Rheology and shear-induced diffusion of dense red blood cell suspensions

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Suspensions of soft particles are ubiquitous. One of the most popular and biologically important examples is blood which is a moderately dense (volume fraction 45%) suspension of red blood cells (RBCs) and other, less abundant constituents. While the rheology and shear-induced diffusion of hard sphere suspensions is relatively well understood, this is less so for suspensions of soft particles. Due to their deformability and aspherical shape, additional time scales and degrees of freedom are present and a theoretical description is more complicated.

In this talk we will present recent progress in the field, supported by combined lattice-Boltzmann-immersed boundary-finite-element computer simulations (Figure 1). Motivated by the dynamical properties of RBCs under confinement, it is possible to construct an effective theoretical model and to predict the viscosity of blood over a remarkably large parameter range, spanning several orders of magnitude in shear rate as well as volume fractions between 10 and 90%. The dependence on shear rate and volume fraction of the shear-induced diffusivity of RBCs can be largely understood by considering the solvent flow in the gaps between the particles. We recover canonical behaviour in the Newtonian regime and a characteristic power-law scaling at high volume fractions and shear rates. Our results are helpful to understand rheological effects in dense soft particle suspensions and to predict suspension properties based on their microscopic features and external control parameters.

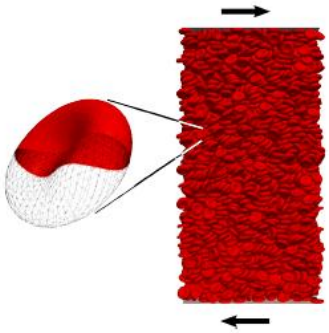

Figure 1: Dense RBC suspension under shear (right) and numerical mesh of a RBC (left).

[1] T. Krueger, M. Gross, D. Raabe, F. Varnik. Crossover from tumbling to tank-treading-like motion in dense simulated suspensions of red blood cells. Soft Matter 9, 9008-9015, 2013

[2] M. Gross, T. Krueger, F. Varnik. Rheology of dense suspensions of elastic capsules: yield stress, jamming and confinement effects. Submitted, http://arxiv.org/abs/1401.2914

[3] M. Gross, T. Krueger, F. Varnik. Fluctuations and diffusion in athermal suspensions of deformable particles. Submitted.