BP 25: Active Matter DY III (joint session DY/CPP/BP)

Time: Wednesday 15:30–18:45 Location: BH-N 243

BP 25.1 Wed 15:30 BH-N 243

Three-body correlations and conditional forces in suspensions of active hard disks — •Andreas Härtel[1], David Richard[2], and Thomas Speck[2] — [1]University of Freiburg, Freiburg, Germany — [2]Johannes Gutenberg-University Mainz, Mainz, Germany

Self-propelled Brownian particles show rich out-of-equilibrium physics, but while decades of studying the structure of liquids have build up a deep understanding of passive systems, not much is known about correlations in active suspensions. For this reason, we derive an approximate analytic theory for three-body correlations and forces in systems of active Brownian disks starting from the many-body Smoluchowski equation. Via this theory we discuss properties of conditional three-body forces, an effective swimming speed, and pair distributions. We further test and validate our theory using particle-resolved computer simulations. They allow us to discuss the modeling of active Brownian swimmers with nearly hard interaction potentials. We finally define appropriate parameters to describe active systems and discuss them as a basis for further studies of correlations in active suspensions and for an emerging liquid state-theory.

BP 25.2 Wed 15:45 BH-N 243

Giant Kovacs-Like Memory Effect for Active Particles — •Rüdiger Kürsten[1], Vladimir Sushkov[2], and Thomas Ihle[1] — [1]Universität Greifswald — [2]Hochschule für angewandte Wissenschaften München

Dynamical properties of self-propelled particles obeying a bounded confidence rule [1] are investigated by means of kinetic theory and agent-based simulations. While memory effects are observed in disordered systems, we show that they also occur in active matter systems [2]. In particular, we find that the system exhibits a giant Kovacs-like memory effect that is much larger than predicted by a generic linear theory. Based on a separation of time scales we develop a nonlinear theory to explain this effect. We apply this theory to driven granular gases and propose further applications to spin glasses.

[1] Phys. Rev. E 90, 063315 (2014)
[2] Phys. Rev. Lett. 119, 188001 (2017)

BP 25.3 Wed 16:00 BH-N 243

Active Brownian Particles in Crowded Media — •Jonathan Ónody[1], Alexander Liluashvili[1], and Thomas Voigtmann[1,2] — [1]Deutsches Zentrum für Luft- und Raumfahrt e.V, Köln, Deutschland — [2]Fachgruppe Physik, Heinrich-Heine Universität, Düsseldorf, Deutschland

We investigate the dynamics of model microswimmers (active Brownian particles) evolving at high densities and in the presence of crowding, i.e., in model porous media, making use of the mode-coupling theory of the glass transition (MCT). The microswimmers are modeled by hard disks in two dimensions undergoing both, translational and rotational diffusion. In addition they posses a constant self-propulsion velocity in their direction of orientation. MCT predicts an idealized active-glass transition, and we discuss the features of the slow dynamics emerging close to that transition. The porous background is treated as a frozen disordered density field. We discuss the structure of the resulting theory, distinguishing between connected and disconnected parts of the correlation functions.

1. Liluashvili, A., Ónody, J., and Voigtmann, Th., Mode Coupling Theory for Active Brownian Particles, Phys. Rev. E in press, arXiv:1707.07373 (2017).
2. Krakoviack, V., Mode-coupling theory for the slow collective dynamics of fluids adsorbed in disordered porous media, Phys. Rev. E 75, 031503 (2007).
3. Götze, W., Complex Dynamics of Glass-Forming Liquids - A Mode-Coupling Theory

BP 25.4 Wed 16:15 BH-N 243

Cans and cannots of heat engines with nonequilibrium baths — •stefano steffenoni[1], viktor holubec[2], gianmaria falasco[3], and klaus kroy[2] — [1]Max Planck for the Mathematics in the Science, leipzig — [2]Institute for Theoretic Physics, Leipzig — [3]University of Luxembourg, Luxembourg

We investigate a heat engine based on a Brownian colloid, confined in a parabolic potential and coupled to an active particles bath. The energetics of the cycle is governed by the variance of the colloid distribution. With a suitable definition of a time-dependent effective temperature, it obeys the same dynamical equation as a passive colloid coupled to a conventional thermal bath. Performance of the active heat engine including maximum efficiency, efficiency at maximum power and maximum efficiency at a fixed power can thus all be understood from ordinary thermodynamics, using the appropriate effective temperature. On this basis, we provide a thorough analysis of recent experiments (Krishnamurty et al. Nat. Phys. 2016) that lead to the spectacular claim that thermodynamic cycles coupled to active baths can surpass the ultimate efficiency of an equilibrium Stirling cycle.

BP 25.5 Wed 16:30 BH-N 243

Dynamics of self-propelled granular particles on a vibrated plate — •Tina Hanselka and Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg

Screws sliding on a periodically vibrating plate can be used as a very simple model system to examine the motion of self-propelled particles in 2D. We analyze the active Brownian motion a single screw performs, then we explore the self-organization of large groups of particles, focusing on mixtures between active and passive materials, realized by screw nuts of comparable weights.

15 min. break

BP 25.6 Wed 17:00 BH-N 243

Diffusive dynamics of complex colloidal particles in active suspensions of microswimmers — •Florian von Rüling, Francine Kolley, Patricia Dähmlow, Hajnalka Nadasi, and Alexey Eremin — Otto von Guericke University Magdeburg

We report experimental studies on the active motion of puller-type microswimmers Chlamydomonas reinhardtii (C.R.) and the entrainment and the diffusion of complex passive particles in thin capillaries. C.R., self-propelled unicellular alga, swims in the regime of low Reynolds number due to its flagellar motion breaking time-reversal symmetry. Having an eyespot, the alga shows phototactic behaviour. Employing a particle tracking algorithm and polarising microscopy, we explore the enhancement of the diffusion of the sphere- and rod-shaped particles by swimming algae. Furthermore, we demonstrate the effect of the microswimmer-induced flow on the director field of nematic droplets dispersed in the active colloid.

BP 25.7 Wed 17:15 BH-N 243

Self-spinning particles phase separate and move collectively — •Christian Scholz[2,1], Michael Engel[1], and Thorsten Pöschel[1] — [1]Institute for Multiscale Simulation, FAU Erlangen, Germany — [2]Institut für Theoretische Physik 2, HHU Düsseldorf, Germany

We create 3d-printed minimalistic robots that perform self-spinning motion. Binary mixtures of clockwise and counter-clockwise spinning particles phase separate and exhibit collective ballistic motion along the interfaces. We compare our experimental system to Langevin simulations to demonstrate that our macroscopic system is a form of active soft matter. Simulations also allow us to demonstrate that confinement in the system, on long time scales, favors symmetric demixing patterns.

BP 25.8 Wed 17:30 BH-N 243

Entropy production of active particles and for particles in active baths — •Patrick Pietzonka[1,2] and Udo Seifert[1] — [1]II. Institut für Theoretische Physik, Universität Stuttgart, Germany — [2]Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK

Entropy production of an active particle in an external potential is identified through a thermodynamically consistent minimal lattice model that includes the chemical reaction providing the propulsion and ordinary translational noise. In the continuum limit, a unique expression follows, comprising a direct contribution from the active process and an indirect contribution from ordinary diffusive motion. From the corresponding Langevin equation, this physical entropy production cannot be inferred through the conventional, yet here ambiguous, comparison of forward and time-reversed trajectories. Generalizations to several interacting active particles and passive particles in a bath of active ones are presented explicitly, further ones are briefly indicated. [1] P. Pietzonka and U. Seifert, J. Phys. A: Math. Theor. **51**, 01LT01 (2018)

BP 25.9 Wed 17:45 BH-N 243

Binary Mixtures of Active and Passive Particles — •Francesco Alaimo[1,2] and Axel Voigt[1,2,3] — [1]Institut für Wissenschaftliches Rechnen, TU Dresden, Dresden, Germany — [2]Dresden Center for Computational Materials Science (DCMS), TU Dresden, Dresden, Germany — [3]Center for Systems Biology Dresden (CSBD), Dresden, Germany

We use a modification of the Binary Phase Field Crystal model to introduce a continuous approach for binary mixtures of passive and active particles.

This continuous model is used to numerically study different effects that arise in binary mixtures. First, we see how activity promotes crystallization and cluster formation in a passive system, a phenomenon that has been observed experimentally. By varying the relative densities we can observe how passive obstacles influence the dynamics of active particles. Finally, we show how, under specific conditions, a crowded environment can lead to a partial trapping of active particles.

BP 25.10 Wed 18:00 BH-N 243

Phase diagram, capillary waves, and interfacial stiffness of active-passive polymer mixtures — •Jan Smrek, Kostas Daoulas, and Kurt Kremer — Max Planck Institute for Polymer Research, Mainz, Germany

The active-passive polymer mixtures serve as a model for phase separation of transcriptionally active and inactive DNA strands in nuclei of living cells. Is it possible to distinguish the equilibrium phase separation, driven by chemical differences, from the non-equilibrium one? Here, we study the interfacial properties of the phase separated steady states of the scalar active-passive polymer mixtures. We construct phase diagrams and extract the analogue of the equilibrium critical exponent β governing the density difference. Looking at the interface fluctuations, we find they follow the equilibrium capillary waves spectrum. This allows us to establish a mechanistic definition of the non-equilibrium interfacial stiffness and its dependence on the activity asymmetry. We show how the interfacial width depends on the activity ratio and comment on the finite size effects. Our results show the non-equilibrium steady state behaves in many respects as an equilibrium polymer mixture with LCST.

BP 25.11 Wed 18:15 BH-N 243

High-motility light-driven AgCl Janus microswimmers interacting with passive beads — •xu wang[1], Larysa Baraban[2], Annie T. Phuong Nguyen[2], Jin Ge[1], Vyacheslav Misko[3], Gianaurelio Cuniberti[2], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany — [2]Institute for Materials Science and Max Bergmann Center of Biomaterials, Dresden University of Technology, 01062 Dresden, Germany — [3]Department Fysica, Universiteit Antwerpen, B-2020 Antwerpen, Belgium

Visible light driven nano/micro swimmers are promising candidates for potential biomedical and environmental applications, which have been highlighted in the study of manmade nanao/micro swimmers stimulated by versatile light sources.1-5 To increase the motile speed, Janus polystyrene (PS)/AgCl microswimmers have been developed, which are capable to be actuated and tuned by blue light and achieve a high moving speed with 7 μm/s in pure water. To understand the interaction mechanism between artificial microswimmers and the surrounding environment, with the stimuli of blue light, prepared clusters composed of different numbers of Janus PS/AgCl particles and PS beads are used as active and passive motile objectives for sub-systematic models. The dynamics of a single Janus particle, single Janus particles assemblies, collective behaviours have been investigated and demonstrated both with experimental and simulated results.

BP 25.12 Wed 18:30 BH-N 243

High-motility visible light-driven AgCl Janus microswimmers interacting with passive beads — •Xu Wang[1], Larysa Baraban[2], Annie T. Phuong Nguyen[2], Jin Ge[1], Vyacheslav Misko[3], Gianaurelio Cuniberti[2], Jürgen Fassbender[1], and Denys Makarov[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf e.V., Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, 01328 Dresden, Germany — [2]Dresden University of Technology, 01062 Dresden, Germany — [3]Universiteit Antwerpen, B-2020 Antwerpen, Belgium

Visible light driven nano/micro swimmers are promising candidates for different applications. However, the previous obtained mean squared displacement (MSD) values are low (up to 200 squared micrometers (10 s)) even under the favorable UV light illumination.[1,2] This is a severe drawback for the applications where the efficient transport of microswimmers is demanded.

We demonstrate AgCl based spherical Janus microswimmers reveal an efficient propulsion under blue (visible) light (λ=450-490 nm)illumination. The proper design of a AgCl based microswimmer can boost the MSD to 3000 squared micrometers (10 s) in pure H2O. We investigate the motion of individual Janus particles as well as their small (3-particles) and large (many particles) clusters. With experimental results and numerical simulations (by Langevin equations), we provide an insight into the collective behavior of the Janus microswimmers surrounded by polystyrene (PS) beads.

1. Angew.Chem.Int.Ed. 2009,48,3308. 2. ChemNanoMat 2017,3,65.