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# Spectral properties of $H_2O$ ice depending on particle size and surface temperature – comparison between laboratory data and icy satellites observations

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## Abstract

Observations of the spectral properties of the icy Jovian and Saturnian satellites reveal that the spectral signature of $H_2O$ ice greatly differs between these bodies, but also varies with location on each body itself [1, 2]. Next to the abundance of ice, the observed variations are often explained with changes in the particle size of $H_2O$ ice. In particular, the band depth ratios (BDRs) of the individual $H_2O$ ice absorptions have been useful to map the particle size variations on these bodies [1]. The derived particle sizes, however, greatly depend on the comparison with modelled $H_2O$ ice spectra using commonly used radiative transfer models [2].

In order to support the investigation of the icy surface properties, we measured the spectral properties of $H_2O$ ice samples for temperatures between 70 and 150 K with the SHINE Spectro-Gonio Radiometer of the Institut de Planétologie et d'Astrophysique de Grenoble (IPAG). The derived spectra have been preliminary analyzed for differences in the BDRs due to particles size, temperature and particle size mixtures, and compared to modeled spectra and the spectral properties of fresh impact craters in the Jovian and Saturnian systems**.**

## 1. Sample characterization

Samples of four different particle sizes (70 ± 30µm, 300 ± 100µm, 680 ± 120 µm, 1060 ± 60µm and 1360 ± 240µm) were prepared by spraying spherical water droplets into liquid $N_2$ or crushing and sieving ice in a cold chamber. Ice particles of ~300 µm were produced and measured in both ways in order to compare spectra of spherical and irregular shaped grains. In addition, three mixtures (mass mixing ratios 25%/75%, 50%/50% and 75%/25%) of 70 ± 30µm and 1060 ± 60µm particles were also measured. All samples were measured at 8 different temperatures from 70 to 150 K. The irregular shaped ~ 300 µm particles were measured twice with decreasing and increasing temperature in order to distinguish between possible spectral changes due to cooling and heating of the sample.

## 2. Comparison with model spectra

BDRs of the individual $H_2O$ ice absorptions increase in the sample spectra with increasing particle sizes (Fig. 1) as expected from radiative transfer models [1]. Apparently, temperature does not greatly affect the BDRs. Nevertheless, the BDR values derived from the samples partly differ from the model values. In general, the BDR model values derived from Mie theory (Model A) seem to provide a better match. For this case, only the BDR 2/1.5 µm-values of particles larger than 200 µm deviate significantly from the model (Fig. 1C). A similar behavior was also noticed in [1]. Nonetheless, the particle sizes indicated by the BDRs including the $H_2O$ ice absorption at 1.25 µm in comparison with the Mie-derived BDR values fit reasonably well to the particle size ranges of the samples (Fig. 1 a, b). Spherical ~300µm-particles are fairly similar in terms of BDRs to irregular shaped ones (Fig. 2 b, d). In comparison with the Mie values, the resulting BDRs still fit into the particle size range of the sample.

## 3. Discussion

The acquired spectra nicely support the investigation of $H_2O$ ice particle sizes on icy bodies in the outer solar system. Although, the measured samples do not cover smaller $H_2O$-ice particles, the derived spectra confirm that BDRs of the major $H_2O$ ice absorptions are useful indicators for mapping $H_2O$ ice particle sizes on the icy surfaces (Fig. 2). In particular, in case of large-grained ice like in Ganymede's old terrain ($Ga_{old}$), where the NIMS- and VIMS-derived BDRs deviate from the BDR model values, the acquired spectra will be very useful for the $H_2O$-ice particle size estimation.

# Acknowledgements

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# References


[1] Stephan, K. et al. (2017): Ice particle size variations and candidate non-ice materials on Ganymede and Callisto, EPSC2017-350-2. [2] Stephan, K. et al. (2018): Spectral properties of fresh impact craters in the Saturnian and Jovian system, EPSC2018-341.


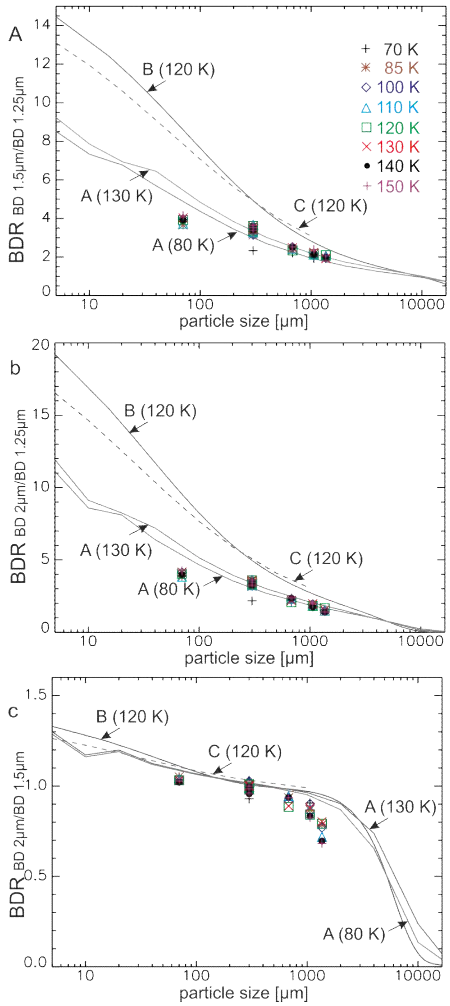


**Fig. 1:** Band depth ratios (BDRs) of the $H_2O$ ice absorptions at 1.25, 1.5 and 2µm derived from the sample spectra in comparison to the BDRs derived from models spectra using the Mie theory (Model A), Shkuratov (Model B) and Hapke (Model C).

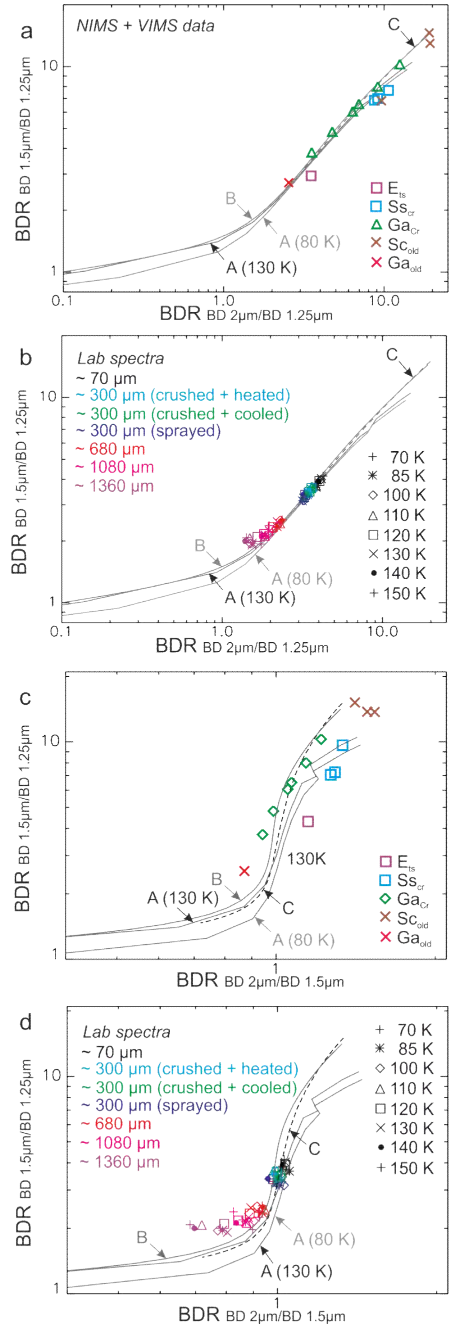


**Fig. 2:** Band depth ratios (BDRs) of the $H_2O$ ice absorptions at 1.25, 1.5 and 2µm derived from NIMS and VIMS spectra (panels a and c) for fresh ice-rich impact craters on Ganymede ($Ga_{cr}$) and the Saturnian satellites ($Ss_{cr}$), tiger stripes on Enceladus ($E_{ts}$), old terrain on Ganymede ($Ga_{old}$) and the Saturnian satellites ($Sc_{old}$) and spectra of samples at different temperatures (panels b and d) compared to the BDRs derived from modeled spectra of $H_2O$ ice of Fig. 1.