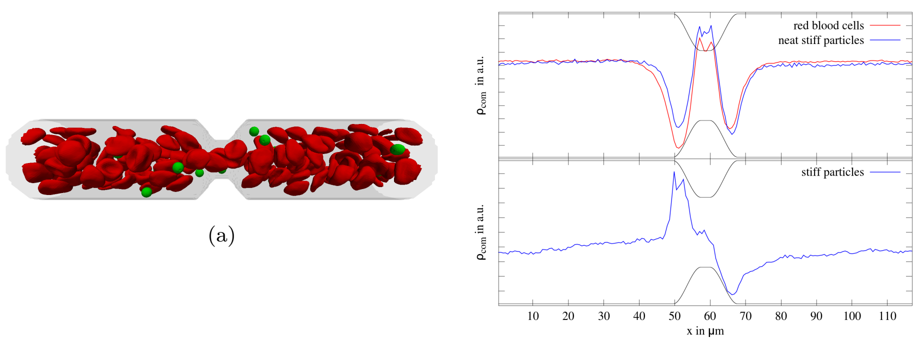
Clustering of microscopic particles in constricted blood flow

Christian Bächer[1] and Stephan Gekle[1]

[1] *Biofluid Simulation and Modeling, University of Bayreuth*



(a) (b)

Figure 1: (a) Stiff spherical particles in a red blood cell suspension flowing through a partially constricted cylinder. (b) In contrast to the red blood cells and neat stiff particles (top) the axial density of the stiff particles in red blood cell suspension increases in front of the constriction (bottom).

The margination, i.e. the cross-streamline migration, of particles stiffer than red blood cells, such as synthetic particles, white blood cells or platelets, in blood flow is well known by means of experiments and simulations. Flowing through a straight cylindrical channel the red blood cells migrate towards the channel center forming a cell-free layer near the channel wall. Due to collisions with the red blood cells stiff particles are expelled into the cell-free layer. It is at present unclear if and how a constriction, such as a pathological narrowing, influences the margination of synthesized particles, which could be used for drug delivery.

Here we use Lattice-Boltzmann simulations to investigate the margination of stiff spherical particles in a red blood cell suspension flowing through a cylindrical channel with a constriction (Fig. 1(a)). Flowing only the stiff particles through the constriction we find the axial density to decrease in front of the constriction (Fig. 1(b) top). The red blood cells exhibit the same behavior as the neat stiff particles. In contrast, in the system containing both the stiff particles and the red blood cells the stiff particle density increases in front of the constriction, i.e. the stiff particles cluster (Fig. 1(b) bottom). Consequently, the interplay of margination and the constriction acting as a barrier causes a clustering of the stiff spherical particles in front of the constriction. Furthermore we investigate the influence of the radius and length of the constricted part. Whereas the length of the constricted part slightly influences the clustering of the stiff particles a smaller radius causes the stiff particle density to increase more strongly.

A constriction strongly influences the margination of stiff synthetic particles. Because of biochemical reaction rates depending on the density, the clustering in front of the constriction could affect the interaction between the synthetic particles and the tissue in microcirculation.