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HYDRODYNAMICS OF FLUCTUATING LIQUID JETS

Developments in nano-fluidics raise questions about the validity of classical two-fluid dynamics, notably the use of sharp interfaces. Indeed, in small-scale systems, compositional and surface fluctuations at, and around, interfaces become important. Recent results indicate that such systems strongly deviate from classical theory. The major innovation of this project is the focus on the effect of fluctuations in near critical phase separated liquids (where fluctuations are amplified) out-of-equilibrium in the presence of soft liquid interfaces. We would like to focus on the influence of fluctuations on hydrodynamic instabilities such as jetting. Fluctuations are bound to play an important role in the dynamics when the dimensions of the jet reach the characteristic length of these interfacial or density fluctuations (usually the so-called thermal length), as predicted illustrated on liquid bridge break up near a critical point [1].

The system studied here may also be seen as an idealization to understand two phase nano-fluidics, where instead of looking at systems whose sizes are in the nanoworld, we increase the characteristic length scale of the fluid (its intrinsic correlation length) to scales close to that of the experimental system where optical imaging methods apply. We will produce jets by destabilizing the interface of a near-critical phase-separated liquid mixture (see Figure 1) using the radiation pressure of a laser wave [2], and the goal is to study the morphology of the jet and the dripping in presence of increasing fluctuations when varying optically the flow inside the jet (using optical scattering forces [3]); as the laser beam power can control as well the liquid flow rate on the one hand and since shear at the interface (due to the flow inside the jet) should reduce the influence of fluctuations on the other hand, a flow rate dependence of the drop production is expected related to the viscous/fluctuation transition.

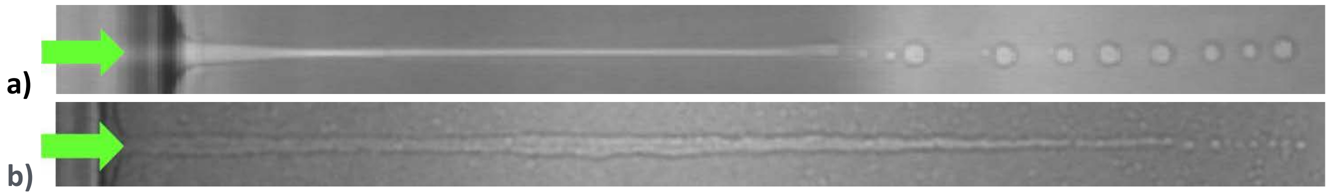

Figure 1: *a) Viscous jet emitting polydispersed droplets (far from criticality). b) Fluctuating jet emitting monodisperse droplets (close to the critical point); note the interface roughness, as an image of the presence of large fluctuations, close to the critical point. The left arrows indicate the direction of the laser beam used to trigger jetting with the optical radiation pressure.*

Considering the novelty of this new optical approach in producing fluctuating interfaces with different geometries (see also [4]), we plan developing this work within the frame of a PhD dedicated to the transition between viscous and fluctuation dominated non-equilibrium behaviors, along two main directions by: (i) ending the investigation on liquid jets and (ii), generalizing to different geometries: relaxation and break up of liquid ligaments, dynamics of deformed droplets, stability of liquid sheets produced by light, all corresponding to situations that have not been studied over the past.

References

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