Internship / Thesis

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Wetting at the Nanoscale : the Puzzling Role of Thermal Fluctuations

The spreading dynamics of a droplet on a substrate is an important scientific question with numerous practical implications, such as fog nets for water harvesting, drying of smart textiles, or wing-coating engineering in aeronautics, to name a few. The underlying principles are well established since Tanner's seminal work. However, fundamental and applied developments in nanofluidics raise questions about the validity of classical, continuum fluid dynamics since compositional and surface fluctuations near interfaces become increasingly important at small scales. To address such a matter, a promising strategy is to study near-critical phase-separated binary mixtures. Indeed, these are model systems where: i) fluctuations can be significantly amplified at will; and ii) the typical sub-millimetric length scales allow for optical imaging methods, in contrast to nanoscale systems. The focus of this project is thus on the relaxation of out-of-equilibrium wetting droplets in such critical mixtures. Experimentally, we plan to use the radiation pressure of a laser wave at a near-critical liquid-liquid interface to produce jets and eventually out-of-equilibrium wetting droplets, having physical properties varying with the temperature proximity to the critical point. After a fluctuation-free calibration far from the critical point, we will investigate the near critical deviations from the latter, and their relations with the increasing roles of density fluctuations, gravity and evaporation. Theoretically, asymptotic and/or numerical solutions of stochastic lubrication models will be constructed for the current geometry, and compared quantitatively to the experimental results. All together, the goal is to establish for the first time on solid grounds the fundamental crossover between the capillary-dominated and fluctuation-dominated regimes of dynamical wetting.