Hydrodynamic simulations of microswimmers in complex environments

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The locomotion of microswimmers such as microorganisms or active colloids in viscous fluids is governed by low-Reynolds-number hydrodynamics and thermal noise. They are self-driven units which move autonomously by converting energy into directed movement, and are inherently out of equilibrium generating fascinating novel physical phenomena. In order to study the dynamics of microswimmers in complex environments mesoscale hydrodynamic simulation techniques are very useful. We are using multiparticle collision dynamics (MPCD) simulations which solve the Navier-Stokes equations on a coarse-grained level and include thermal noise. I will present results on the locomotion of spherical microswimmers in the presence of boundaries, and in Poiseuille flow, and show how hydrodynamic flow fields influence the collective behavior of active particles under confinement.

Interestingly, swimming bacteria such as Heliobacter Pylori or Pseudomonas aeruginosa, as well as sperm cells, are moving through viscoelastic fluids such as mucus in the human body. Theoretical models for these complex fluids are typically based on continuum equations which assume a constant density of sufficiently small polymers, homogeneously embedded in a Newtonian fluid. However, real viscoelastic fluids in the human body are less simple, i.e. they consist of heterogeneously distributed, up to micrometer long macromolecules such as mucin polymers. We will present first results of MPCD simulations of a flagellated bacterium swimming in an explicitly modeled polymer solution.