Life Sciences Seminar

Hydrodynamic simulations of swimming cells in biological fluids and networks

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Many cells in the human body have to move through dense complex fluids such as various cells in the extracellular matrix or bacteria in mucus. While the motion of swimming bacteria in simple Newtonian fluids can be well quantified using continuum low Reynolds number hydrodynamics, the presence of supramolecular elements such as biopolymers leads to a much more complex behavior. Although the presence of polymers generally lowers particle mobility, surprisingly, several experiments have shown that bacterial speeds increase in polymeric fluids, but there is no clear understanding why. We perform extensive coarse-grained MPCD simulations of a bacterium swimming in explicitly modeled solutions of supramolecular model polymers of different lengths, stiffness and densities [1]. We observe an increase of up to 60% in swimming speed with polymer density and show that this is a consequence of a non-uniform distribution of polymers in the vicinity of the bacterium leading to an effective slip. However, this alone cannot explain the large speed-up, but coupling to the chirality of the bacterial flagellum is essential. We also present results for swimming in crosslinked polymer networks where hydrodynamics is screened and the heterogeneous network microstructure induce a diverse migration behavior. Our approach can be used to study other important transport processes in biological fluids, such as sedimentation of differently shaped nano-and microparticles [2], which are of relevance for drug delivery through mucus or motion of food particles in the gut. Finally we suggest how our approach could be used to study physical principles of the migration of deformable cells in fibrous networks such as the extracellular matrix.[1] A. Zttl and J. M. Yeomans, Enhanced bacterial swimming speeds in macromolecular polymer solutions, Nature Physics 15, 554 (2019).[2] A. Zttl and J. M. Yeomans, Driven spheres, ellipsoids and rods in explicitly modeled polymer solutions, J. Phys.: Condens. Matter 31, 234001 (2019)

Tuesday, September 17, 2019 10:00am - 11:00am
Mondi Seminar Room 2, Central Building

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