DROPLET GENERATION VIA BURSTING, IMPACTING, AND JETTING, WITH SURFACTANTS

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Liquid atomisation processes are widely used to break down a liquid stream into smaller droplets to enhance its mixing with a stagnant phase. These streams may be contaminated with surfactants, whose concentration variations lead to surface tension gradients and Marangoni stresses. Here, we study the effect of surfactant on the complex interfacial dynamics associated with a turbulent jet. We use three-dimensional (3D) direct numerical simulations (DNS) and a hybrid front-tracking/level-set method[1] to capture the dynamics of the complex topological changes in this flow. The numerical method allows the natural tracking of the concentration of interfacial surfactant species and the faithful modelling of its spatio-temporal evolution. Our model also accounts for surfactant solubility and bulk-interface mass exchange. We perform a parametric study of the effect of surfactant properties on the dynamics. The effect of Marangoni stresses is analysed in terms of the mechanisms giving rise to the droplet size distributions depending on the elasticity number. An attempt to understand the interaction between the observed vortical structures accompanying the flow and the regions of elevated surfactant concentration will also be presented.

Countless instances of bursting bubbles over the oceans contribute significantly to the exchange of heat and chemicals with the atmosphere. Understanding bursting bubble physics could be the key to tackling the ever-growing environmental problem. When a bubble is close to a free surface, it forms a hole which leaves an open unstable cavity that undergoes collapse; the change of the interface curvature leads to the formation of a central jet, which breaks into droplets according to the Plateau–Rayleigh instability. The surfactant-free interfacial dynamics are well understood, however, the surfactant-laden bursts are still unexplored. By neglecting gravity, the Laplace number is the only dimensionless control parameter measuring the relative importance of surface tension to viscous forces i.e. $La = \rho\sigma R/\mu^2$, where ρ, μ, σ, and R represent the liquid density, viscosity, surface tension, and the initial radius of the droplet, respectively. The fate of the central jet is analysed with help of a 3D DNS simulations, where the effect number of surfactant related non-dimensional parameter. Results regarding the importance of Marangoni stresses on the jet formation will be discussed.

Finally, we consider the impact of drops on solid and fluid substrates whose rich phenomena have been the source of fascination for decades. Recent experimental work[2] has investigated the effect of surfactants on “crown” splashing and found that they affect significantly the propagation of capillary waves, the evolution of the crown, and the formation of secondary droplets. Here, we employ 3D DNS to examine drop impacts on thin surfactant-laden films. We couple the hybrid interface-tracking/level-set method for the interfacial dynamics to a convective-diffusion equation for the surfactant concentration to carry out the computations. We vary different surfactant properties (i.e. diffusion, elasticity, and solubility) to study their effect on the phenomena accompanying the drop impact.

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