PhD Project

Computational study of oxygen delivery by red blood cells

It has long been known that red blood cells (RBCs) exhibit a rich variety of dynamic modes of motion when flowing through the capillary network of the human body. The complete "phase diagram" of these shapes however has only been obtained fairly recently as illustrated in figure 1. It is a fascinating idea to think that nature may have specifically tailored these RBC dynamics in order to optimize their physiological function, i.e. delivery of oxygen to tissue. Currently however, all studies on oxygen transport completely ignore the RBC dynamics.

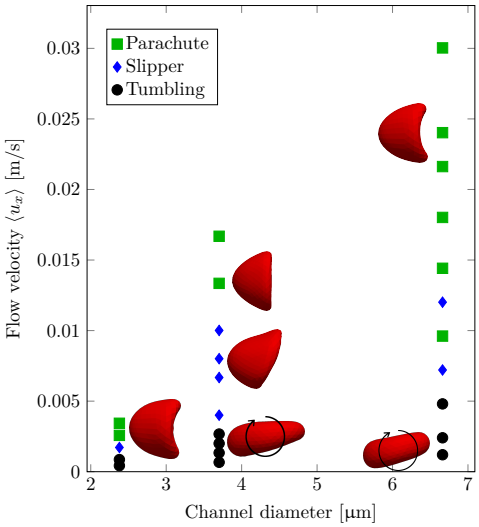

Fig. 1: Shapes of red blood cells flowing through a microchannel under different circumstances

The goal of the PhD project is to fill this gap by extending the Lattice-Boltzmann-immersed-boundary code of our group with a convection-diffusion-reaction (CDR) solver for predicting the local oxygen concentration and flow. For the oxygen concentration $c(\mathbf{x}, t)$, the CDR equation reads:

$$\frac{\partial c}{\partial t} + \mathbf{v} \cdot \nabla c - D\Delta c = R$$

where D is the diffusion coefficient and $\mathbf{v}$ is the local flow velocity. The right-hand side R contains a reaction term modeling absorption/release of oxygen by endothelial cells and hemoglobin. After implementation of this extension, the oxygen delivery by red blood cells will be studied in detail first for single cells and later for dense RBC suspensions as occuring in the microcirculation.

The required supercomputer ressources will be provided by the local computing cluster available at the University of Bayreuth as well as by projects on national supercomputing system such as SuperMUC (Garching) and JURECA (Jülich).

The successful candidate must possess a strong background in theoretical physics, numerical mathematics, computational engineering or a similar discipline. Interest in writing and using computer codes (C/C++) is required. A background in fluid mechanics or biology is desirable, but not explicitly required. Research will be conducted in the Biofluid Simulation and Modelling group at the University of Bayreuth, Germany. Bayreuth is a medium-sized town with a fairly large student population and is situated in a beautiful natural setting between the mountains of the "Fränkische Schweiz" and "Fichtelgebirge".

For applications or further information please contact: Stephan Gekle, stephan.gekle@uni-bayreuth.de or see our website biofluid.physik.uni-bayreuth.de