ESRF	**Experiment title:** Interface Melting of Ice: Smooth Interface	**Experiment number**: SI-954
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Report:

We are investigating the interfacial melting of ice, i.e. the formation of an interfacial quasiliquid layer at temperatures below the bulk melting point. Interfacial roughness can have a strong influence on wetting phenomena in general and interfacial melting in particular. It can even switch an interfacial melting scenario from non-melting to melting (roughness-induced wetting) [1]. In a first experiment (SI-899) [2], we have studied ice in contact with a SiO_2-Si model substrate. A substrate with relatively strong self-affine roughness has been used, since roughness is expected to have the general tendency to promote interfacial melting. We could observe the formation of a quasiliquid layer and determined its thickness and density as a function of temperature.
In this experiment (SI-954), we intended to study the influence of the substrate morphology. Therefore, an extremely smooth SiO_2-Si substrate (rms roughness ~0.27 nm) has been used, which is about the closest one can get to an ideally flat substrate. The sample preparation was identical to the preceding experiment. A polished Si blocked has been carefully cleaned with “Piranha solution”, RCA and HF dips. Exposure to air then leads to the formation of a thin native amorphous oxide. A high-purity single crystal of ice with basal (00.1) orientation has been used for the preparation of the ice-substrate interface. Measurements close to the melting point are possible due to a special sample chamber, which allows a precise control of the temperature. We have used the high-energy X-ray transmission scheme developed in our group [3] to perform X-ray reflectivity measurements at the buried ice-substrate interface. The experiments were carried out at an X-ray energy of 71 keV and an energy bandwidth of

165 eV. A compound refractive lense was used for focussing of the beam to a spot size of 7 μm in the vertical and 24 μm in the horizontal direction.

The reflectivity measurements (see Fig. 1) reveal the occurrence of a quasiliquid layer. As in the case of the rough substrate, the density of this layer is about 20% higher than the density of bulk water and points to a structural connection with the high-density amorphous (HDA) ice.

The temperature dependence of the layer thickness (see Fig. 2) can be very well described by a logarithmic growth law with a growth amplitude slightly smaller than the literature values for the bulk correlation length of water. The behaviour of the rough substrate agrees well with the smooth substrate for low temperatures. But for higher temperatures, the quasiliquid layer thickness at the rough substrate increases much faster with temperature, reaching 5.5 nm at -0.036°C, which is about twice as large as the corresponding layer thickness for the smooth substrate. The extremely good fit to a logarithmic growth law in the case of the smooth substrate suggests that a reinterpretation of the growth law for the rough substrate, so far also approximated by a logarithmic growth law, is necessary.

The observation of a strong roughness effect on interfacial melting is important for the interpretation and comparison of previous and future studies of interfacial melting. It is also of great importance for estimating the effect of interfacial melting on phenomena in nature, where the relevant interfaces are always rough, as in the case of glacier motion, for example.

[1] R. R. Netz and D. Andelman, Phys. Rev. E **55**, 687 (1997).

[2] S. Engemann *et al.*, Phys. Rev. Lett. **92**, 205701 (2004).

[3] H. Reichert *et al.*, Physica B **336**, 46 (2003).

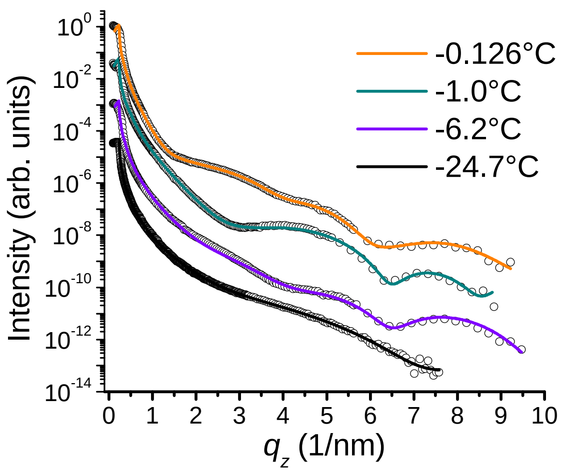

Figure 1: Reflectivity measurements of ice-substrate interface (smooth substrate).

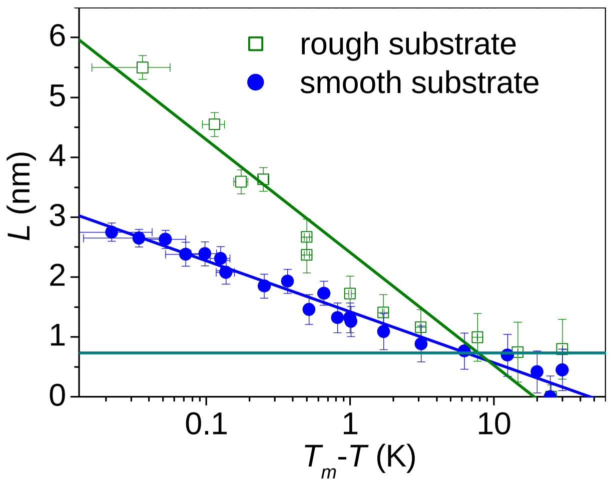

Figure 2: Quasiliquid layer thickness L as a function of temperature and fits with logarithmic growth laws.