Fluid flow in Very Thin Films

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The Navier-Stokes equations for continuum flow are well known, and understood, and along with suitable boundary conditions can be used to describe fluid flow. At solid–liquid interfaces, solutions to the Navier Stokes equation fit macroscopic data well if one assumes a boundary condition in which the liquid is at rest with respect to the solid. This is known as the no-slip boundary condition. However, there are about 100 recent papers making claims that this condition is violated in very thin films. This potential violation has great significance because of the large number of applications (mineral and oil processing, filtration, microscale processing, control of skin friction for ships etc). In this talk, I will describe our measurements showing that, in fact, the no-slip boundary condition is usually obeyed with great precision even in nanometer-scale films. I will describe one subtle deviation for a very weakly bonded liquid. On the other hand, partial slip is expected at solid–vapour interfaces and I will describe our recent efforts to measure fluid flow through very narrow channels in air. These measurements utilized an interesting method in which we analyse the thermal vibrations of an Atomic Force Microscope cantilever.