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"Suspensions of soft capsules: rheology and multiphase flows"

Abstract:

Soft particles at fluid interfaces play an important role in many aspects of our daily life, such as the food industry, paints and coatings, and medical applications. Analytical methods are not capable of describing the emergent effects of the complex dynamics of suspensions of many soft particles, whereas experiments typically either only capture bulk properties or require invasive methods. Computational methods are therefore a great tool to complement experimental work. However, an efficient and versatile numerical method is needed to model dense suspensions of many soft particles. Here we present a method to simulate soft particles in a multi-component fluid, both at and near fluid-fluid interfaces, based on the lattice Boltzmann method. Although capillary interactions between rigid particles are well studied, much is still to be understood about the behaviour of soft particles and the role of their softness during the final stages of film drying. We investigate the drying process of a film with suspended soft particles. Our measured menisci deformations and lateral capillary forces, show that the deformations become smaller with increasing particles softness, resulting in weaker lateral interaction forces. At large interparticle distances, the force approaches that of rigid particles. Finally, we investigate the time dependent formation of particle clusters at the late stages of the film drying. In a second part of the talk we investigate the rheology of strain-hardening spherical capsules, from the dilute to the concentrated regime under a confined shear flow using three-dimensional numerical simulations. We consider the effect of capillary number, volume fraction and membrane inextensibility on the particle deformation and on the effective suspension viscosity and normal stress differences of the suspension. The suspension displays a shear-thinning behaviour which is a characteristic of soft particles such as emulsion droplets, vesicles, strain-softening capsules, and red blood cells. In essence, our results reveal that strain-hardening capsules share rheological features with both soft and solid particles depending on the ratio of the area dilatation to shear elastic modulus. Furthermore, the suspension viscosity exhibits a universal behaviour for the parameter space defined by the capillary number and the membrane inextensibility, when introducing the particle geometrical changes at the steady-state in the definition of the volume fraction.

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