arm) of the new setup enclosure. The box has a beveled shape to permit measurements at larger phase angles on one side. On the left panel (Figure 1A), a door was designed to permit these larger phase angle measurements on both sides of the sample (i.e. reaching 60° phase angle, see the dotted red line on Figure 1B). The use of this particular configuration would of course be efficient only for non-icy samples.

3. Sample preparation and measurements

We obtained first results of pure water ice measurements with the first campaign of experiments with POLICES. The evolution of the ice because of metamorphism processes such as sintering is well understood and the resulting migration of the opposition peak and of the Negative Polarisation Branch (NPB) toward smaller phase angles is described in [2]. Furthermore, the growth of water frost nuclei and the Mie oscillations associated to this phenomenon is also described and could be detected without ambiguities. Enriched with these first analyses, we now schedule to extend our measurements to more complex icy samples.

As widely suggested in literature, the surface of icy moons in the Galilean and Saturnian system is contaminated with a non-water-ice compound. Hydrated phases of sulfates and chlorides seems to be the most serious candidate so far [6]. To produce such samples, we used the Setup for Production of Icy Planetary Analogues (SPIPA) developed several years ago in the University of Bern [5, 7, 8]. It allows us to produce spherical particles of known size distribution in a reproducible way. The concentration of salts (for example $MgSO_4$, or NaCl) in solution can range from realistic percentages (from 1 to 10wt%) to complete saturation. The purpose could be either to clearly identify a systematic behaviour related to the concentration of salt in the analogue, mimic the results obtained from ground-based observations, and on the longer term be compared to observations from an orbiter, a lander or a rover. The icy sample is produced either by nebulizing the solution directly inside liquid nitrogen, or by mixing manually pure water ice spheres with salt or dust in an intimate mixture.

4. Summary and Perspectives

The high sensitivity of polarization to the grain size and degree of sintering of ice particles is going to be a robust base to push further our experiments [2]. The impact of the salt on the ongoing processes on the icy planetary surfaces and on the particles themselves could be inferred, at least partially, through polarimetric measurement of well-characterized icy analogues. POLICES has been improved to allow us building a database of polarimetric measurements of icy analogues including samples more or less enriched in salt and with different mixing processes. Particles subjected to the icy moons environment are constantly bombarded by energetic particles, affecting their reflectance properties (Cerubini et al., this conference). The new measurements campaign with complex icy analogues is now underway and the first results will be presented at the conference.

Acknowledgements

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