Effects of micro-confinement on diphasic systems.

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The emergence of microfluidics has led to a significant increase in the study of multiphase fluid flows at micrometric scales, both for dense (foams, emulsions) and diluted systems. Although multiphase flows have been studied for many decades, a simple question arises: are there other mechanisms involved at these scales (e.g. by the presence of interfaces) that modify the behavior of the studied systems? This question is crucial as droplet microfluidic systems are becoming more complex and their development requires an understanding of the peculiarities of flows at these scales. This presentation does not intend to present the results of a specific experiment, but rather to show through two experimental configurations, that there are a number of situations where microfluidics provide new experimental and theoretical advances to better understand the dynamics of micro-confined two-phase flows.

In a first step, we will present the main results obtained in the case of dense systems, namely a two-dimensional soap foam. Because of the small confinement, the pressures involved are large, preventing the development of liquid films between adjacent bubbles. This property has the advantage of reducing the theoretical aging time of microscale dry foams and making them model systems for flow studies. More precisely, we will show that the monodispersity of foams obtained in these systems, coupled with the absence of films, make them model systems for studying interfacial rheology. In a second step, we addressed the crucial question in microfluidics, to determine the velocity of a droplet in a Hele-Shaw cavity when it is carried by an external fluid of set velocity. Predicting the speed of the droplets requires identifying beforehand the mechanisms of dissipation in the droplet, in the menisci and in the lubrication film. Our approach was therefore initially to analyze the topography of the lubrication film by adapting an interferometric instrumentation (RICM). In particular, we show that the intermolecular forces, the disjoining pressure, intervening on the nanometric scale directly influence the dynamics of the droplets. Microfluidics even makes it possible to establish isotherms of disjoining pressure. The analysis of the topography of the lubrication film makes it possible to go back to the local properties of the interface (interfacial velocity, surface tension).

[1] V. Miralles, E. Rio, I. Cantat and M.-C. Jullien, Investigating the role of a poorly soluble surfactant in a thermally driven 2D microfoam, Soft Matter **12**, 7056-7062 (2016)

[2] A. Huerre, O. Theodoly, A. Leshanky, M.-P. Valignat, I. Cantat, and M.-C. Jullien, Phys. Rev. Lett., **115**, 064501 (2015).

[3] B. Reichert *et al.*, JFM submitted.