DY 20: Active Matter B (joint session DY/CPP)

Time: Tuesday 14:00–15:45 Location: H3

DY 20.1 Tue 14:00 H3

Collective behavior of active colloids in confined viscoelastic fluids — •N Narinder[1], Mahsa Sahebdivani[1], Juan Ruben Gomez-Solano[2], and Clemens Bechinger[1] — [1]Fachbereich Physik, Universität Konstanz, Konstanz, Germany — [2]Instituto de Física, Universidad Nacional Autónoma de México, México.

The natural habitat of microorganisms is complex not only in geometrical aspects but also in the sense that it is viscoelastic [1]. The fundamental question to address is what prime role such sophisticated surroundings play. To uncover this, we experimentally study the motion of light activated Janus particles in a viscoelastic fluid inside hard wall circular confinements. Unlike a Newtonian liquid [2], we observe that particles in viscoelastic fluids [3] experience an elastic repulsion from the walls which strongly depends on their activity and the elasticity of the surrounding fluid. Furthermore, strongly confined many-particle system inside circular pores exhibits a transition from liquid-like to a well-organized crystal-like behavior upon increasing the activity of particles. A further increase in activity liquifies the system and thus a reentrant liquid-like behavior is observed.

[1] J. Elgeti, R. G. Winkler, and G. Gompper, Rep. Prog. Phys. 78, 056601 (2015).
[2] G. Volpe, I. Buttinoni, D. Vogt, H. Kümmerer and C. Bechinger, Soft Matter 7, 8810 (2011).
[3] N. Narinder, C. Bechinger, and J. R. Gomez-Solano, Phys. Rev. Lett. 121, 078003 (2018).

DY 20.2 Tue 14:15 H3

Two-step melting in two-dimensional active matter — Juliane Klamser[1], •Sebastian Kapfer[2], and Werner Krauth[1] — [1]Laboratoire de Physique Statistique, Département de physique de l'ENS, Ecole Normale Supérieure, Paris, France — [2]Theoretische Physik 1, FAU Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany

Phase transitions in active matter offer a window to study the elusive critical phenomena outside equilibrium and have taken the center stage of studies in modern statistical physics. We present a kinetic Monte Carlo model of interacting active particles which can be connected to the equilibrium phase diagram. Using extensive numerical simulations, we show that this active model exhibits a rich phase behavior, including liquid-gas coexistence (motility induced phase separation) and the first ever evidence of two-stage melting via solid-hexatic-liquid outside equilibrium.

DY 20.3 Tue 14:30 H3

Self-organized large-scale order in active fluids — Martin James[1,2], Dominik Suchla[1,2], and •Michael Wilczek[1] — [1]Max-Planck-Institut für Dynamik and Selbstorganisation, Göttingen — [2]Georg-August-Universität Göttingen

Active fluids, such as dense suspensions of bacteria or microtubules and molecular motors, display a fascinating range of dynamical states. Active stresses exerted by the individual agents, along with their hydrodynamic interactions, generically lead to the emergence of mesoscale vortex patterns reminiscent of two-dimensional turbulence. In this presentation, we discuss how ordered flows emerge in a minimal continuum model of active fluids. In particular, we focus on a novel type of turbulence-driven pattern formation: a self-organized, dynamic vortex crystal. Crucially, this state emerges from an extended disordered transient characterized by an upscale energy transfer. Exploring the transition from active turbulence to the vortex crystal state with a focus on the role of fluctuations and system size, we find surprising analogies to classical phase transitions. For example, we observe locally ordered crystal domains, which share similarities with magnetic domains in ferromagnetic materials, separated by turbulent boundaries. Our results therefore explore one route to self-organization in active flows.

DY 20.4 Tue 14:45 H3

Dynamics of confined phoretic colloids — •Prathyusha Kokkoorakunnel Ramankutty, Suropriya Saha, and Ramin Golestanian — Max Planck Institue for Dynamics and Self Organization, Am Fassberg 17, Gottingen, Germany

Phoretic colloids are known to form clusters by mechanisms similar to those in black holes formed by long ranged gravitational forces. The long ranged interactions are driven by phoretic response of one colloid to the chemical field generated by others. We investigate the dynamics of uniformly coated colloidal assembly in a confined geometry using Brownian dynamics simulation. In steady state, the colloids self assemble to form a cluster and exhibits slow spontaneous fluctuations. The interesting cluster dynamics is studied as a function of number of particles and strength of phoretic interaction. The mean square displacement shows distinct plateaus indicating cage breaking dynamics.

DY 20.5 Tue 15:00 H3

Continuum model for active polar fluids with density variations — •Vasco M. Worlitzer[1], Avraham Be'er[2], Gil Ariel[3], Markus Bär[1], Holger Stark[4], and Sebastian Heidenreich[1] — [1]Department of Mathematical Modelling and Data Analysis, Physikalisch-Technische Bundesanstalt, 10597 Berlin, Germany — [2]Zuckerberg Institute for Water Research, The Jacob Blaustein Intitutes for Desert Research, Ben-Gurion University, Sede Boqer Campus, Midreshet Ben-Gurion, Israel — [3]Department of Mathematics, Bar-Ilan University, Ramat Gan, Israel — [4]Institute of Theoretical Physics, Technical University of Berlin, 10623 Berlin, Germany

Bacterial suspensions are intriguing examples for active polar fluids which exhibit large scale collective behavior from mesoscale turbulence to vortex lattices. For dense bacterial suspensions an effective fourth-order polar field theory was introduced modelling the collective dynamics in agreement with experimental findings [1,2]. However, in recent experiments of Bacillus subtilis suspensions anomalous velocity statistics and density variations are found which are not captured by the theory. In our contribution, we present a phenomenological theory for an active polar fluid with density and swimmer-velocity variations. We show that these variations result in an anomalous velocity statistics as observed in recent experiments [3].

[1] J Dunkel, S Heidenreich, K Drescher, HH Wensink, M Bär and RE Goldstein, Phys. Rev. Lett. 110 (2013) 228102. [2] S Heidenreich, J Dunkel, SHL Klapp and M Bär, Phys. Rev. E 94 (2016) 020601(R). [3] SD Ryan, G Ariel, A Be'er, Biophys J. (2016) 247.

DY 20.6 Tue 15:15 H3

Systematic extension of the Cahn-Hilliard model for motility-induced phase separation — Lisa Rapp, •Fabian Bergmann, and Walter Zimmermann — Universität Bayreuth, Germany

We consider a continuum model for motility-induced phase separation (MIPS) of active Brownian particles [J. Chem. Phys. **142**, 224149 (2015)]. Using a recently introduced perturbative analysis [Phys. Rev. E **98**, 020604(R) (2018)], we show that this continuum model reduces to the classic Cahn-Hilliard (CH) model near the onset of MIPS. This makes MIPS another example of the so-called active phase separation. We further introduce a generalization of the perturbative analysis to the next higher order. This results in a generic higher order extension of the CH model for active phase separation. Our analysis establishes the mathematical link between the basic mean-field MIPS model on the one hand, and the leading order and extended CH models on the other hand. Comparing numerical simulations of the three models, we find that the leading order CH model agrees nearly perfectly with the full continuum model near the onset of MIPS. We also give estimates of the control parameter beyond which the higher order corrections become relevant and compare the extended CH model to recent phenomenological models.

DY 20.7 Tue 15:30 H3

Spatially periodic patterns succeed active phase separation — •Lisa Rapp, Fabian Bergmann, and Walter Zimmermann — Theoretische Physik I, Universität Bayreuth, 95440 Bayreuth

We investigate a model equation for a conserved order-parameter field that covers as special cases the conserved Swift-Hohenberg model and the extended Cahn-Hilliard model for active phase separation. This model shows a primary bifurcation from a homogeneous state to large-scale phase separation - as typical for active phase separation [1,2]. We show here that with increasing distance from the primary bifurcation, however, a novel secondary bifurcation to spatially periodic patterns occurs. We explore these secondary periodic patterns in more detail including hysteresis and bistability/coexistence of patterns.

[1] F. Bergmann et al.: Phys. Rev. E 98, 020603(R) (2018)
[2] L. Rapp et al.: arXiv:1901.03203 (2019)