BP 17: Microswimmers II (Joint Session DY/BP)

Time: Tuesday 14:30–15:45 Location: HÜL 186

BP 17.1 Tue 14:30 HÜL 186

Self-propelled Janus Droplets: Properties and Applications — •Leonard Li[1], Mahmoud Hosseinzadeh[1], Martin Brinkmann[1], Ignacio Pagonabarraga[2], Ralf Seemann[1], and Jean-Baptiste Fleury[1] — [1]Saarland University, 66123 Saarbrücken, Germany — [2]University of Barcelona, 08028 Barcelona, Spain

We report the existence of a new type of self-propelling Janus droplets in a continuous oil/surfactant solution. At start, the self-propulsion originates from a Marangoni flow generated by the solvent solubilization into the oily phase. During active motion, the droplets absorb a large amount of surfactant, which is preferentially soluble in the solvent phase. This surfactant adsorption into the droplet and the loss of solvent from the droplet lead, after some time, to spontaneous water/solvent phase separation and the formation of Janus droplet. In the Janus state, the solvent-rich droplet acts as a sink for the surfactant molecules, which get transported to and dissolved in the trailing droplet and thus drive the locomotion. Depending on initial solvent concentration the time before phase separation and thus the duration in the different propulsion regimes and with it different delivery modes can be programmed. After describing the properties of these active janus droplets, we will present their possible applications.

BP 17.2 Tue 14:45 HÜL 186

Collective dynamics of active emulsions under light sheet microscopy — •Babak Vajdi Hokmabad, Carsten Krüger, and Corinna Maass — MPI for Dynamics and Self Organization, Göttingen

Liquid crystal droplets exhibit Marangoni-flow-induced self-propulsion in an aqueous surfactant solution well above the critical micelle concentration. We can mass produce identical droplets with biomimetic properties, rendering these artificial swimmers promising experimental models to investigate the collective dynamics of biological microswimmers. We have previously shown that dimensional confinement plays a crucial role in the collective behavior of such active emulsions.

We study the collective dynamics of dense droplets ensembles in various conditions of number density, swimmer speed and buoyancy, resulting in effects like clustering and caging, using a custom built light sheet fluorescence microscope. A macroscopic sample volume, containing several hundred swimmers, is scanned via a system of a synchronized thin laser sheet and selective plane microscope, and individual trajectories for multiple swimmers can be recorded over long time scales.

BP 17.3 Tue 15:00 HÜL 186

Chemotaxis and auto-chemotaxis of self-propelling droplets — Chenyu Jin, Carsten Krüger, and •Corinna Maass — MPI for Dynamics and Self Organization, Göttingen

Chemotaxis and auto-chemotaxis are key mechanisms in the dynamics of micro-organisms. However, chemical signalling and the natural environment of biological swimmers are generally complex, making them hard to access analytically. Simple artificial systems showing biomimetic features can provide vital insights. We present self-propelling droplet swimmers with both chemotactic and autochemotactic properties, as well as microfluidic assays to study them quantitatively and reproducibly.

We demonstrate chemotaxis by guiding droplets through mazes in the presence of a chemical gradient.

To study auto-chemotaxis, we let swimmers pass through bifurcating microfluidic channels and record anticorrelations between the branch choices of consecutive droplets. We present an analytical model balancing a Brownian process versus a diffusion-governed gradient force able to explain our experimental findings.

BP 17.4 Tue 15:15 HÜL 186

Extreme fluctuations of active Brownian motion — •Patrick Pietzonka, Kevin Kleinbeck, and Udo Seifert — II. Institut für theoretische Physik, Universität Stuttgart

In active Brownian motion, an internal propulsion mechanism interacts with translational and rotational thermal noise and other internal fluctuations to produce directed motion. We derive the distribution of its extreme fluctuations and identify its universal properties using large deviation theory [1]. The limits of slow and fast internal dynamics give rise to a kink-like and parabolic behavior of the corresponding rate functions, respectively. For dipolar Janus particles in two- and three-dimensions interacting with a field, we predict a novel symmetry akin to, but different from, the one related to entropy production. Measurements of these extreme fluctuations could thus be used to infer properties of the underlying, often hidden, network of states.

[1] P. Pietzonka, K. Kleinbeck, U. Seifert, New. J. Phys. **18**, 052001 (2016)

BP 17.5 Tue 15:30 HÜL 186

Collective Sedimentation of Squirmers under Gravity — •Jan-Timm Kuhr, Felix Rühle, Johannes Blaschke, and Holger Stark — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

Biological microswimmers such as algae or plankton experience gravity. Recent theoretical studies on the sedimentation of microswimmers often explore the dilute case, where hydrodynamic and steric interactions between them can be neglected [1,2]. We apply parallelized MPCD simulations to study sedimentation of spherical squirmers under gravity and thereby explicitly include long-ranged hydrodynamic interactions also with bounding surfaces. We measure density profiles for systems of thousands of microswimmers and analyze how the ratio of active velocity to passive sedimentation velocity as well as the squirmer type (neutral, pusher, and puller) affect sedimentation.

Lower regions of the system are dominated by incomplete hexagonal layer formation with distinct orientation, whereas we recover an exponential density profile in the upper, less dense region. The average vertical orientation of the squirmers depends strongly on their vertical position as well as their type. Furthermore, we find that hydrodynamics organizes the microswimmers into convection cells, the strength of which changes with squirmer type and influences the sedimentation length.

[1] M. Enculescu and H. Stark, Phys. Rev. Lett. **107**, 058301 (2011).
[2] K. Wolff, A. Hahn, and H. Stark, Eur. Phys. J. E **36**, 43 (2013).