

BP 28: Active Matter 4 - organized by Carsten Beta (Potsdam), Andreas Menzel (Magdeburg) and Holger Stark (Berlin) (joint session DY/BP)

Time: Wednesday 11:00–13:00

Location: DYb

BP 28.1 Wed 11:00 DYb

Wrinkling instability in 3D active nematics — TOBIAS STRUEBING, AMIR KHOSRAVANIZADEH, ANDREJ VILFAN, EBERHARD BODENSCHATZ, RAMIN GOLESTANIAN, and ●ISABELLA GUIDO — Max Planck Institute for Dynamics and Self-Organization, Goettingen, Germany

Networks of biopolymers and motor proteins are useful model systems for the understanding of emergent behaviour of active matter. An interesting class of such systems comprises active nematics, fluids constituted by self-organising elongated particles that in-vitro assemble in dynamical structures at length scales larger than those of their components by several orders of magnitude. In the last years the active nematic behaviour of biopolymer-motor networks confined on a 2D substrate was reported. Here we present an experimental and theoretical study on 3D active nematics made of microtubules, kinesin-1 motor proteins and a depleting agent. The network is subjected to the force exerted by the motors that crosslinked the filaments and let them slide against each other. In this way the system evolves toward a flattened and contracted 2D sheet that undergoes a wrinkling instability in the third dimension and subsequently transitions into an active turbulent state. We observe that the wrinkle wavelength is independent of the ATP concentration. A theoretical model describes its relation with the appearance time and a numerical simulation confirms the key role of kinesin motors in the contraction and extension of the network. Finally, we show how motor concentration and environmental cues influence the network properties

BP 28.2 Wed 11:20 DYb

A minimal model for dynamical symmetry breaking in active matter — MATTHEW DAVISON and ●PATRICK PIETZONKA — Department of Applied Mathematics and Theoretical Physics, University of Cambridge, UK

It is well known that asymmetrically shaped passive particles immersed in active matter move in a persistent direction. Recent work provides a thermodynamic framework and design principles for engines exploiting this mechanism [1]. We build on these results and reveal that symmetric passive particles in contact with active matter perform such a persistent motion as well. Its direction is determined through spontaneous symmetry breaking and remains fixed in time in the limit of a large number of active particles. We present an analytically solvable one-dimensional model for a single passive particle interacting with many active particles, which provides a physical understanding of these effects.

[1] P. Pietzonka *et al.*, Phys. Rev. X **9**, 041032 (2019)

BP 28.3 Wed 11:40 DYb

Boundary-interior principle for microbial navigation in complex geometries — ●JAN CAMMANN^{1,2}, FABIAN JAN SCHWARZENDAHL^{2,3}, TANYA OSTAPENKO², DANYLO LAVRENTOVICH², OLIVER BÄUMCHEN^{2,4}, and MARCO G. MAZZA^{1,2} — ¹Loughborough University, UK — ²Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — ³Heinrich-Heine-Universität, Düsseldorf, Germany — ⁴University of Bayreuth, Germany

Microswimmers have attracted considerable interest due to the biological and ecological implications of understanding the mechanisms governing their dynamics. The motion of a motile cell appears erratic, and yet the combination of nonequilibrium forces and surfaces can produce striking examples of organization in microbial systems. While our current understanding is based on bulk systems or idealized geometries, it remains elusive how self-organization emerges in complex geometries. In this talk I will describe experiments, analytical and numerical calculations [1] to study the motion of motile cells in complex geometries, and demonstrate that a robust topology of probability flux loops organizes active motion even at the level of a single cell in an isolated habitat. Accounting for the interplay of activity and interfacial forces, we find that the boundary's curvature determines the nonequilibrium probability fluxes. We predict a universal relation between fluxes and global geometric properties that is confirmed by experiments.

[1] J. Cammann, et al. "Boundary-interior principle for microbial

navigation in geometric confinement." arXiv:2011.02811 (2020).

BP 28.4 Wed 12:00 DYb

The role of inertia in active nematic turbulence — ●COLIN-MARIUS KOCH and MICHAEL WILCZEK — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Suspensions of active agents with nematic interactions can exhibit complex spatio-temporal dynamics such as mesoscale turbulence. Continuum descriptions for such systems are inspired by the hydrodynamic theory of liquid crystals and introduce additional effects of active stresses. The resulting equations feature an advective nonlinearity which represents inertial effects. The typically low Reynolds number of such active flows raises the question of the importance of the inertial effects. To address this question, we investigate mesoscale turbulence in a two-dimensional dense suspension of active nematic liquid crystals. We compare numerical simulations with and without nonlinear advection of the flow field. We find that for sufficiently high activity, the simulations including nonlinear advection exhibit large-scale motion which is not observed when excluding advection. Performing a spectral analysis of the energy budget, we identify an inverse energy transfer to the largest scales highlighting the importance of inertial effects in this model. We additionally show that surface friction, mimicked by a linear friction term, dissipates the transported energy and suppresses the large-scale motion.

BP 28.5 Wed 12:20 DYb

Rheotaxis of active droplets in confinements — ●RANABIR DEY^{1,2}, CAROLA M. BUNESS^{1,3}, BABAK VAJDI HOKMABAD¹, CHENYU JIN^{1,4}, and CORINNA C. MAASS^{1,3,5} — ¹Max Planck Institute for Dynamics and Self-Organization, Germany — ²Indian Institute of Technology Hyderabad, India — ³Georg August Universität Göttingen — ⁴University of Bayreuth, Germany — ⁵University of Twente, the Netherlands

Biological microswimmers commonly navigate confined spaces having liquid flows, e.g. locomotions of spermatozoa through the reproductive tract and bacteria in the gut. The directed motion of the microorganisms in response to the external velocity gradients is classically referred to as 'rheotaxis'. Over the last few years, rigorous efforts have been made to understand the rheotaxis of microorganisms, specifically bacteria. In contrast, there is very little quantitative understanding of rheotaxis of artificial microswimmers. It must be noted that artificial microswimmers, e.g. those designed for cargo delivery, are often required to navigate confinements having external flows. Here, we elucidate the swimming dynamics of a common type of artificial microswimmer, i.e. active droplets, in micro-confinements having Poiseuille flow. We experimentally quantify the the swimming characteristics of these droplet microswimmers in response to velocity gradients of varying strength. We also try to understand the observed rheotaxis in confinements by considering the long range hydrodynamic interactions with the confining walls.

BP 28.6 Wed 12:40 DYb

Collective search strategies — ●ADAM WYSOCKI and HEIKO RIEGER — Department of Theoretical Physics and Center for Biophysics, Universität des Saarlandes, Saarbrücken, Germany

How long does it take to find N targets by M searchers? This question arises, for example, if animals search for food or immune cells chase for pathogens (our main motivation). The usual goal is to minimize the time needed to catch all targets. One obvious possibility would be to increase the number of ideal searchers another to search collectively by utilizing communication between the searchers. It is known, that cells of the immune system talk to and influence one another by secreting small proteins that bind to and activate each other. For instance, T cells (a type of lymphocyte) are chemotactic, i.e. they move in response to a chemical stimulus, however, it is unknown if chemotaxis is important in the coordination of the search for pathogens. We use a simulation model of chemotactic active particles together with a self-generated chemorepellent in order to test the possibility and the benefit of collective search strategies in microbiological systems.