The macroscopic contact angle of water on ice

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Résumé

Wettability quantifies the affinity of a liquid over a substrate and determines whether the surface is repellent or not. When both the liquid and the solid phases are made of the same chemical substance and are at thermal equilibrium, complete wetting is expected in principle, as observed, for instance, with drops of molten metals spreading on their solid counterparts. However, this is not the case for water on ice. Although there is a growing consensus on the partial wetting of water on ice and several estimates available for the value of the associated macroscopic contact angle, the question of whether these measurements are conducted at mechanical and thermal equilibrium is still open. In the present work, we study this problem experimentally and demonstrate the existence of such a macroscopic contact angle of water on ice. Indeed, when depositing water droplets on smooth ice layers with accurately controlled surface temperatures, we observe that spreading is unaffected by thermal effects and phase change close enough to the melting point (namely, for undercoolings below 1 K) so that conditions of thermal equilibrium are closely approached. Whereas the short time motion of the contact line is driven by an inertial-capillary balance, the evolution towards mechanical equilibrium is described by a viscous-capillary dynamics and is therefore capillary-related. The resulting contact angle remains constant and very close to 12∘ for undercoolings below 1 K. We anticipate this key finding will significantly improve the understanding of capillary flows in the presence of phase change, which is of special interest in the realm of ice morphogenesis and glaciology.

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