INTERNSHIP PROPOSAL

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Internship location: LPENS (24 rue Lhomond, 75005, Paris)
Thesis possibility after internship: YES
Funding: POSSIBLY

Thermal avalanches and depinning transition of a contact line

Thermal avalanches serve as a unifying mechanism for heterogeneous flows in disordered materials and glassy systems. The dynamical heterogeneities in these materials, which reflect the interplay between endogenous mechanical noise and exogenous thermal noise, have primarily been studied theoretically in the context of creep flows of pinned elastic manifolds and in simulations of super-cooled liquids, with the notable exception of the logarithmic aging of crumpled sheets. The aim of the internship and the PhD thesis is to investigate the effect of finite temperature on the depinning transition of a contact line, utilizing a combination of controlled laboratory experiments, theoretical analysis, and numerical simulations.

Context — As the volume of a liquid drop on a solid surface gets smaller, the three-phase contact line grows in importance compared to bulk phenomena. In microfluidics and other advanced liquid-handling applications, liquid-based heat exchangers, or the delivery of essential drugs at low flow rates, pinning of the contact line on nanoscale defects and the associated kinetics can play a preponderant role. At these scales, the energy barriers to motion can be overcome by thermal activation, and it is not possible to understand the fundamental processes by only looking at quantities averaged over time and space, as is done in standard wetting studies. Instead, we need to understand the statistical nature of the contact line.

However, thermally-activated depinning of a contact line has never been directly observed in experiment because this would involve rapid imaging of the motion of the contact line on nanometer or sub-nanometer scales. Instead, we propose to study the problem by:

(1) A novel scaling of the experimental problem — A thermalized bath is one where the spectral density of the waves resembles that of thermal capillary waves. In principle, one can use multiple vibrators or loudspeakers to produce an artificial "high temperature" thermalized bath. Then, fluctuations will be on the optical scale and the motion of the contact line over a single defect can be imaged under microscope in real-time and compared to that expected for thermally-activated pinning and depinning.

(2) Theory and numerical simulations — By balancing capillary and defect forces, numerical simulations allow us to calculate the force landscape and deformation of a contact line as it moves over one defect or over a random collection of defects. Then the objective is to calculate the dynamics of the contact line by solving the stochastic differential equations of motion which include the numerically-determined force landscape. Here the goal is to make the link between the properties of the defects (size, density…) and the measured dynamics (which have been described by a "hopping length").

Condensed Matter Physics: NO
Quantum Physics: NO
Soft Matter and Biological Physics: YES
Theoretical Physics: YES