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Self-propelled magnets - from magnetotactic bacteria to magnetic active matter

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Active, directional self-propulsion is crucial for many microscopic organisms as well as for applications of synthetic biohybrid micro-robotic devices. Magnetic fields provide a promising guiding mechanism that allows for the remote control of the direction of motion. This mechanism is explored in micro-robots, but has also evolved in natural microorganisms, a prominent example being magnetotactic bacteria, which orient in magnetic fields with the help of a chain of magnetic organelles called magnetosomes[1]. I will give an overview on some experiments on the motility of magnetotactic bacteria and how this motion can be modeled by Active Brownian Particles with a magnetic dipole moment. Specifically, I will focus on motion in complex environments based on experiments in microfluidic systems. These experiments have shown that interactions with walls result in alignment along the wall and potentially against the magnetic field, so complex dynamical behavior arises from the competition of the two types of alignment. These behaviors include U-turn trajectories in circular chambers and trapping and escape dynamics in channels with overlapping cylindrical obstacles [2]. In a phenomenological picture, the resulting motion can be described in an Active Brownian Particle model by introducing a wall torque that competes with the magnetic torque. This wall torque can be inferred from trajectories. Interactions between such self-propelled dipolar particles (with and without an external magnetic field) result in a variety of patterns, at least in simulations [3]. These patterns are characterized three types of ordering: clustering, chain formation and alignment.

References

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