On Slippery Ice

Lukasz Baran[a], Pablo Llombart[b], Wojciech Rzysko[a], Luis G. MacDowell[c]

[a]*Department of Theoretical Chemistry, Faculty of Chemistry, Maria-Curie-Sklodowska University in Lublin, Lublin, Poland*
[b]*Departamento de Física Teórica de la Materia Condensada, Instituto Nicolás Cabrera, Universidad Autónoma de Madrid 28049 Madrid*
[c]*Departamento de Química-Física, Facultad de Ciencias Químicas, Universidad Complutense de Madrid 28040 Madrid*

E-mail: lgmac@quim.ucm.es

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Sliding on ice is a familiar experience, but the reason why ice has such a low friction has a long and controversial history. For many years, it has been assumed that the main reason for the low friction of ice is due to the formation of a thick lubrication layer of melt water. However, there is no consensus on the origin of the melt water film. Among the different hypothesis enumerated are pressure melting, ice premelting and frictional heating of the surface [1]. Very recently, however, it has been suggested that lubrication plays no role whatsoever, and that ice friction is mainly given by adhesive and mechanical properties of ice [2].

Unfortunately, these hypothesis cannot be easily confirmed by macroscopic experiments. What is the actual thickness of the watery lubrication film under static conditions? Does it change significantly with the nature of the substrate? Does it become thicker upon increasing the pressure or shearing? Is the resulting thickness sufficient for the establishment of a lubricating Couette flow?

In our work we borrowed tools from our recent investigations on the structure of ice premelting in order to understand better the microscopic origin of the low friction coefficient of ice [3-4]. We found that ice friction is the result of spontaneous surface premelting, pressure melting and frictional heating operating simultaneously during sliding [5].

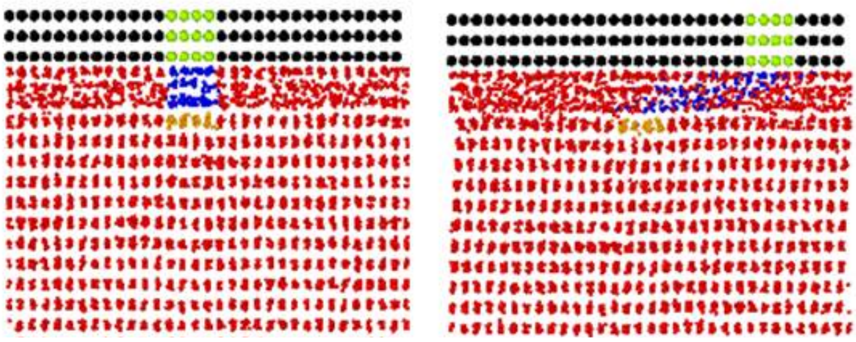

Figure: Computer simulation of ice slinding. The figure displays the flow profile of an interfacial premelting film between the slider (black atoms) and ice (red atoms). The interfacially premelted film is visible as a disordered layer of water molecules. At time t=0, the central atoms in the film are tagged in blue and the central atoms of the solid slider are tagged in green. After t=0.5 ns, the slider has moved to the left as evidenced by the green tagged atoms, and the premelted water molecules have been dragged in a case of Couette flow.

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