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Peculiar distribution of RBCs in dilute suspensions: experiments and simulations

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The emerging microfluidic technology has provided a useful approach to explore the biomechanics and dynamics of red blood cells (RBCs) [1]. Here, we report an adverse effect found in microfluidic experiments of diluted blood, where counterintuitive cell distribution takes place: contrary to the normal distribution with RBCs concentrating in the centre of a microchannel, a peculiar bimodal profile is observed in our experiments using blood of low haematocrits. To reveal the underlying physics behind this phenomenon, high-fidelity computer simulations are performed, which successfully reproduce the cell distribution and suggest that the bimodality would persist for a long distance. For particle flows in microfluidics, entrance effects exist due to various factors such as inlet configuration and tubing connection, which will impose an impact on the initial status of particles. Ideally, such effects would vanish over some distance and the particle distribution far downstream can be fully developed. However, because of the weakened particle-particle interactions in a dilute suspension at low Reynolds number, the evolution of particle distribution is very slow and the memory of the initial status is retained even after several millimetres.

In this work, the microfluidic channels for experiments are designed following a biomimetic principle [2]. Numerical simulations are run with a computational model employing the immersed-boundary-lattice-Boltzmann method (IB-LBM) [3], which considers blood as a suspension of deformable RBCs. This model is developed on the basis of the highly parallel flow solver HemeLB (open source at http://ccs.chem.ucl.ac.uk/hemelb).

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