Particle capture and trapping by large deformable drops in turbulent three-phase flow

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Abstract :

In this talk, we will examine the interaction between a swarm of small (sub-Kolmogorov) inertial particles and large deformable droplets in turbulent channel flow. This problem is relevant to a large variety of systems involving the adsorption of solid particles to the fluid interface between droplets/bubbles and a carrier liquid. Industrial applications where such phenomenon occurs include scrubbing and froth flotation processes. To simulate such solid-liquid-liquid flow, we exploit an Eulerian-Lagrangian methodology based on direct numerical simulation of turbulence, coupled with a Phase Field Model to capture the interface dynamics and Lagrangian tracking to compute particle trajectories. We quantify particle-interface interaction in a situation where the droplets have the same density and viscosity of the carrier liquid (mimicking a water-oil emulsion), and particles are one-way coupled with the carrier phase. This allows us to isolate the role played by surface tension in driving particle adhesion and leading to the formation of a layer that may change the mechanical and mass transport properties of the interface. Particle distribution is obtained considering excluded-volume interactions, i.e. by enforcing particle collisions. Particles are initially dispersed in the carrier flow and are driven in time towards the surface of the drops by jet-like turbulent fluid motions. Once captured by the interfacial forces, particles disperse on the surface. Excluded-volume interactions bring particles into long-term trapping regions where the average surface velocity divergence sampled by the particles is zero. These regions correlate well with portions of the interface characterized by higher-than-mean curvature, indicating that modifications of the surface tension induced by the presence of very small particles will be stronger in the highly convex regions of the interface.