LadHyX Seminar – October 19, 10:45

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Transport and mixing of blood suspensions in the microcirculation

In this presentation, I will discuss the role of blood being a dense suspension of highly deformable red blood cells (RBCs) on two problems associated to the microcirculation.

First at the capillary scale, RBCs have to travel in reticulated networks of tiny vessels forcing the cells to deform in a rich variety of shapes to deliver gases of the respiration as close as possible to the cells of the organism. I will question how the cells interaction with individual nodes of a network contributes to the overall perfusion efficiency of blood. To investigate this "network rheology", I will present experiments on the flow of RBCs through uniform networks with varying geometry and topology that show how transport characteristics at the capillary scale are non-linear with the applied peripheral pressure. The flow increases for increasing pressure difference. This non-linearity depends not only on the volume fraction of RBCs but also on the topology of the network. Our first observations show that this is likely correlated to the local behavior of RBCs membrane as they travel through the network.

In the second part of the presentation, I aim to discuss the importance of blood being a well-mixed fluid at the arterio-venule scale of the microcirculation. Mixing at these small scales is indeed notoriously hard. This property of small-Reynolds-number flows is especially critical to overcome at the scale of the microcirculation in order for blood to transport nutrients and metabolic wastes in a well-mixed state. In vivo observations have shown how RBCs do not mix in vivo and mixing seems limited to pure diffusion. However, granular suspensions are known to present signs of shear-enhanced diffusion which could help mixing for blood suspensions which are however far from model granular systems. Using squared-cross-sectional microchannels, we investigate the mixing of fluorescent macromolecules in a suspension of RBCs with different volume fractions and flow rates around physiological values. Our experiments show that the mixing depends not only on the volume fraction of RBCs but also strongly on the flow rate. Mixing improves at higher flow rates for fixed volume fractions, and we found an optimum that maximizes mixing at the levels of volume fractions found in vivo. These trends are also observed in aggregated RBCs and is prominent in denser suspension. Our results suggest that RBCs not only are oxygen transporter but also help to maintain blood in a well-mixed state in microcirculatory flows.