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Visco-elasticity of foam films

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Liquid foam exhibits surprisingly high viscosity, higher than each of its phases. This dissipation enhancement has been rationalized by invoking either a geometrical confinement of the shear in the liquid phase, or the influence of the interface viscosity. However, a precise localization of the dissipation, and its mechanism at the bubble scale, is still lacking. To this aim, we simultaneously monitored the evolution of the local flow velocity, film thickness and surface tension of a five films assembly, induced by different controlled deformations. These measurements allow us to build local constitutive relations for this foam elementary brick. We first show that, for our millimetric foam films, the main part of the film has a purely elastic, reversible behavior, thus ruling out the interface viscosity to explain the observed dissipation. We then highlight a generic frustration at the menisci, controlling the interface transfer between neighbor films and resulting in the localization of a bulk shear flow close to the menisci. A model accounting for surfactant transport in these small sheared regions is developed. It is in good agreement with the experiment, and demonstrate that most of the dissipation is localized in these domains. The length of these sheared regions, determined by the physico-chemical properties of the solution, sets a transition between a large bubble regime in which the films are mainly stretched and compressed, and a small bubble regime in which they are sheared. Finally, we discuss the parameter range where a model of foam viscosity could be built on the basis of these local results.

Orateur: CANTAT, Isabelle (CNRS, Université de Rennes)