DY 54: Poster: Active Matter and Microswimmers (joint session DY/TT)

Time: Thursday 15:00–18:00 Location: P1A

DY 54.1 Thu 15:00 P1A

Colloidal rods with visual perception: a simple cone of sight model. — •Anton Lüders, Philipp Stengele, and Peter Nielaba — Universität Konstanz, Konstanz, Deutschland

We introduce a simple model system of two-dimensional colloidal spherocylinders which become self-propelled under visual stimuli triggered by their neighboring particles. Via conventional Brownian dynamics simulations, the clustering phenomena and the collective motion in systems of multiple colloidal rods with visual perception are analyzed. In our model system, every particle is linked to a predefined cone of sight. A specific particle moves according to active Brownian motion if there is another particle's center inside the corresponding cone of sight but fluctuates according to normal passive Brownian motion otherwise. By analyzing the clustering phenomena of large systems we find a regime dominated by a clustering mechanism characteristic for the rods with visual perception in the range of small number densities. This regime leads to an unusual enhancement of the mean cluster size by reducing the number density of the system. Furthermore, it is studied how a small number of grouped spherocylinders with visual perception spread inside an infinite system. We find that the dynamics of rods inside this system is based on metastable states of passive Brownian motion and small flocks of activated particles. The dynamics of the particles inside the infinite system is further compared to more complex model systems of colloidal spherocylinders with visual perception.

DY 54.2 Thu 15:00 P1A

Inertial effects in collective microswimmer hydrodynamics — •Jan Cammann and Michael Wilczek — Max Planck Institute for Dynamics and Self-Organization, Göttingen

Microswimmers, such as bacteria, sperm cells, and motile algae, are typically found in regimes where the relevant length and velocity scales allow their hydrodynamic interactions to be studied in the limit of low Reynolds numbers. This simplifies the Navier-Stokes to the Stokes equations. In this approximation, inertial effects are completely neglected. For individual swimmers, this approximation is known to work well, whereas for the collective motion of a large number of swimmers the situation is less clear. For dense suspensions, the hydrodynamic flows produced by the individuals may interfere constructively, making inertial effects relevant. To elucidate this, we perform direct numerical simulations of swimmers immersed in a fluid described by either the Navier-Stokes or the Stokes equations. By directly comparing the dynamical properties, we probe the limits of this approximation for the collective hydrodynamics.

DY 54.3 Thu 15:00 P1A

Target search of active agents in complex environments. — •Luigi Zanovello[1,2], Michele Caraglio[1], Pietro Faccioli[2], and Thomas Franosch[1] — [1]Institut für Theoretische Physik, Universität Innsbruck, Technikerstraße 21A, A-6020 Innsbruck, Austria — [2]Statistical and Biological Physics Group, Dipartimento di Fisica, Università degli studi di Trento, Via Sommarive 14, 38123 Trento, Italy

Often living microorganisms, i.e. bacteria, move in complex landscapes in search of some target, i.e. nutrients, and use self propulsion to optimize their search.

Transport properties of single active Brownian particles in disordered environments are here investigated by computer simulations. Typically, in such random environments many paths exist connecting a starting region to the target. Furthermore, reaching the target likely involves the overcome of many barriers, which introduces a separation of time scales and makes the target search a rare event. Thus, with naive brute force molecular dynamics, characterizing the transition paths ensemble can be very demanding, if not unfeasible.

To cope with these issues, we design enhanced sampling techniques for active Brownian particles, which are inspired from methods used for the determination of rate constants in chemical reactions and protein folding. In particular, we design an active particle's version of transition path sampling and self-consistent path sampling. As a case study, the transition paths properties of active particles are compared with those of passive ones in simple potential landscapes with few local minima.

DY 54.4 Thu 15:00 P1A

Shearing an Active Glass — •Rituparno Mandal[1] and Peter Sollich[1,2] — [1]Institut für Theoretische Physik, Göttingen, Germany — [2]King's College London, London, United Kingdom

Recent experiments and simulations have revealed glassy features of cytoplasm, tissues and dense assemblies of self propelled colloids. This prompts the fundamental question of whether non-equilibrium (active) amorphous materials are essentially equivalent to their passive counterparts, or whether they can present qualitatively different behaviour. To tackle this challenge we investigate the yielding and mechanical behaviour of a model active glass former, a Kob-Andersen glass in two dimensions where each particle is driven by a constant propulsion force whose direction varies diffusively over time. Using extensive Molecular Dynamics simulations, we focus in particular on the effects of the intermittent dynamics in the regime of highly persistent activity and reveal a novel type of shear induced orientational ordering in the system.

DY 54.5 Thu 15:00 P1A

Collective behaviour of self-propelled elliptical particles — •Ashreya Jayaram, Andreas Fischer, and Thomas Speck — Institute of Physics, Johannes Gutenberg-University Mainz, Germany

Ensembles of anisotropic self-propelled particles exhibit a rich variety of emergent phases. A combination of short-ranged excluded volume interactions, which induce inter-particle forces and torques, and self-propulsion determines the resulting macroscopic structure. Starting from a point in parameter-space which displays motility-induced phase separation (MIPS) for isotropic particles, we systematically increase the aspect ratio of the constituent ellipses. On doing so, first, MIPS breaks down paving way to a spatially homogeneous state comprising polar domains. Secondly, at sufficiently large aspect ratios, particles aggregate into polar bands. We rationalize these observations from simulations by extracting two effective parameters, *viz.*, the force imbalance coefficient and the coupling to the local polarization, that enter the mean-field description of the system.

DY 54.6 Thu 15:00 P1A

Chimera states and waves in cilia arrays — •Albert von Kenne, Markus Bär, and Thomas Niedermayer — Physikalisch-Technische Budesanstallt (PTB), Berlin 10587

The study of coupled oscillators revealed a multitude of collective dynamics including synchronous motion, asynchronous motion, wave-like motion and a peculiar synchronization pattern known as chimera state. Here, a population of identical oscillators branches into coexisting subpopulations that are synchronized and desynchronized, respectively. Particularly, the constituents of living matter often exhibit cyclic processes with a tendency to synchronize. For example motile cilia and flagella – hair-like projections of eukaryotic cells that push fluid in motion to cause transport phenomena. We study numerically a generalized version of a simple phase oscillator model for the coupling of cilia. The model is linked to wave formation [1] and encompasses the features relevant for the emergence of chimera states [2]. We investigate chimera states and waves in cilia arrays and discuss its properties with respect to transport generation and switching of motility states.

[1] Niedermayer et. al., Chaos: 18(3) 2008; [2] Niedermayer et. al., DPG Spring Meeting 2017: Contributed talk DY 52.1

DY 54.7 Thu 15:00 P1A

Nanoscale Temperature Imaging using Liquid Crystal Phase Transitions — •Martin Fränzl and Frank Cichos — Molecular Nanophotonics Group, Peter Debye Institute for Soft Matter Physics, Universität Leipzig, Germany

With the growing number of applications of thermoplasmonics in a variety of different fields there is a need to for a simple and reliable temperature measurement of optically heated metal nanostructure. We present a method to study such temperature distributions at the nanoscale utilizing the 5CB liquid crystal nematic-isotropic phase transition. The technique is based on a conventional optical microscopy and capable of imaging isothermal contours around heated nanostructures as well as to retrieve the absolute temperature increment. The setup is easy to implement with any conventional optical microscope requiring no external modifications of additional components. We demonstrate our technique for various plasmonic nanostructures such as gold nanoparticles, Janus particles and continuous gold films. The spatial resolution of this technique is diffraction limited and temperature variations smaller than 0.1 K can be detected.

DY 54.8 Thu 15:00 P1A

Random Caustics in active random walks in random environments — •King Hang Mok[1,2] and Ragnar Fleischmann[1] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation, Göttingen, Germany — [2]Institut für Dynamik komplexer Systeme, Georg-August-Universität Göttingen

The trail patterns of Argentine ants can show striking resemblance to the branched flow patterns of waves in correlated random environments. Branched flow is a general phenomenon that is widely observable in nature, such as in the electron flow in semiconductors, tsunami waves in the ocean or the propagation of light and sound through turbulent media. An important mechanism in branched flows is the formation of random caustics, singularities in the ray density corresponding to the wave flow.

We study the density fluctuations of active random walks biased by correlated random environments, resembling the motion of Argentine ants in Gaussian random fields of pheromones. We analyse in which parameter regimes reminiscences of the caustics of the deterministic dynamics in quenched disorder can be observed in the random walk.

DY 54.9 Thu 15:00 P1A

Can a passive colloid in an active bath be modeled as an active Brownian particle? — •Jeanine Shea[1], Friederike Schmid[1], and Gerhard Jung[2] — [1]Johannes Gutenberg University — [2]University of Innsbruck

Passive colloids in baths of active particles exhibit vastly different behavior than passive colloids in thermal baths. In particular, Wu and Libchaber [1] found experimentally that a passive colloid immersed in an active bath exhibits superdiffusive behavior on short time scales and normal diffusive behavior in the long-time limit. This behavior is analogous to that of an active particle, which is characterized by this transition between superdiffusive and diffusive behavior. Although Wu and Libchaber were able to relate this crossover time to experimental observables such as the length scale of collective motion, they did not explicitly relate the parameters of the system of active particles, such as the density, the rotational diffusion coefficient, or the force of active particles, to this characteristic crossover time. We investigate the detailed mechanisms that lead to the "activity" of the passive colloid and aim to explicitly map the dynamics of a passive colloid in an active bath to the model of an Active Brownian Particle.

[1] Wu, X.-L., and A. Libchaber, 2000, "Particle diffusion in a quasi-two-dimensional bacterial bath," Phys. Rev. Lett. 84, 3017-3020.