Dynamics of deformable capsules immersed in a fluid: application to biofluid flows

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Particle-scale hemodynamical simulations have been performed over the years mostly in the non-inertial regime. Recent years have seen the development of solvers that consider the full Navier-Stokes equations and are capable of simulating flows laden with deformable capsules in the inertial regime. Stress-free equilibrium capsule shape can be either spherical or bi-concave, depending on the targeted application. There is still much to explore and understand, in particular to enhance the design of emerging inertial microfluidic devices or to improve targeted drug delivery efficiency. We investigate the dynamics of deformable capsules immersed in a Newtonian fluid in simple and complex domain geometries. We consider both non-inertial and inertial flow regimes. We leverage the power of parallel octree grid computing and deliver new insight on the dynamics of capsule suspensions. We discuss our most recent results on the suspension of spherical capsules in a simple shear flow, examine the problem of maximum deformation of multiple capsules flowing through a corner in a narrow square channel and show new results on the flow of deformable capsules in complex domain geometries. The numerical model is implemented in the plateform Basilisk and is fully open source. Future extension of the numerical model involves (i) considering non-Newtonian (and primarily viscoelastic) suspending fluids and (ii) adding other classes of particles such as rigid bodies of size comparable to the capsule size (to model white blood cells and platelets) and much smaller rigid bodies (to model drug nano-carriers).