Investigation of shear-induced migration, ordering, and shape-morphing dynamics in soft particle and red blood cell suspensions

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The immersed boundary – lattice Boltzmann method (IB-LB) is employed to model the dynamics of deformable particle suspensions undergoing shear and Poiseuille flow in microchannels. The deformation energy of a model particle is designed to capture realistic droplet emulsions and cells. For a model red blood cell undergoing simple shear flow, a rich state diagram of RBC morphology with rolling, tumbling, tank-treading, swinging, and flipping dynamics is predicted by the model, verifying recent experimental observations [1].

For a deformable cell in micro-flow, IB-LB captures cell migration away from the channel walls due to near-wall inertia- and deformation-driven hydrodynamic forces. The lift forces verify theoretical predictions at low Reynolds (Re) and Weissenberg (Wi) numbers. In addition, the model predicts relatively weaker migration velocity at moderate Re and Wi [2]. It was also found that increasing the fluid viscosity inside the particle can reverse the migration flux, as had been observed in recent experiments with oil droplets [3].

We also investigated shear-induced ordering of a dense droplet emulsion suspension undergoing simple shear in a Hele-Shaw cell. In suspensions of soft particles, shear-induced order occurs at higher volume fractions compared to hard colloids. In addition, it was found that very strong shear strongly deforms the particles and leads to dis-order. Interesting consequences for the suspension viscoelasticity will be discussed.