CPP 6: Active Matter 1 (joint session BP/CPP/DY)

Time: Monday 10:30–12:45 Location: H16

Invited Talk CPP 6.1 Mon 10:30 H16

Computer simulations of self-motile active droplets and colloid-active gels composites — •Davide Davide Marenduzzo — School of Physics and Astronomy, University of Edinburgh, Edinburgh, UK

In this talk we will show results from computer simulations probing the behaviour of composite materials based on active gels.

In the first part of the talk we will investigate the behavior of active nematic or cholesteric droplets inside an isotropic fluid. In different regions of parameter space, we find regular motility and chaotic behaviour, and discuss the relevance of these results to biophysical systems such as microbial motility.

In the second part of the talk, we will study the dynamics of a dispersion of passive colloidal particles in an active nematic host. We find that activity induces a dynamic clustering of colloids even in the absence of any preferential anchoring of the active nematic director at the particle surface. When such an anchoring is present, active stresses instead compete with elastic forces and re-disperse the aggregates observed in passive colloid-liquid crystal composites.

CPP 6.2 Mon 11:00 H16

Chloroplasts in dark-adapted plants show active glassy behavior — •Nico Schramma, Cintia Perugachi Israëls, and Mazi Jalaal — University of Amsterdam, Amsterdam, Netherlands

Photosynthesis in plants is one of the main drivers for the survival of whole ecosystems on earth. To guarantee the efficiency of this process, plants have to actively adapt to ever-changing light conditions. On large time scales plants can grow towards the light. However, this process is too slow to adapt towards transient stimuli. To do this plants can re-arrange the intracellular structure by the active motion of chloroplasts on short timescales. These organelles are confined between the cell membrane and vacuole and can move inside the cytoplasm via actin polymerization forces. Remarkably, the simple - yet elegant - interplay of light-sensing and active forces leads to various modes of collective motion. Here, we show that the chloroplasts under dark conditions are densely packed systems, driven by a-thermal noise and can exhibit active glassy motion. Furthermore, we aim to establish chloroplast motion as a new framework to study the dynamics of light-controlled dense biological systems featuring intriguing dynamic phase transitions.

CPP 6.3 Mon 11:15 H16

Activity-induced polar patterns of filaments gliding on a sphere — •Chiao-Peng Hsu, Alfredo Sciortino, Yu Alice de la Trobe, and Andreas Bausch — Center for Protein Assemblies and Lehrstuhl für Zellbiophysik E27, Physics Department, Technische Universität München, Garching, Germany

Active matter systems feature the ability to form collective patterns as observed in a plethora of living systems, from schools of fish to swimming bacteria. While many of these systems move in a wide, three-dimensional environment, several biological systems are confined by a curved topology. The role played by a non-Euclidean geometry on the self-organization of active systems is not yet fully understood, and few experimental systems are available to study it. Here, we introduce an experimental setup in which actin filaments glide on the inner surface of a spherical lipid vesicle, thus embedding them in a curved geometry. We show that filaments self-assemble into polar, elongated structures and that, when these match the size of the spherical geometry, both confinement and topological constraints become relevant for the emergent patterns, leading to the formation of polar vortices and jammed states. These results experimentally demonstrate that activity-induced complex patterns can be shaped by spherical confinement and topology.

15 min. break

CPP 6.4 Mon 11:45 H16

The effect of chiral flows on pattern formation on active cell surfaces — Lucas Wittwer[2], Eloy de Kinkelder[1], and •Sebastian Aland[1,2] — [1]TU Freiberg — [2]HTW Dresden

Mechanochemical processes play a crucial role during morphogenesis, the formation of complex shapes and tissues out of a single cell. On the cellular level, the actomyosin cortex governs shape and shape changes. This thin layer of active material underneath the cell surface exerts an active contractile tension, the strength of which being controlled by the concentration of force-generating molecules. Advective transport of such molecules leads to a complex interplay of hydrodynamics and molecule concentration which gives rise to pattern formation and self-organized shape dynamics. In this talk, we present a novel numerical model to simulate an active viscoelastic surface immersed in viscous fluids. The resulting patterning, flows and cell shape dynamics are shown for different parameter configurations. It is further demonstrated that adding a chiral (i.e. counter-rotating) force at the cell surface can promote a ring of high molecule concentration and facilitate cell division.

CPP 6.5 Mon 12:00 H16

Premelting controlled active matter in ice — •Jeremy Vachier[1] and John S. Wettlaufer[1,2] — [1]Nordita, KTH Royal Institute of Technology and Stockholm University, Hannes Alfvéns väg 12, SE-106 91 Stockholm, Sweden — [2]Yale University, New Haven, Connecticut 06520-8109, USA

Self-propelled particles can undergo complex dynamics due to a range of bulk and surface interactions. In the case of a foreign particle inside a subfreezing solid, such as a particle in ice, a premelted film can form around it allowing the particle to migrate under the influence of an external temperature gradient, which is a phenomenon called thermal regelation. It has recently been shown that the migration of particles of a biological origin can accelerate melting in a column of ice and thereby migrate faster. We have previously shown that the effect of regelation plays a major role in the migration of inert particles and impurities inside ice, with important environmental implications. In particular, the question of how the activity affects a particle's position over time is essential for paleoclimate dating methods in ice cores. We re-cast this class of regelation phenomena in the stochastic framework of active Ornstein-Uhlenbeck dynamics and make predictions relevant to this and related problems of interest in geophysical and biological problems.

CPP 6.6 Mon 12:15 H16

Emergent collective behavior of active Brownian particles with visual perception — •Rajendra Singh Negi, Roland G. Winker, and Gerhard Gompper — Theoretical Physics of Living Matter, Institute of Biological Information Processing (IBI-5), Forschungszentrum Jülich, 52425 Jülich, Germany

Collective behavior of self-propelled agents emerges from the dynamic response of individuals to various input signals [1,2]. One such input signal is visual perception. We explore the behavior of a model of self-steering active Brownian particles with visual perception in two dimensions [3]. Several non-equilibrium structures like motile worms, worm-aggregate coexistence, aggregates, and a dilute-gas phase are obtained, depending on the system parameters. The strength of the response to the visual signal, vision angle, packing fraction,rotational diffusion, and activity (velocity v_0) determine the location and extent of these phases in the phase diagram. The radius-of-gyration tensor is used to distinguish between the worm and the aggregate phase. Our results help to understand the collective behavior of cognitive self-propelled particles, like animal herds and micro-robotic swarms.

[1]. J. Elgeti, R. G. Winkler, and G. Gompper, Rep. Prog. Phys. **78**, 056601 (2015).
[2]. M. R. Shaebani, A. Wysocki, R. G. Winkler, G. Gompper, and H. Rieger, Nat. Rev. Phys. **2**, 181 (2020).
[3]. L. Barberis and F. Peruani, Phys. Rev. Lett. **117**, 248001 (2016).

CPP 6.7 Mon 12:30 H16

Diffusiophoretic propulsion of an isotropic active particle near a finite-sized disk — •Abdallah Daddi-Moussa-Ider[1], Andrej Vilfan[1,2], and Ramin Golestanian[1,3] — [1]Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [2]Jozef Stefan Institute, 1000 Ljubljana, Slovenia — [3]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford OX1 3PU, United Kingdom

We employ a far-field analytical model to quantify the leading-order contribution to the induced phoretic velocity of an isotropic active colloid near a finite-sized disk of circular shape resting on an interface separating two immiscible viscous incompressible Newtonian fluids. To this aim, we formulate the solution of the phoretic problem as a mixed-boundary-value problem which we then transform into a system of dual integral equations on the inner and outer domains. Depending on the ratio of different involved viscosities and solute solubilities, the sign of phoretic mobility and chemical activity, as well as the ratio of particle-interface distance to the radius of the disk, we find the isotropic active particle to be repelled from the interface, be attracted to it, or reach a stable hovering state and remain immobile near the interface. Our results may prove useful in controlling and guiding the motion of self-propelled phoretic active particles near aqueous interfaces.

Reference: A. Daddi-Moussa-Ider, A. Vilfan, and R. Golestanian, *J. Fluid Mech.* **940** A12 (2022)