Evolution of photometric and polarimetric phase curves of fine-grained water ice particles due to grain sintering. B. Jost[1,2*], R. Cerubini[2], O. Poch[3], A. Pommerol[2], and N. Thomas[2]. [1]NASA Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, USA. [2]University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland. [3]Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France. *bernhard.jost@jpl.nasa.gov

Introduction: The discovery of cryovolcanism on Enceladus [1] and recent potential findings on Europa [2,3] lead to questions about the nature and the age of plume deposits under the harsh conditions in the outer Solar System. Major questions are the chemical composition, the physical structure and the deposition rate of plume material. The deposition rate mainly defines the surface age and corresponding timescales for processes such as thermal crystallization, thermal sintering and space weathering.

Thermal sintering, a morphological change driven by diffusion processes where individual ice particles grow together, is a key mechanism when studying scattering properties of surfaces, as the single particle scattering is highly affected by creating optical bonds between individual grains. The increased grain sizes could also lead to modifications in thermal inertia and explain observed thermal anomalies [3].

To make the transition from remote sensing data to physical interpretation, the study of well characterized and reproducible water ice samples in the laboratory is an appropriate approach.

Methods and samples: The laboratory for Outflow Studies of Sublimating icy materials (LOSSy) has been developed for this purpose at the University of Bern since 2010. The PHIRE-2 radio-goniometer [4] is designed to acquire photometric phase curves in the 450-1064nm spectral range at phase angles from 0 to 140° with an angular resolution of 0.5°. It is operated in a freezer at -35°C. The POLarimeter for ICE Samples (POLICES) [5] allows to measure the Stokes parameters (Q, U, V, I) describing the polarization of the scattered light at wavelengths of 530/625/810nm at phase angles between 1.5 and 30°.

Multiple setups have been developed to ensure a standardized and reproducible production of spherical water ice particles with grain sizes from a few microns to some tens of microns [4,6,7]. Such fine grained particles are believed to be a good proxy for surfaces of Enceladus or Europa.

Results & Discussion: In terms of photometric phase curves it has been shown that ongoing grain sintering mainly influences the ratio between backscattered and forward scattered light at non-zenith illumination geometries, non-sintered samples being more backscattering [4,6], see Fig. 1. Further it is observed that the amplitude of the opposition effect (OE) is decreasing with sintering, where the grain size determines the initial amplitude, smaller particles having a stronger OE. Optical effects such as glories [4] are mainly observed on non-sintered samples since their formation is restricted to spherical particles. The same phenomenon is observed in polarimetric phase curves where similar optical effects, including secondary maxima, disappear with time when particles sinter. Smaller particles tend to have lower values of linear polarization in the negative branch (Q<0).

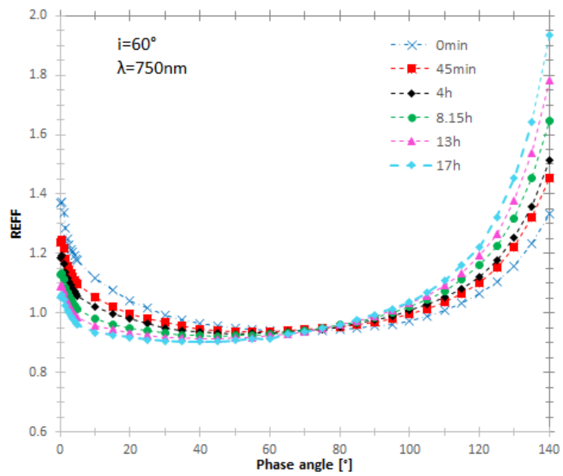

Figure 1: Photometric phase curves from a sample of spherical ice particles with grain sizes 5-100µm. The sample changes to less backscattering and more forward scattering with time.

In general polarization phase curves are more sensitive to grain size and grain surface texture such as frost condensation while photometric phase curves are more influenced by macroscopic sample roughness and bulk porosity.

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