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Aktuelle Fragen der Nanophysik

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Atomic-scale insights into ice and water via high-resolution SPM

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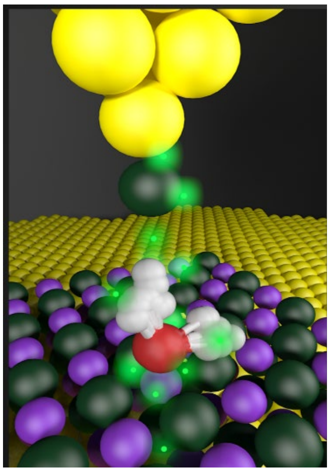
Water is fundamental to life, yet as a many-body quantum system with a complex hydrogen-bond network and strong nuclear quantum effects, it still poses many open questions. Recently, we developed hydrogen-sensitive scanning probe microscopy (SPM) based on higher-order electrostatic forces[1], successfully applying it to interfacial water/ice systems. We begin from 3D bulk hexagonal ice (ice Ih) and its surfaces. By developing a universal high-resolution imaging method for insulating surfaces, we are able to directly image ice Ih surfaces at the atomic scale[2]. These measurements reveal unique superstructures and premelting phenomena at the ice surface. By lowering the dimensionality, we then identify an intrinsic 2D ice I phase[3], an interlocked double bilayer, stabilized on weakly interacting substrates such as Au(111), graphene, and hBN. We show that subtle changes in surface electrostatics can switch the superlubricity of 2D ice I on or off[4]. By ion doping, we can also stabilize and control a variety of more complex and intriguing ice phases[5,6]. Finally, we address how ice evolves from disordered to ordered states, both in the oxygen skeleton and in the coherently ordered proton subsystem. These findings offer new insights into phase behavior and physicochemical properties of ice, providing a deeper understanding of its fundamental nature and potential applications in materials science.



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