DY 44: Active Matter C (joint session DY/CPP)

Time: Thursday 10:00–12:45 Location: H19

DY 44.1 Thu 10:00 H19

Self-propelled Janus particles in evaporating droplets — Maziyar Jalaal[1,2], Borge Ten Hagen[1], Hai Le The[3], Christian Diddens[1], Detlef Lohse[1,2], and •Alvaro Marin[1] — [1]Physics of Fluids, University of Twente, The Netherlands — [2]Max-Planck Center for Complex Fluid Dynamics, University of Twente, The Netherlands — [3]BIOS-Lab on a Chip, University of Twente, The Netherlands

According the kids britannica encyclopedia: "Living things have the ability to move in some way without outside help.". Following this precise definition, artificial self-propelled particles are not alive, but they almost are since they move taking advantage of chemical/physical reactions or more complex interactions with their environment. Such active particles have been developed and thoroughly characterized in recent years *in vitro*: in either quiescent liquid media or stationary flow fields. However, in most situations *living things* encounter unsteady flows and interfaces of different types. To approach more realistic situations, we choose to study the dynamics of self-propelling Janus particles in evaporating droplets. Our system consists on polysterene-platinum Janus colloids immersed in a sessile droplet containing an hydrogen peroxide solution. The system is analyzed using three-dimensional particle tracking measurements and numerical simulations of the nontrivial fluid flow within the evaporating droplet. To our surprise, the dynamics of the active particles turns to be extremely rich due to several mechanisms as the proximity to interfaces, concentration gradients and evaporation-driven flows.

DY 44.2 Thu 10:15 H19

Tuning propulsion modes in active emulsions — •Corinna C. Maass, Babak Vajdi Hokmabad, and Kyle A. Baldwin — Max-Planck-Institut für Dynamik und Selbstorganisation

Single cell organisms show a variety of swimming behaviours: e.g. persistent, helical, run-and-tumble or switch-and-flick, all dependent on intricate biophysical machinery and serving various strategies of navigation, e.g. persistence against external flow, efficiency of gradient sensing or expanding their range of exploration. Their locomotion has to adapt to low Reynolds numbers, highly viscous or non-Newtonian environments. An important aspect to the construction of biomimetic model swimmers is to mimic as many of those strategies as possible, based on simple principles of non equilibrium physics without requiring intricate biochemical machinery. Here, we investigate the dynamics of active droplets dependent on the viscosity of the bulk phase. We can tune their propulsion from almost ballistic persistence over a quite diffusive "run-and-spiral" mode to a "stop-and-go" behaviour that is noisy on short, but persistent on long time scales, simply by changing the composition of the bulk phase with a varying fraction of glycerol. Such unsteady swimming is caused by a dynamic instability in the chemical and hydrodynamic fields around the droplets which we have mapped simultaneously via multichannel fluorescent video microscopy.

DY 44.3 Thu 10:30 H19

Swimming droplet in confined geometries — •Charlotte de Blois, Mathilde Reyssat, and Olivier Dauchot — Gulliver Laboratory, UMR CNRS 7083, ESPCI Paris, PSL University

Micro-swimmers rarely evolve in a 3D infinite and unbounded medium. Instead, they are confined by external geometries which strongly modify their behavior. There is however no exact theoretical knowledge of the flow fields in this context and experimental data are scarce. Here we consider a swimming water droplet [1], denser than the continuous phase, in confined geometries from 2D motion parallel to a bottom wall to 1D motion in capillaries. [1] Izri et al. PRL 113, 248302 (2014).

DY 44.4 Thu 10:45 H19

Active liquid crystal shells: stability and dynamics — •Babak Vajdi Hokmabad, Kyle A. Baldwin, Carsten Krüger, Christian Bahr, and Corinna C. Maass — Max Planck Institute for Dynamics and Self-organization

Production of controllable, active microcapsules is of great interest in synthetic biology and microchemistry. Inactive microcapsules, also known as double emulsions or droplet shells, are already widely used as artificial cells, micro-reactors, and in food and drug applications. However, combining activity, stability, and control remains a significant challenge. Using established concepts of active emulsions we have developed a new approach to the problem of encapsulation by using nematic active double emulsions, where a solubilization mechanism induces activity and the molecular nematicity provides stability. We show that using a nematic liquid crystal as the shell material and imposing homeotropic anchoring at both interfaces will result in a nematoelastic force on the internal droplet and act as a topological barrier against the coalescence of the core droplet with the outer phase. We further present a peculiar self-propulsion mode where the interplay of spontaneous symmetry breaking and autochemotaxis results in a "shark-fin meandering" motion of the shell in a 2D-confined geometry and a helical swimming in 3D. This behavior can be controlled or switched off by introducing chemical gradients, topographical guidance or through shell topology variation.

DY 44.5 Thu 11:00 H19

Flow of active granular particles through a bottleneck — •Tina Hanselka and Ralf Stannarius — Otto-von-Guericke-Universität Magdeburg

We use screws performing a self-propelled motion on a vibrated plate as a simple model to analyze the collective behavior of active matter systems passing through a constriction. For this we employ a slight tilt of the plate to simulate an effective gravity and to give the particles a preferred direction towards the bottleneck, and we examine the characteristics of flow and clogging as a function of geometrical and driving parameters.

15 min. break

DY 44.6 Thu 11:30 H19

Autonomous engines driven by active matter: Energetics and design principles — •Patrick Pietzonka[1], Etienne Fodor[1], Christoph Lohrmann[2], Michael E. Cates[1], and Udo Seifert[2] — [1]Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK — [2]II. Institut für Theoretische Physik, Universität Stuttgart, Germany

We explore how active matter in a non-equilibrium steady state can autonomously deliver mechanical work against a constant mechanical force or torque. For this purpose, we consider systems that contain one or several active components and a single passive component that is asymmetric in its geometrical shape or its interactions. Generally, one expects that such an asymmetry leads to a persistent, directed current in the passive component, which can be used for the extraction of work. We show which two-dimensional shapes of the passive particle are best suited for the extraction of work. Approximating their effect on the dynamics of the particles leads to analytical results for the power and efficiency. A mean field approach reveals that the interaction with the passive particle can mediate cooperativity between otherwise non-interacting active particles, leading to an enhanced efficiency.

DY 44.7 Thu 11:45 H19

Pair-distribution function of active Brownian particles in three spatial dimensions* — •Stephan Bröker, Jens Bickmann, and Raphael Wittkowski — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany

The pair-distribution function is a key quantity for analyzing many-particle systems. It characterizes the particle configuration and is often required when describing such systems via field theories. While for passive particles this correlation function has been extensively studied and analytical approaches exist for it, little is known about the pair-distribution function for active particles.
Therefore, based on Brownian dynamics simulations, we have determined the full pair-distribution function of a homogeneous system of spherical active Brownian particles in three spatial dimensions. The full pair-distribution function takes not only the positions, but also the orientations of the particles into account and depends additionally on the speed and mean concentration of the particles. We discuss the structure of this function and present an analytical expression that represents the function with good accuracy. In addition, we present a new field theory for active Brownian particles that uses this expression. Our results will be beneficial for future research that aims at describing the collective dynamics of active Brownian particles or at developing methods for predicting the pair-distribution function in nonequilibrium

many-particle systems.
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DY 44.8 Thu 12:00 H19

Locomotion of self-acoustophoretic colloidal particles — •Johannes Voss and Raphael Wittkowski — Institut für Theoretische Physik, Westfälische Wilhelms-Universität Münster, D-48149 Münster, Germany

During the last two decades, a large number of different realizations of artificial self-propelled colloidal particles has been developed. A particularly advantageous realization is given by self-acoustophoretic colloidal particles, which exhibit self-propulsion when they are exposed to ultrasound. Compared to other types of artificial self-propelled particles, they have a biocompatible propulsion mechanism and can move in various liquids and soft materials. Furthermore, they can permanently be supplied with energy and, via the ultrasound intensity, it is even possible to adjust their speed. This makes self-acoustophoretic particles relevant for potential applications in, for example, medicine and materials science. Up to now, however, these particles have not been investigated in depth. Even the details of their propulsion mechanism are still unclear.

Therefore, based on direct computational fluid dynamics simulations, we have extensively studied the locomotion of self-acoustophoretic colloidal particles. We present results that explain the self-propulsion mechanism of these particles and how their locomotion depends on the shape and other properties of the particles. Our results are helpful especially for future experimental work further investigating or applying self-acoustophoretic colloidal particles.

DY 44.9 Thu 12:15 H19

Pairing, waltzing and scattering of chemotactic active colloids — •Suropriya Saha[1], Sriram Ramaswamy[2], Ramin Golestanian[1], and Ramin Golestanian[1] — [1]Max Planck Institute for Dynamics and Self-Organization, Am Faßberg 17 37077 Göttingen — [2]Indian Institute of Science, Bangalore, India

Two chemotactic active colloids, which can rotate their polar axis to align with an imposed chemical gradient, form bound states by cancellation of velocities. Their interactions are dynamical in origin, with contributions from self-propulsion and phoretic response to chemical field generated by each other, are thus non-central and non-reciprocal. Two swimmers remain bound at long times when the chemotactic response of at least one of the swimmers is positive, i.e. it rotates its polar axis to point up a linear gradient. These bound states fall in two broad categories *(i) active dimers, separation fixed and polar axes orient along a line (ii) periodic orbits, relative inclination of the polar axes fixed, while the centre of mass executes cyclic motion. Chemotactic swimmers unbind and scatter away depending on initial conditions or with an increase of self-propulsion; while mutually anti-chemotactic swimmers always scatter away. These findings are summarized in state diagrams and representative trajectories are calculated to illustrate the rich dynamics. For the special case of a swimmer moving in a localised source of fuel, the fixed points underlying the bound states and the bifurcations that lead to transition between from one type of f inal state to another are classified.

DY 44.10 Thu 12:30 H19

Diffusion of active particles in a complex environment: role of surface scattering — •Theresa Jakuszeit, Ottavio A. Croze, and Samuel Bell — Cavendish Laboratory, University of Cambridge, Cambridge CB3 0HE, U.K

Microfluidic experiments have shown that self-propelled particles can slide along the surface of a circular obstacle without becoming trapped over long times for obstacles below a critical radius. Using simulations and theory, we study the impact of different boundary conditions on the diffusive transport of active particles in a lattice of such obstacles. We find that particle dynamics with sliding boundary conditions can result in large diffusivities even at high obstacle density, unlike classical specular reflection as in the Lorentz gas. These dynamics are very well described by a model based on Run-and-Tumble particles with microscopically derived tumbling frequencies and reorientation functions arising from obstacle-induced tumbles. This model, however, fails to describe fine structure in the diffusivity at high obstacle density predicted by simulations. Using a simple deterministic model, we show that this structure results from particles being guided by the lattice.