Vesicles and Cells in Hydrodynamic Flows

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Abstract:
The flow behavior of cells and vesicles is important in many applications in biology and medicine. For example, the flow properties of blood in micro-vessels is determined by the rheological properties of the red blood cells. Furthermore, microfluidic devices have been developed recently, which allow the manipulation of small amounts of suspensions of particles or cells.
While the membrane of vesicles just consist of a fluid lipid bilayer, red blood cells have a composite membrane which has in addition an anchored polymer network. This implies that the elastic properties of vesicles and red blood cells are very different.
Due to the large length- and time-scale gap between the atomic and the mesoscopic domain in soft matter systems, several mesoscale simulation techniques have been developed in recent years to study their hydrodynamic behavior. We have investigated one of these techniques, multi-particle-collision dynamics [1], in some detail. In particular, it has been shown that the method properly describes hydrodynamic interactions at low Reynolds numbers, if the parameters are in an appropriate range [2]. This method has then be applied to study the dynamical bevavior of fluid vesicles and model red blood cells both in shear and capillary flows [3-5]. Several types of dynamical behaviors as well as shape transformations occur as a function of shear rate (or flow velocity), membrane viscosity and internal viscosity, which will be discussed in some detail.

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