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Slip and friction at the liquid/solid interface

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Almost two hundred years ago, Navier and then Stokes have derived the famous Navier-Stokes equation to describe the motion of flowing fluids. Because it is a differential equation, it requires boundary conditions. For liquids flowing past solid surfaces, Navier has proposed that the force exerted by the liquid on the solid would be proportional to the velocity of the liquid at the surface. If we write this force F, the total contact area A and the velocity of the liquid at the wall V_s, we can write this hypothesis in the form $F = \lambda A V_s$, where λ is called a friction coefficient.

This assumption has been quickly simplified, and until the end of the XXth century, many people have assumed that the velocity of liquids relative to the velocity of the solid surface is zero, or in other words that λ was infinite. This is the so-called "no-slip"boundary condition. Though this hypothesis turned out to be verified in many cases, the emergence of polymer physics as well as nanofluidics has raised again the question: is it possible for a liquid to slip on a solid wall and what would be the underlying mechanisms?

This is a challenging question to answer, because it usually requires measurements over very small length scales. Some cutting-edge techniques as well as molecular dynamics simulations (and more recently quantum simulations) have brought new perspectives on this topic for low-viscosity fluids. An other part of the community have tackled this issue using high-viscosity polymers, which are known to strongly deviate from the no-slip boundary condition. Since polymers are long molecules, their behavior near surfaces is completely different from shorter molecular liquids. This gives rise to fascinating behaviors at the solid/liquid interface.

In particular, the effect of temperature on liquid/solid friction is still an open question. Playing with temperature is a good way to probe the molecular mechanisms underlying friction, since it allows one to change the mobility of the liquid molecules. In addition, it is tempting to cool the liquid down to its melting or glass transition temperature in order to compare the liquid/solid friction and the corresponding solid/solid friction.

After summarizing the evolution of the so-called "slip"boundary condition, I will discuss slip of liquid polymers, their peculiar behavior near solid walls, and the paramount role of temperature on their interaction with the solid surface, and on the liquid/solid friction in general.

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