BP 29: Active Matter 5 - organized by Carsten Beta (Potsdam), Andreas Menzel (Magdeburg) and Holger Stark (Berlin) (joint session DY/BP)

Time: Wednesday 14:30–15:50 Location: DYb

BP 29.1 Wed 14:30 DYb

Barrier-mediated predator-prey dynamics — •Fabian Jan Schwarzendahl and Hartmut Löwen — Institut für Theoretische Physik II: Weiche Materie, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany

The survival chance of a prey chased by a predator depends not only on their relative speeds but importantly also on the local environment they have to face. For example, a wolf chasing a deer might no be able to cross a river which can be crossed by the deer. Here, we propose a simple predator-prey model for a situation in which both the escaping prey and the chasing predator have to surmount an energetic barrier. Different barrier-assisted states of catching or final escaping are classified and suitable scaling laws separating these two states are derived. We discuss the effects of diffusion on the catching times and determine states in which catching or escaping is more likely. Including hydrodynamic and chemotactic interactions, we further identify trapping or escaping states which are determined by hydrodynamics and chemotaxis. Our results are of importance for both microbes and self-propelled unanimous microparticles following each other by nonreciprocal interactions in inhomogeneous landscapes.

BP 29.2 Wed 14:50 DYb

Irreversibility of active particles: Fluctuation Theorem and Mutual Information — Lennart Dabelow[1], •Stefano Bo[2], and Ralf Eichhorn[3] — [1]Fakultät für Physik, Universität Bielefeld — [2]Max Planck Institute for the Physics of Complex Systems — [3]Nordita, Royal Institute of Technology and Stockholm University

The defining feature of active particles is that they locally consume energy, which enables them to self-propel and prevents them from equilibrating with their thermal environment. Within the framework of active Ornstein-Uhlenbeck particles we derive the path probability of a particle subject to both, thermal and active noise. By comparing the path probabilities for observing a particle trajectory forward in time versus observing its time-reserved twin trajectory we obtain a generalized "entropy production" for active Brownian motion, which fulfills an integral fluctuation theorem. We show that those parts of this "entropy production", which are different from the usual dissipation of heat in the thermal environment, can be associated with the mutual information between the particle trajectory and the history of the non-equilibrium environment. We then investigate the time-reversal properties of steady-state trajectories of a trapped active particle. We find that steady-state trajectories in a harmonic potential fulfill pathwise time-reversal symmetry exactly despite their active nature, while this symmetry is typically broken in anharmonic potentials.

BP 29.3 Wed 15:10 DYb

Shape-anisotropic Microswimmers: Influence of Hydrodynamics — •Arne W. Zantop and Holger Stark — Institute of Theoretical Physics, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

Constituents of active matter, e.g. bacteria or active filaments, are often elongated in shape. The shape and the stiffness of the active components clearly influence their individual dynamics and collective pattern formation. On length scales much larger than the size of the constituents, active materials exhibit many fascinating phenomena such as the formation of vortices or turbulent structures [1,2]. To identify how steric and hydrodynamic interactions as well as thermal fluctuations influence collective behavior is subject of current research. In this context, we model shape-anisotropic microswimmers with rod shape by composing them of overlapping spherical squirmers. We simulate their hydrodynamic flow fields using the method of multi-particle collision dynamics. With increasing aspect ratio of the rods, we find that a force quadrupole moment dominates the hydrodynamic flow field, whereas in quasi-2D confinement between two parallel plates (Hele-Shaw geometry) the far field is determined by a two-dimensional source dipole moment [3]. Investigating the collective dynamics of the squirmer rods, we identify with increasing density and aspect ratio of the rods a disordered, a swarming, and a jamming state.

[1] Dunkel *et al.*, Phys. Rev. Lett. **110**, 228102 (2013)
[2] Wensink *et al.*, Proc. Natl. Acad. Sci. **109**, 14308-14313 (2012)
[3] A. W. Zantop and H. Stark, Soft Matter **16**, 6400-6412 (2020)

BP 29.4 Wed 15:30 DYb

Feedback Control of Multiple Active Microswimmers — •Alexander Fischer[1], Giovanni Volpe[2], and Frank Cichos[1] — [1]Peter Debye Institute for Soft Matter Physics, Universität Leipzig — [2]Physics Department, Gothenburg University

Sensing and reacting to signals is a fundamental component of life. The exchange of information is used to organize ensembles of active objects into collective states that appear as flocks, swarms or even tissue. Here we explore the emergent collective behavior as a result of an information exchange between synthetic microswimmers by computer-controlled feedback processes. We have created a setup where multiple active microswimmers can respond to local signals in space or their distance to other microswimmers [1]. Our system consists of symmetric self-thermophoretic swimmers that are propelled by light-to-heat conversion allowing us to implement almost arbitrary control of propulsion speed and direction. Using this system, we study in particular the delayed response of the swimmers to environmental signals, where the swimmers remember previous information on a signaling landscape or infers future signals from experience. We find that this type of delayed response is modifying the collective behavior enhancing local swimmer densities depending on delay time, extrapolation or memory and the rotational diffusion time. Our data suggest the existence of optimal delays for the given landscapes.

[1] U. Khadka, V. Holubec, H. Yang, F. Cichos, Nat. Commun. 9, 3864 (2018)