Active particle systems under gravity and in Poiseuille flow

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Systems of active particles or moving microorganisms have emerged recently as an attractive research direction. Since the systems reside constantly in non-equilibrium, novel phenomena and collective patterns are expected. The talk illustrates this with two examples.

We first consider theoretically the sedimentation of a dilute suspension of chemically powered colloids, so-called active Brownian particles, under gravity. This system has been studied experimentally and it was found that the sedimentation length increases with the propulsion velocity of the particles [1]. Based on a Smoluchowski equation for non-interacting active Brownian particles including rotational diffusion, we determine the steady sedimentation profile of the suspension both by perturbation analysis and by numerically solving the Smoluchowski equation [2]. We show that sedimentation is accompanied by polar order of the active particles, with the mean swimming velocity oriented against the gravitational field. We suggest realistic parameter values to observe this ordering which increases strongly with the particle radius. The origin of the predicted polar order is purely kinetic. It results from the active motion and is not due to any particle interactions. The same is true for an enhanced orientational ordering at surfaces, which we also predict together with a strong accumulation of particles, as observed in the experiment [1].

In the second example I demonstrate how microswimmers behave in a microchannel. This mimics, for example, a swimming microorganism in blood vessels. I present simulations for a model swimmer called squirmer but also discuss analytical predictions. In particular, I show that for strong Poiseuille flow, the motion of the microswimmer can be mapped onto the dynamics of a non-linear oscillator.

[1] J. Palacci, C. Cottin-Bizonne, C. Ybert, and L. Bocquet, Phys. Rev. Lett. **105**, 088304 (2010).
[2] M. Enculescu and H. Stark, to be published in Phys. Rev. Lett.