Slip at Polished Surfaces

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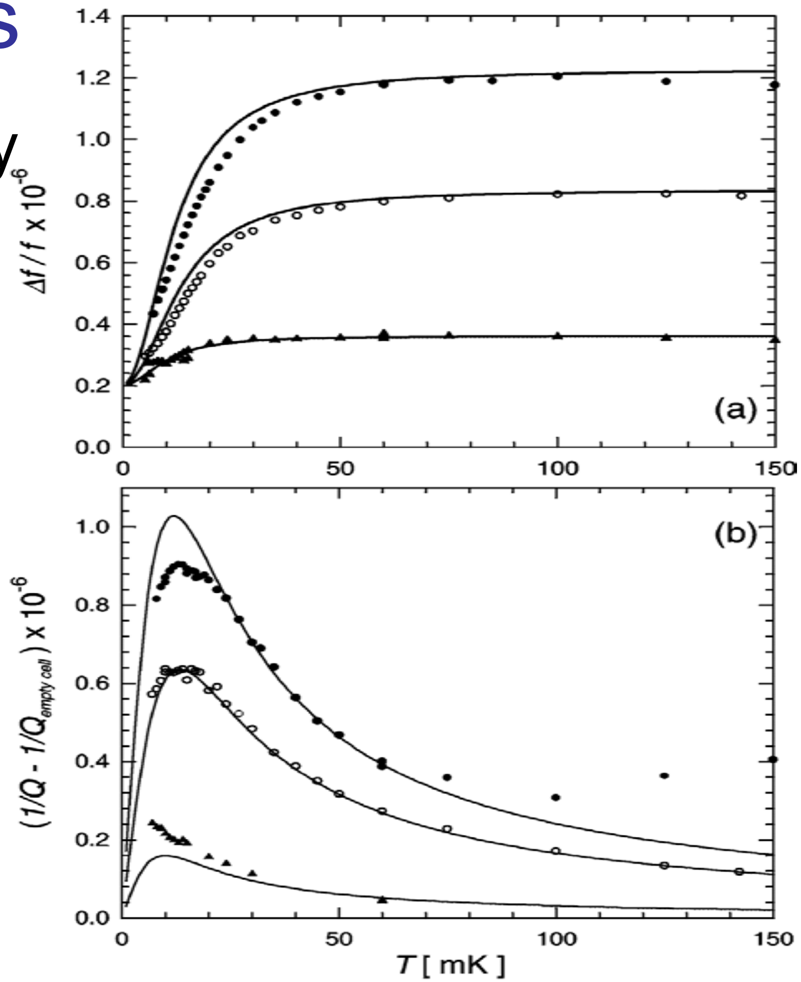
Micro-fluidics has allowed the assay of ultra small quantities of reagents or biological matter. But how much do we know about flow in these micro channels?

^{3}He, a quantum fluid, allows special insight into this problem. Its viscosity increases 10000-fold as the temperature is lowered from 100 to 1mK, all at a constant density.

By polishing the surface (surprisingly without going to atomic scale roughness) we found that the fluid decouples, "slips", at the surface and skates almost like an ice cube. This holds promise for increasing the flow in ultra-small channels.



Mass coupled to oscillator (top panel) and friction term for three films 100, 240 an 350 nm thick as the temperature is lowered from 150 to 5mK. As the viscosity increases *less* mass is coupled to the oscillator (counter to intuition) on a polished surface.

Casey, Parpia, Schanen, Cowan, Saunders, Phys. Rev. Lett., **92,** 255301 (2004)

A quasi-2D film of 3He decouples from the surface of a highly polished silver torsional oscillator. The oscillator has an ultra high stability (3 parts in 10^{10}) and can detect the inertia from a 0.1nm thick film. We examined film thicknesses of 100, 240 and 350nm with a view to exploring 2D superfluidity of ^{3}He. The film decouples (except for a ~50nm equivalent capillary condensed in the corner) by 5mK (see top panel) accompanied by dissipation (bottom panel). The result is understood interms of an interfacial friction model.

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New (unpublished) results show a suppressed superfluid transition in a similar deliberately roughened surface oscillator. In this case, all the films' mass stays coupled to the oscillator down to the lowest temperature.

Coll. With Royal Holloway (UK)

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- International Collaboration

This work was a collaboration between the Cornell and Royal Holloway (UK) groups.

Andrew Casey, a grad student at Royal Holloway (is now a post doc at Royal Holloway).

Roch Schanen a post doc at Royal Holloway is now in Grenoble.

Cowan and Saunders are Professors at Royal Holloway.

- Societal Impact

The ability to alter fluid flow behavior by tailoring the surface is particularly important in ultra-small channels. Perhaps changing the surface structure will allow flow in biological structures (like capillaries) to be increased.