BP 10: Self Propulsion

Time: Tuesday 14:00–15:00 Location: C 243

BP 10.1 Tue 14:00 C 243

Cilia Dynamics — •Jens Elgeti and Gerhard Gompper — Institut für Festkörperforschung, Forschungszentrum Jülich, 52425 Jülich, Germany

Cilia are hair-like extensions of some cells that propel fluid over its surface by performing a whip-like motion. Cilia appear in many places in nature, e.g. to remove mucus from the human respiratory system, or on the surface of *Paramecium.*

We present simulation results for a two-dimensional array of autonomously beating cilia, solely coupled by hydrodynamic interactions. These hydrodynamic interactions are sufficient to lead to synchronization of cilia motion in the form of a "metachronal wave". We show that the metachronal wave enhances velocity and efficiency of solute transport compared to synchronously beating cilia. The transport velocity increases up to a factor of 3, when the cilia are packed more densely, while transport efficiency increases almost an order of magnitude.

Furthermore, we characterize transport and wave properties as functions of the viscosity, effective stroke direction and cilia spacing. For example, we show that the main correlation direction roughly coincides with the effective stroke direction, and that the beat frequency decreases through metachronal coordination while the energy consumption per beat is largely independent of cilia spacing, effective stroke direction, and metachronal coordination.

We believe, that for the fitness of the cell, both the efficiency and especially the transport velocity are essential. The metachronal wave pattern is thus of great functional significance for ciliated cells.

BP 10.2 Tue 14:15 C 243

Theory and simulation of artificial cilia — •Matthew Downton and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin, Germany

We present simulations that explore the possibility of creating magnetically actuated artificial cilia. Motivated by experiments on an artificial swimmer[1,2], we analyse a model that consists of a simple bead-spring chain interacting with an external magnetic field able to induce a magnetic moment in the beads. Low Reynolds number hydrodynamic interactions are introduced at the Rotne-Prager level and different beating kinematics of the filament are studied by varying the time dependence of the applied field. We examine separate cases of the beating pattern of individual filaments and use a measure of propulsion to study their ability to transport fluid. The behavior of multiple interacting filaments is also studied. By choosing the phases of the actuating magnetic fields separately for each filament, we are able to study how phase shifts between neighboring filaments influence the dissipated energy and the propulsive performance of several filaments. This might be important for the understanding of the so-called metachronal waves that occur in fields of biological cilia.

[1] Dreyfus et al., Nature, 437, 862 (2005)
[2] Gauger and Stark, Phys. Rev. E, 74, 021907 (2006)

BP 10.3 Tue 14:30 C 243

Orientational ordering and clustering in a simple model of self-propelled particles — Fernando Peruani[1,2,3], Andreas Deutsch[2], and •Markus Bär[3] — [1]MPIPKS Dresden — [2]TU Dresden — [3]PTB Berlin

We study the emergence of collective effects in a two-dimensional stochastic systems of self-propelled particles interacting locally through an apolar, liquid crystal-based alignment mechanism. In the model particles are driven at constant speed and align their direction of motion to the local director. We show through extensive simulations hat the behavior of the system at high and low densities is remarkably different. At high density orientational order emerges upon decrease of the noise strength. The phase transition appears to be of mean-field type. In contrast at low density, an instability leading to inhomogeneous particle density and clustering is found upon decrease of the noise strength. A comparison between active and diffusive particles reveals that diffusive particles can exhibit orientational order for high densities in a similar fashion as self-propelled particles, while clustering at low densities and related orientational order is absent low densities.

BP 10.4 Tue 14:45 C 243

Diffusion in different models of active Brownian particles of relevance in biological self-propelled motion — •Ernesto M. Nicola and Benjamin Lindner — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany

Self-propelled motion is one of the most fascinating aspects of biological systems. This motion can appear in many different biological contexts either inside cells or on the multi-cellular level. Simple phenomenological models can help to understand the dynamics of self-propelled entities and their statistics (including their transport properties). One class of models successfully studied during the last 15 years are active Brownian particles (ABP). Here we study, both theoretically and numerically, the effective diffusion coefficient of one-dimensional ABP models. We show that, depending on the choice of the friction function, the diffusion coefficient does or does not attain a minimum as a function of noise intensity. We furthermore discuss the case of an additional bias breaking the left-right symmetry of the system. We show that this bias induces a drift and that it generally reduces the diffusion coefficient. For a finite range of values of the bias, the models can exhibit a maximum in the diffusion coefficient vs. noise intensity.