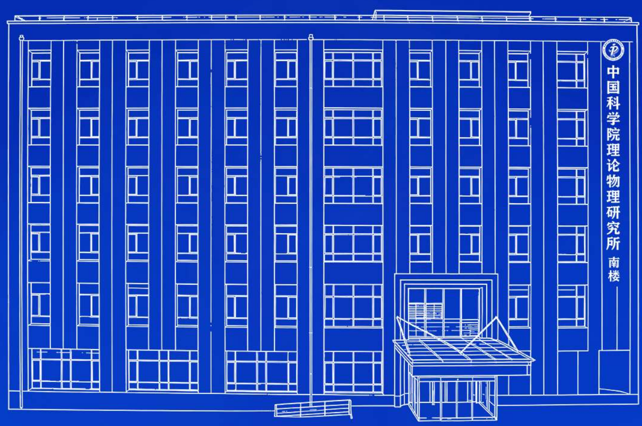
2026年国际软物质与生物物理理论研讨会

2026 International Workshop on Soft Matter and Biophysics Theories (SMBT2026)
AND Advanced Core-to-Core Network for the Physics of Self-organizing Active Matter Workshop

Sept. 20th – 25th, 2026 I Beijing, China (中国北京)



主办单位：中国科学院理论物理研究所
Institute of Theoretical Physics, Chinese Academy of Sciences

Active Matter c2c

About the workshop:

The "International Workshop on Soft Matter and Biophysics Theories (SMBT)", has annually been organized by Institute of Theoretical Physics, Chinese Academy of Sciences (ITP-CAS) since the year of 2016, of which the aim is to promote interactions and collaborations between theoreticians and experimentalists working on the chosen topic of each year. This year, SMBT2026 will be held jointly with "Advanced core-to-core network for the physics of self-organizing active matter" workshop, which was previously held in Kyoto (2023), Edinburgh (2024) and Dresden (2025), and will also be organized in collaboration with "Dynamical Materials Science".

The theme of this year SMBT2026 is: "Active Matter Theories".

The workshop will be held on Sept. 20th – Sept. 25th, 2026 at Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing, China.

Organising Committee:

Zhong-Can Ou-Yang (ITP-CAS)	Haijun Zhou (ITP-CAS)
Yanting Wang (ITP-CAS)	Hualin Shi (ITP-CAS)
Pan Zhang (ITP-CAS)	Fanlong Meng (ITP-CAS)
Weikang Wang (ITP-CAS)	Shigeyuki Komura (WIUCAS)
Ryoichi Yamamoto (Kyoto University)	Matthew Turner (University of Warwick)
Holger Stark (Technical University of Berlin)	Kazumasa Takeuchi (Tokyo University)

Brief Schedule (Beijing time):

Sept. 20th	14:00-20:00	Registration at Liaoning International Hotel
	(Buffet Dinner | First Floor, Sheng'an Hui Restaurant |18:00 – 20:00)	
Sept. 21st –24th	09:00-18:00	Talks and poster presentations
Sept. 25th	09:00-12:00	Talks

Conference Program

Sept. 21st, 2026 (Monday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

8:30-8:50	**Registration on the 6th floor of South Building of ITP**	
8:50-9:00	**Opening Remarks**	
Session 1 • Chair: Hepeng Zhang		
Beijing Time	**Speaker**	**Title**
9:00-9:30	**Holger Stark** Technical University of Berlin	Controlling and designing active paranematic flow
9:30-10:00	**Marco Mazza** Loughborough University	Topological Transitions in Active Spaghetti: from Motion to Structure
10:00-10:30	**Yongfeng Zhao** Soochow University	Surface tensions and interfacial phenomena in scalar active matter
10:30-11:00	**Group Photo and Coffee break**	
Session 2 • Chair: Holger Stark		
11:00-11:30	**Hepeng Zhang** Shanghai Jiao Tong University	Bacterial turbulence drives interfacial waves and shape dynamics in phase-separated droplets
11:30-12:00	**Daiki Matsunaga** The University of Osaka	Active Transport and Control of Liposomes Driven by Encapsulated Microorganisms
12:00 Lunch at 4th floor of Wuke Hotel（物科餐厅四层）		

Sept. 21st, 2026 (Monday)

Venue: Meeting room 6620, South Building of ITP (理论物理所南楼 6620 会议室)

Session 3 • Chair: Fabio Marchesoni		
Beijing Time	**Speaker**	**Title**
14:00-14:30	**Oliver Bäumchen** University of Bayreuth	Emergence of Collective Effects in Microbial Suspensions
14:30-15:00	**Qunli Lei** Nanjing University	Liquid-gas Criticality of Non-equilibrium Hyperuniform Fluids
15:00-15:30	**Vahid Nasirimarekani** Max Planck Institute for Dynamics and Self-Organization	Gliding Chiral Active Matter
15:30-16:30	**Poster presentation 1 and Coffee break** (The third floor coffee lounge)	
Session 4 • Chair: Oliver Bäumchen		
16:30-17:00	**Fabio Marchesoni** Tongji University	Collective dynamics in nonreciprocal 2D chiral suspensions
17:00-17:30	**Guangyin Jing** Northwest University	Activity-Driven Bacterial Turbulence
17:30-18:00	**Xinliang Xu** Hainan University	Bacterial dynamics near surfaces: residence time and surface diffusivity
18:00 Dinner at 4th floor of Wuke Hotel（物科餐厅四层）		

Sept. 22nd, 2026 (Tuesday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

Session 5 • Chair: Qi-huo Wei		
Beijing Time	**Speaker**	**Title**
9:00-9:30	**Erwin Frey** Ludwig-Maximilians-Universität München	Emergence and Self-organisation in Biological Systems
9:30-10:00	**Zhihong You** Xiamen University	The Physics of Perceptive Matter: Information-Mediated Constitutive Laws
10:00-10:30	**Luca Cocconi** University of Cambridge	Mechanosensing via inhibition of dissipation in a thermodynamically consistent active solid
10:30-11:00	**Coffee break**	
Session 6 • Chair: Erwin Frey		
11:00-11:30	**Qi-huo Wei** Southern University of Science and Technology	Walls, Vortices and Monopoles in Polar Liquids
11:30-12:00	**Sebastian Heidenreich** Physikalisch Technische Bundesanstalt	Polar or nematic active fluid? The collective dynamics of bacterial suspensions
12:00 Lunch at 4th floor of Wuke Hotel（物科餐厅四层）		

Sept. 22nd, 2026 (Tuesday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

Session 7 • Chair: Limei Xu		
Beijing Time	**Speaker**	**Title**
14:00-14:30	**Juliane Simmchen** University of Strathclyde	Spontaneous symmetry breaking enables anti-rolling motion of MnO2 microrods
14:30-15:00	**Rui Zhang** Hong Kong University of Science and Technology	Defect Dynamics in Liquid Crystals with Odd Nematic Elasticity
15:00-15:30	**Azusa Kage** Muroran Institute of Technology	An experimental Biologist's View on Bioconvection and Gravitaxis of Unicellular Microswimmers
15:30-16:30	**Poster presentation 2 and Coffee break** (The third floor coffee lounge)	
Session 8 • Chair: Juliane Simmchen		
16:30-17:00	**Limei Xu** Peking University	TBD
17:00-17:30	**Yunyun Li** Tongji University	Active phase separation triggered by defects
17:30-18:00	**Robert Ross** Westlake University	Hyperdisordered Cell Packing on a Growing Surface
18:00 Banquet **Venue:** 8th floor, Liaoning Hall A, Liaoning International Hotel（辽宁大厦 8 层辽宁 A 厅）		

Sept. 23rd, 2026 (Wednesday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

Session 9 • Chair: Junhua Yuan		
Beijing Time	**Speaker**	**Title**
9:00-9:30	**Olivier Dauchot** French National Center for Scientific Research	Hydrodynamic Theories for Fluids of Learning Robots
9:30-10:00	**Kabir Husain** University College London	The Evolution of Non-equilibrium Error-correction
10:00-10:30	**Xinpeng Xu** Guangdong Technion-Israel Institute of Technology	Deep learning-based statistical inference of stochastic cell migration in a complex microenvironment
10:30-11:00	**Coffee break**	
Session 10 • Chair: Olivier Dauchot		
11:00-11:30	**Junhua Yuan** University of Science and Technology of China	Hydrodynamic phase entrainment drives synchronization of sperm flagella
11:30-12:00	**Kai Qi** Shanghai Institute of Microsystem and Information Technology	Hydrodynamic Simulations of Microswimmers in Complex Fluids
12:00 Lunch at 4th floor of Wuke Hotel（物科餐厅四层）		
14:00-18:00	**Free Discussion**	

Sept. 24th, 2026 (Thursday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

Session 11 • Chair: Carsten Beta		
Beijing Time	**Speaker**	**Title**
9:00-9:30	**Chenxu Wu** Xiamen University	Dynamics of microvesicle formation driven by glycocalyx
9:30-10:00	**Shoichi Toyabe** Tohoku University	Efficient transport of thermal and active systems in experiments
10:00-10:30	**Kento Yasuda** Nihon University	Extended Onsager's Variational Principle for Active Matter
10:30-11:00	**Coffee break**	
Session 12 • Chair: Chenxu Wu		
11:00-11:30	**Carsten Beta** Potsdam University	TBD
11:30-12:00	**Wei Wang** Harbin Institute of Technology, Shenzhen	New observations of Quincke roller collective behaviors
12:00 Lunch at 4th floor of Wuke Hotel（物科餐厅四层）		

Sept. 24th, 2026 (Thursday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

Session 13• Chair: Fangfu Ye		
14:00-14:30	**Cathy McNamee** Kyoto University	Changing the forces between materials in aqueous solutions with audible sounds
14:30-15:00	**Azam Gholami** New York University, Abu Dhabi, UAE	Spontaneous flows and interfacial instabilities in oxygen-sensitive living active matter
15:00-15:30	**Daniel Pearce** University of Geneva	Scale and order in active nematics
15:30-16:30	**Poster presentation 3 and Coffee break** (The third floor coffee lounge)	
Session 14 • Chair: Cathy McNamee		
16:30-17:00	**Fangfu Ye** Institute of Physics, CAS	ECM-mediated Cell Migration and Self-Organization
17:00-17:30	**Hiroshi Kori** University of Tokyo	Data, Dynamics, and Networks: Insights from Synchronization Theory
17:30-18:00	**Yi Peng** Institute of Physics, CAS	Flocking Phase Separation and the Collective Modes in Inertial Active Matter
18:00 **Dinner** at 4th floor of Wuke Hotel（物科餐厅四层）		

Sept. 25th, 2026 (Friday)

Venue: Meeting room 6620, South Building of ITP（理论物理所南楼 6620 会议室）

Zoom: 880 4357 4732 **Passcode:**113763
https://us06web.zoom.us/j/88043574732?pwd=GODbXNBOStMrliCPkTKCJxKSl73Kco.1

Session 15 • Chair: Suropriya Saha		
Beijing Time	**Speaker**	**Title**
9:00-9:30	**Mingcheng Yang** Institute of Physics, CAS	Surface Tension Between Coexisting Phases of Active Particles
9:30-10:00	**Hao Wu** Wenzhou Institute, UCAS	A Parity-Based No-Go Theorem for Uniform Odd Viscosity in Active Fluids
10:00-10:30	**Kazuaki Takasan** University of Tokyo	Quantum Active Matter
10:30-11:00	**Coffee break**	
Session 16 • Chair: Mingcheng Yang		
11:00-11:30	**Suropriya Saha** Max Planck Institute for Dynamics and Self-Organization	Spinning Mixtures: Nonreciprocity Transfers Chirality Across Scales in Scalar Densities
11:30-12:00	**Sifan Yin** Max Planck Institute for the Physics of Complex Systems	Developmental mechanics of divergent buckling patterns in chick gut
12:00 Lunch at 4th floor of Wuke Hotel（物科餐厅四层）		

Poster Sessions

Poster Presentation 1

Sept. 21, 2026, 15:30-16:30

No.	Name	Affiliation	Title
1	Shigeyuki Komura	Wenzhou Institute, UCAS	Covariant Langevin Equation Using Scalar Free Energy
2	Anish Kumar	IIT (BHU) Varanasi	From LRO to Disorder via QLRO in Spatially Inhomogeneous Polar Flock
3	Hiroki Matsukiyo	Kyoto University	Numerical study on the defect configuration of an active nematic around a circular obstacle with ridge effect
4	Zihan Tan	TU Berlin	Swimming trypanosome in confinements
5	Changle Liao	Tokyo University	Near-field Hydrodynamics Disentangles Angular Correlations in Confined Active Suspensions
6	Charu Datt	Keio University	Fluid dynamics in chemically active emulsions
7	Toshihiro Omori	Tohoku University	Elasto-plastic hydrodynamics of a microswimmer encapsulated in a capsule
8	Chung Wing Chan	Kyoto University	Symmetry, Localization, and Topology in Scalar-Patterned Flocks
9	Mingqi Yan	LMU Munich	Stochastic bubble dynamics in phase-separated scalar active matter
10	Zhongqiang Xiong	Wenzhou Institute, UCAS	Taylor dispersion in sedimentation of an axisymmetric Brownian particle with centre offset
11	Mizuki Nakamura	Chiba University	Selection of Rayleigh-Bénard convection patterns in two immiscible liquid layers with an undeformed interface
12	Mohd Yasir Khan	South China University of Technology	Frustrated Flocking: Anti-alignment-driven ordering transitions in a modified Vicsek model

No.	Name	Affiliation	Title
13	Changhao Li	Zhejiang University	Entropy Production and Its Scaling with Spatiotemporal Scales in Nonreciprocal Phase Separation
14	Daniel Zhou	LMU München	Duality Between Chemical Potential Dynamics and Reaction–Diffusion Systems
15	Debsuvra Ghosh	OIST	Strain-event redistribution in corrugated bacterial channels
16	Kei Oriyose	Tokyo University	Rectification of Active Particles in Asymmetric Periodic Potentials
17	Fedor Zavalko	SRI for Systems Biology	Immobilization of glycolytic enzymes on nanoparticles results in glycolytic complex formation with functional obertones that are regulated by assembly order and immobilization density
18	Shun Sasaki	Kyushu University	Complex Viscoelastic Response of Concentrated Emulsion Suspensions in the Glass–Jamming Regime
19	Salah Eddine Ghellab	Chalmers University of Technology	Programming phoretic interaction through supramolecular recognition
20	Cheng Qi	Shenzhen University	Fingering instability of a non-equilibrium coacervate system

Poster Presentation 2

Sept. 22, 2026, 15:30-16:30

No.	Name	Affiliation	Title
1	BenChang Wu	Xiamen University	Nonreciprocity-induced crystallization and melting
2	Yujie Gao	Tokyo University	Flocking behavior with Cucker-Smale model under Markov switching mechanism
3	Michael Schindler	ESPCI Paris	Self-propelled hard disks: Implicit alignment and transition to collective motion
4	Weiqi Wen	Tokyo University	Phase Response of Active Particles under Chaotic Flow Forcing
5	Zhiwei Peng	University of Alberta	Macrotransport theory for active matter
6	Airi N. Kato	Meiji University	Active particle in a thin film droplet and their coupled dynamics
7	Song-Chuan Zhao	Kyushu University	Active Fluidization and Critical Power-Law Rheology in Dense Glassy Bacterial Suspensions
8	Kiyoto Kubo	Tohoku University	Complex viscosity of dilute microswimmer suspension under oscillating shear flow
9	Kaustav Mondal	IISER Thiruvananthapuram	Competing effects of activity and diffusive noise in collective ordering of rod-like particles
10	Hiroyuki Kitahata	Chiba University	Effective Diffusion Resulting from Reciprocal Linear Flows
11	Wahaj Ur Rehman	University of Granada	Mechanochemical Waves in Epithelial Tissues
12	Bin Zheng	Wenzhou Institute, UCAS	Neural optimization of the most probable paths of 3D active Brownian particles
13	Hiroyuki Ebata	Osaka University	Liquid-like dynamics in dense cancer cell collectives

No.	Name	Affiliation	Title
14	Tomoya Nakamura	Chiba University	Effect of Surfactants on the Pattern Formation Dynamics of Metal Dendrites
15	Shiyuan Hu	Beihang University	Hydrodynamic Interactions in the Swimming of Microorganisms
16	Sotaro Fukuda	Tokyo University	Analysis of Large-Scale Pedestrian Trajectory Data in Shinjuku Station
17	John Molina	Kyoto University	Optimal Control for (Altruistic) Social Distancing in an Epidemic
18	Alexey Dmitriev	ITMO University	Experimental studies of cluster formation and collective phenomena in robotic swarms
19	Zhilan Deng	Max Planck School	High-throughput profiling of red blood cell mechanics for anti-malaria drug screening
20	Zhuqin Li	Nanjing University	Fluidization and anomalous density fluctuations in 2D Voronoi cell tissues with pulsating activity

Poster Presentation 3

Sept. 24, 2026, 15:30-16:30

No.	Name	Affiliation	Title
1	Yuan Li	Xiamen University	Pressure-Mediated Long-Range Synchronization and Condensation of Confined Active Vortices
2	Yuto Hosaka	Kyoto University	Hydrodynamics of particles in a linear viscous flow with parity violation
3	Shota Nakano	Osaka University	Elastohydrodynamics of flow-maximising ciliary coordination
4	Zhen Li	Tokyo University	Structural balance under heterogeneous social temperatures
5	Zhiyuan Zhao	Zhejiang University of Science and Technology	Viscoelasticity reshapes the frequency response of an asynchronously rotating magnetic sphere
6	Zhanglin Hou	Wenzhou University	Driving Particles Using Information
7	Subhransu Sekhar Mishra	Institute of Physics, Bhubaneswar	Orientational Relaxation Restructures Collective Motion in Polar Active Matter
8	Zhiwei Liu	Wenzhou Institute, UCAS	Wall slip behavior of airway mucus under large amplitude oscillatory shear as biomarker
9	Natsuki Kurita	Tokyo University	Martingale approach to parameter identifiability with an application to stochastic flocking models
10	Sakurako Tanida	Tokyo University	Synchronization and nonmonotonic waiting times in scheduled and on-demand elevators
11	Ryosuke Ueta	Tokyo University	Exploration of Colloidal Gel Structures via Particle-Fluid Simulation
12	Sohei Nakamura	Kyushu University	Cell Migration Responding to Substrate Stiffness Patterns
13	Hiroki Sugiyama	Tokyo University	Mathematical Foundations of a Privacy-Preserving Human Flow Sensing System

No.	Name	Affiliation	Title
14	Debasish Saha	IISER Bhopal	Non-Markovian escape under stochastic resetting
15	Daisuke Makieda	Tokyo University	Data Analysis and Simulation of Human Exploration Behavior during an Exhibition at Tokyo Big Sight
16	Yudai Shirasaka	Kyushu University	Microrheology of Concentrated Colloidal Suspensions under an Applied Macroscopic Shear Field
17	Anastasiia Sibiriakova	Sanquin, Netherlands	Ising-Based Optimization Model of Fibrin Network Formation
18	Rozhin Sahafi	Institute for Advanced Studies in Basic Sciences	Diffusive motion of a bacterium in an inhomogeneous and anisotropic hydrodynamic medium near a wall and its entropy production
19	Qingju Qi	ESPCI Paris - PSL	Numerical Study of the Transition to Collective Actuation in Polar Active Solids
20	Tai Han	Institute of Theoretical Physics, CAS	Stochastic Model and Optimal Controls of an Active Tracking Particle with Information Processing

Holger Stark
Technical University of Berlin

Controlling and Designing Active Paranematic Flow

Abstract:
Active turbulence is one of the prominent features of active matter and occurs in diverse systems with rod-shaped self-propelling constituents such as bacterial suspensions, biopolymeric assemblies, and tissues. One of the current challenges is to control the occuring turbulent flow patterns for powering processes at small scales and to purposefully design them. We rely on a continuum description of active paranematics, the Doi-Edwards theory supplemented by an active stress tensor [1]. In the beginning, we show that only extensile active stresses induce paranematic order and characterize the occuring turbulent flow. Then, motivated by the possibility to control the activity of bacteria by light, we first consider a square lattice of spots, where activity drops to zero. Depending on the lattice constant and the size of the spots, we identify a trapped-vortex and, most interestingly, a multi-lane flow state. The latter consists of lanes with opposite flow directions separated by a street of vortices. It displaysmultistability and can also appear transiently. By introducing interstitial inactivity spots, we even generate a flow-vortex lattice with antiferromagnetic order. Second, in the simpler configuration of a single activity spot and by tuning its size, we are able to control the occurence of topological defects, which can enter and leave through the open boundary. This allows a controlled routetowards active turbulence in the bulk fluid [2]. [1] A. Partovifard, J. Grawitter, and H. Stark, Controlling Active Turbulence by Activity Patterns, Soft Matter 20, 1800 (2024). [2] A. Partovifard and H. Stark, Controlled route to active turbulence: filling an activity spot with topological defects, Soft Matter 22, 2139 (2026).

Marco Mazza
Loughborough University

Topological Transitions in Active Spaghetti: from Motion to Structure

Abstract:
Many active systems are capable of forming intriguing patterns at scales significantly larger than the size of their individual constituents. Cyanobacteria are one of the most ancient and important phyla of organisms that has allowed the evolution of more complex life forms. Despite its importance, the role of motility on the pattern formation of their colonies is not understood. Here, we investigate the large- scale collective effects and rich dynamics of gliding filamentous cyanobacteria colonies, while still retaining information about the individual constituents' dynamics and their interactions. We investigate both the colony's transient and steady-state dynamics and find good agreement with experiments. We furthermore show that the Péclet number and aligning interaction strength govern the system's topological transition from an isotropic distribution to a state of large-scale reticulate patterns. Although the system is topologically non-trivial, the parallel and perpendicular pair correlation functions provide structural information about the colony, and thus can be used to extract information about the early stages of biofilm formation. Finally, we find that the effects of the filaments' length cannot be reduced to a system of interacting points. Our model proves to reproduce both cyanobacteria colonies and systems of biofilaments where curvature is transported by motility.

Yongfeng Zhao
Soochow University

Surface tensions and interfacial phenomena in scalar active matter

Abstract:
Active particles can form liquid droplets that exhibit rich interfacial phenomena, including wetting on solid surfaces and capillary action. Surface tensions are state variables that are expected to control interfacial phenomena in equilibrium systems. However, in active systems, the surface tensions are not well understood, especially when the liquid-gas surface tension is argued to be negative. In this talk, we provide mechanical justifications for the negative liquid-gas surface tension. Then we construct the active Young-Dupré equation, which controls the wetting contact angle, and the active Jurin's law for capillary action. We show that the negative surface tension still enters the force balance that controls the wetting of adsorbed droplets and capillary rise, but the self-organized steady particle currents, which are common in active systems, enter and even dominate the interfacial phenomena in active systems. The existence of currents leads to richer behavior of active interfaces than passive interfaces.

Hepeng Zhang
Shanghai Jiao Tong University

Bacterial Turbulence Drives Interfacial Waves and Shape Dynamics in Phase-separated Droplets

Abstract:
Active particles can form liquid droplets that exhibit rich interfacial phenomena, including wetting on solid surfaces and capillary action. Surface tensions are state variables that are expected to control interfacial phenomena in equilibrium systems. However, in active systems, the surface tensions are not well understood, especially when the liquid-gas surface tension is argued to be negative. In this talk, we provide mechanical justifications for the negative liquid-gas surface tension. Then we construct the active Young-Dupré equation, which controls the wetting contact angle, and the active Jurin's law for capillary action. We show that the negative surface tension still enters the force balance that controls the wetting of adsorbed droplets and capillary rise, but the self-organized steady particle currents, which are common in active systems, enter and even dominate the interfacial phenomena in active systems. The existence of currents leads to richer behavior of active interfaces than passive interfaces.

Daiki Matsunaga
The University of Osaka

Active Transport and Control of Liposomes Driven by Encapsulated Microorganisms

Abstract:
Inspired by biological vesicles used for transport, liposomes provide a soft and biocompatible platform for constructing microscale biohybrid systems. In this study, we investigate a biohybrid microswimmer, termed chlamylipo, in which motile hlamydomonas reinhardtii cells are encapsulated within giant liposomes. We examine how the encapsulated cells and the surrounding liposome membrane together generate swimming motion. By combining controlled perturbations and fluid mechanical analysis, we characterise the relationship between membrane deformation and swimming velocity. We further explore how the motility of chlamylipo can be modulated by changing the physical state of the liposome membrane. Our results suggest that liposome encapsulation can serve not only as a compartment for carrying active components, but also as a means of regulating microscale motility.

Oliver Bäumchen
University of Bayreuth

Emergence of Collective Effects in Microbial Suspensions

Abstract:
Living suspensions consist of metabolically active microorganisms that thrive in liquid media and may interact via various types of physical and chemical interactions. In addition, these cells may also respond to environmental cues, such as gravity and light. Shaped by evolution photosynthetic microbes have successfully adapted to spatially and temporally varying environmental conditions in their complex microhabitats throughout all ecosystems. In this presentation I will discuss the effects of the metabolic activity on the single-cell motility as well as on the emergence of collective flows on the population level.

Qunli Lei
Nanjing University

Liquid-gas Criticality of Non-equilibrium Hyperuniform Fluids

Abstract:
In statistical physics, it is well established that the liquid-gas (LG) phase transition with divergent critical fluctuations belongs to the Ising universality class. Whether non-equilibrium effects can alter this universal behavior remains a fundamental open question. In this work, we theoretically prove that non-equilibrium hyperuniform (HU) fluids with additional center-of-mass conservation exhibit LG criticality different from the Ising universality class. As a specific case, we investigate a 2D HU fluid composed of active spinners, where phase separation is driven by dissipative collisions. Strikingly, the critical point is calm yet highly susceptible, in fundamental violation of the conventional fluctuation-dissipation relation. Consistently, we observe short-range pairwise correlation functions coexisting with quasi-long-range response functions at the critical point. Based on a generalized Model B and renormalization-group analysis, we prove that hyperuniformity reduces the upper critical dimension d_c from 4 to 2 and the critical point exhibits Gaussian density fluctuations. Furthermore, the HU fluid undergoes non-conventional spinodal decomposition, where the decomposition time diverges but the characteristic length scale remains finite as the critical point is approached. The origin of the above anomalies lies in the non-equilibrium nature of the system which obeys a generalized fluctuation-dissipation relation 2 Im χ (q, ω)= ω C(q, ω)\/k_B T_eff (q) with a scale-dependent effective temperature T_eff (q)∝q^2.

Vahid Nasirimarekani
Max Planck Institute for Dynamics and Self-Organization

Active Transport and Control of Liposomes Driven by Encapsulated Microorganisms

Abstract:
Chiral active matter, systems of self-propelling and rotating units, exhibits rich emergent behavior driven by structural asymmetry. I explore the motility of filamentous cyanobacteria, which exhibit a distinct form of chiral gliding motion along surfaces. I show that this behavior arises from the intrinsic chirality of the organism, enabling a robust mechanism for directed navigation. Extending this principle, I demonstrate that chirality transfers from the individual to the collective level, where the handedness of single units dictates the organization of large-scale structures. Through self-organization, these chiral components spontaneously assemble into stable structures. These findings establish a framework linking microscopic chirality to macroscopic collective dynamics in active matter systems.

Fabio Marchesoni
Tongji University

Collective dynamics in nonreciprocal 2D chiral suspensions

Abstract:
Non-reciprocal interactions are increasingly recognized as a key design principle for collective behavior in active matter, yet their full implications remain largely unexplored. Here, we introduce a minimal model of chiral active particles whose chirality sign switches based on the local density of neighbors within a restricted visual cone—a form of quorum sensing. Despite the absence of attractive forces, this simple non-reciprocal rule gives rise to a remarkable panoply of emergent phenomena. For narrow visual angles, the system self-organizes into robust hexagonal honeycomb lattices that maximize packing efficiency along cell boundaries, reminiscent of biological honeycombs. For larger visual angles, the same rule drives the spontaneous formation of stationary edge currents that encircle dense clusters or cavities, leading to a novel form of motility-induced phase separation driven entirely by chirality switching. These edge currents persist even in the absence of steric repulsion, confirming their purely non-reciprocal origin. At intermediate visual ranges, the suspension transitions into a globally hyperuniform state characterized by long-range density correlations, signaling a subtle coexistence of opposite-chirality phases. Finally, we demonstrate that even a tiny fraction of such quorum-sensing chiral particles can "herd" passive colloids into dense circulating aggregates, suggesting potential applications in programmable microrobotics and targeted material transport.

Guangyin Jing
Northwest University

Activity-Driven Bacterial Turbulence

Abstract:
Activity is the defining intrinsic feature of active matter, yet quantitatively defining and controlling it remains a significant experimental challenge. In this talk, we utilize a quintessential active matter system—dense bacterial suspensions—to establish a precise control of activity at the individual level. Leveraging this well-controlled motility, we explore activity-induced collective dynamics, addressing some interesting questions of how microscopic drive dictates macroscopic emergent behaviors. First, we introduce a robust experimental methodology to tune bacterial activity by modulating the environmental pH, which allows us to directly regulate the self-propulsion capability of individual bacteria. This clean "activity knob" enables us to systematically navigate the phase space of active fluids. Through this approach, we report the observation of conformal phase transitions—a novel class of phase transitions emerging at specific activity thresholds. Furthermore, we characterize the kinetic energy spectra of the active flow, revealing how multiscale energy transfer and spectral scaling laws are dynamically governed by the underlying microscopic motility. Finally, we present preliminary experimental results on the mixing efficiency of active turbulence. By applying the mathematical framework of braid dynamics, we decode the complex topological features of chaotic advection in these systems, offering new understanding into how tunable bacterial activity can be harnessed for optimal fluid mixing at the microscale.

Xinliang Xu
Hainan University

Bacterial Dynamics near Surfaces: Residence Time and Surface Diffusivity

Abstract:
Run-and-tumble is a common but vital strategy that bacteria employ to explore environment suffused with boundaries, as well as to escape from entrapment. We investigate if and how this strategy and the resulting dynamical behavior can be sensitively regulated by bacterial dimensions. Our results reveal that the logarithm of the surface residence time for bacteria with constant tumble bias is linearly related to a dimensionless parameter of bacterial intrinsic size characteristics, where a small variation in bacterial dimensions, which is natural in a suspension, reproduces well the large variation in bacterial residence time that is observed in experimental studies. Furthermore, our results predict that the optimal tumble bias corresponding to the maximum surface diffusivity depends strongly on bacterial intrinsic size characteristics, where the same small variation in bacterial dimensions gives rise to a strongly diversified optimal tumble bias.

Erwin Frey
Ludwig-Maximilians-Universität München

Emergence and Self-organisation in Biological Systems

Abstract:
Living cells achieve their remarkable functions through the spatiotemporal organization of proteins on deformable membranes. In this talk I will present our understanding of how protein patterns self-organize, what governs their dynamics, and how they couple to the geometry and elasticity of the membrane. Using examples such as Min protein oscillations, cortical polarity, and curvature-sensitive protein assemblies, I will show how the interplay between protein patterning and membrane shape gives rise to cell-like behaviors including polarization, division, and shape change. These results provide physical design principles for the rational engineering of synthetic cells with life-like functionality.

Zhihong You
Xiamen University

The Physics of Perceptive Matter: Information-Mediated Constitutive Laws

Abstract:
Matter can organize not only through forces and interactions, but also through the information its constituents acquire from their surroundings. Here we introduce perceptive Brownian particles as a model system to investigate how nonlocality and nonreciprocity—two fundamental properties of information transfer—shape nonequilibrium organization. We show that information can govern collective behaviour by reshaping the constitutive law of the material through an information-mediated chemical potential. Consequently, distinct nonequilibrium states emerge as different modes of information transfer are introduced. In particular, nonlocal perception restructures the ordering pathway by activating a cascade of instabilities, producing a hybrid phase-separated state in which macrophase separation coexists with microphase ordering. Nonreciprocal perception, by contrast, breaks mirror symmetry by shifting the chemical potential relative to the density field, generating a current-neutral treadmilling state in which structures migrate unidirectionally while the total current remains zero. Together, these results establish information acquisition as a constitutive principle of nonequilibrium matter, capable of controlling both phase stability and the dynamical pathways through which order emerges.

Luca Cocconi
University of Cambridge

Mechanosensing via Inhibition of Dissipation in a Thermodynamically Consistent Active Solid

Abstract:
A key challenge in understanding the non-equilibrium dynamics of dense living systems is to identify the mechanistic origins of the underlying mechano-chemical couplings, which are often obscured in phenomenological models. Here, we develop a bottom-up, thermodynamically consistent active solid (TCAS) model and show that dissipation is maximized at finite stress but suppressed at large stress, where the system effectively reverts to passive behaviour. We connect this stress-induced inhibition of dissipation to the nonmonotonic dependence of catalytic efficiency on crowder density in bimolecular condensates, and derive thermodynamic bounds on the Fisher information rate for the corresponding force-inference problem. These results establish a mechanistic link between mechanical stress, chemical activity, and information acquisition in dense active matter, and provide design principles for “smart” mechanosensitive materials that generate chemical signals in response to local mechanical perturbations.

Qi-huo Wei
Southern Technology University

Walls, Vortices and Monopoles in Polar Liquids

Abstract:
In this talk, I will talk about the topological structures, including walls, vortices, and other hybrid defects in polar liquid crystals, and demonstrate that they are generically hybrid, composed of entangled defects of different dimensionalities. I will show how this hybrid nature is related to the intrinsic symmetry breaking of the system.

Sebastian Heidenreich
Physikalisch Technische Bundesanstalt

Polar or Nematic Active Fluid? The Collective Dynamics of Bacterial Suspensions

Abstract:

Bacterial suspensions are prime examples of active fluids that exhibit striking large-scale collective dynamics, ranging from ordered and disordered phases to so-called active turbulence and the formation of vortex lattice structures. Over the past decade, significant progress has been made in their theoretical description, ranging from continuum and minimal models to more complex models in which the relaxation dynamics of the order parameter are coupled to the surrounding flow field. In parallel, numerous experimental studies have successfully validated key predictions of these continuum theories. Nevertheless, it remains unclear whether the relevant effective description is best captured by an active polar, an active nematic, or a mixed continuum theory. In this presentation, I will examine and discuss both continuum-model predictions and experimental results for bacterial suspensions. Starting from a microscopic description of an ensemble of microswimmers that considers both polar and nematic interactions, I demonstrate how to derive active polar and active nematic continuum equations. Moreover, I will briefly discuss the resulting phenomena and compare the behavior of active nematics and active polar fluids. I will focus on the emergence of a characteristic length scale and on topological defects, as well as on how these features relate to active polar fluids or active nematics. The talk will conclude with an open discussion.

Juliane Simmchen
University of Strathclyde

Spontaneous Symmetry Breaking Enables Anti-rolling Motion of MnO2 Microrods

Abstract:
Spontaneous symmetry breaking in colloidal systems increasingly fascinates scientists due to the promise of new, emergent functionalities and unique properties. Here, we introduce a chemically active system, where symmetry is spontaneously broken in the particle motion rather than being encoded into their structure. Using symmetric MnO2 microrods without any apparent structural features or chirality, we observe the emergence of a combination of rotational and translational motion near a substrate that resembles rolling. This motion is further enhanced if a chemically active substrate is present. To explain the occurrence of highly active motion, we investigate the flows that lead to propulsion. The results are rationalised by a theoretical model showing spontaneous symmetry breaking with a bifurcation above a critical Peclet number. To identify the chemical reactions leading to the occurrence of flow, we confirm the species involved using Electron Paramagnetic Resonance (EPR) and X-ray Photoelectron Spectroscopy (XPS) spectroscopy. Overall, the results demonstrate the potential of spontaneous symmetry breaking to accomplish active rolling motion of symmetric chemically active microparticles.

Rui Zhang
Hong Kong University of Science and Technology

Defect Dynamics in Liquid Crystals with Odd Nematic Elasticity

Abstract:
Conventional solids are characterized by the reciprocal Maxwell–Betti relation and a well-defined elastic energy. In contrast, out-of-equilibrium anisotropic structured materials can exhibit nonreciprocal responses associated with odd elasticity. Here, we extend this concept to liquid crystals, introducing the notion of odd liquid crystals (OLCs). This nonequilibrium material is governed by a universal complex Ginzburg–Landau equation, with odd nematic elasticity arising from nonreciprocal interactions between neighboring directors. Within this framework, we find that domain walls become self-propelled entities and are accompanied by bidirectional flows. In addition, point defects exhibit spontaneous rotation and evolve into spiral patterns sustained by vortical flows. The dynamics of defect pairs display rich behavior that goes beyond that observed in conventional active nematics. Our framework can be generalized to a broader class of odd viscoelastic materials and provides a pathway for controlling topological defects in nonequilibrium systems with nonreciprocal interactions.

Azusa Kage
Muroran Institute of Technology

An experimental Biologist's View on Bioconvection and Gravitaxis of Unicellular Microswimmers

Abstract:

Theoretical models of active matter have provided profound insights into the collective behaviors of microswimmers. However, real unicellular organisms present biological complexities that often challenge idealized physical models. In this presentation, I will discuss the phenomena of bioconvection and gravitaxis from the perspective of an experimental biologist. Gravity acts as a fundamental cue for these microorganisms, driving individual gravitactic responses that, coupled with hydrodynamic interactions, cascade into macroscopic collective patterns known as bioconvection. Focusing on model organisms such as ciliates and green algae, I will highlight experimental observations of these dynamics and discuss the potential roles of intrinsic biological factors. By emphasizing the "living" nature of these active systems, I aim to bridge the gap between experimental biology and theoretical physics, and discuss how empirical insights can stimulate further dialogue between theory and experiment in active matter research.

Yunyun Li
Tongji University

Active phase separation triggered by defects

Abstract:
We numerically investigate the diffusion behavior in a two-dimensional athermal suspension of active particles undergoing motility-induced phase separation (MIPS). When plotted against the global packing fraction, the effective diffusion constant exhibits a hysteresis loop characterized by abrupt transitions at the gaseous binodal and spinodal. In contrast, no such hysteresis is observed in the dense phase, as its binodal and spinodal lines appear to overlap. However, simulating MIPS at low packing fractions (the binodal region) requires extremely long relaxation times, raising the question of how phase separation can be achieved within computationally feasible time scales. To address this, we demonstrate that defects can act as nucleation sites to rapidly initiate local particle aggregation. Under suitable conditions, these aggregates detach from the defects and grow continuously until full phase separation is realized. We present a systematic investigation of this defect-triggered MIPS in the binodal region. This mechanism provides physical insights into bacterial biofilm formation, where nutrient particles may serve as chemotactic attractors driving bacterial aggregation.

Robert Ross
Westlake University

Hyperdisordered Cell Packing on a Growing Surface

Abstract:
Growing tissues continuously add new material while preserving dense spatial organisation. In this talk, I will discuss chromatophore patterns on developing squid skin as a model system for cell packing on an expanding surface. We find that relative density fluctuations in chromatophore number grow with observation scale, defining a hyperdisordered regime in contrast to hyperuniform systems, where large-scale fluctuations are suppressed. A minimal model in which hard disks are randomly inserted into a homogeneously growing surface quantitatively reproduces the observed behaviour, suggesting that growth exports local fluctuations to progressively larger scales. These results identify hyperdisordered scaling as a distinct nonequilibrium packing phenomenon in growing dense systems.

Olivier Dauchot
French National Center for Scientific Research

Hydrodynamic theories for fluids of learning robots

Abstract:
On one hand swarm robotics deals with the programming of a large number of robots so that the swarm as a whole performs a given task. Spectacular achievements are the live shows of drones displaying patterns in the night sky. Such performances however essentially rely on powerful central control and fast communication. This brute force methodology can hardly be generalized to more complex task and is not scalable to very large swarms. On the other hand active fluids are known for their rich collective dynamics, which emerge from dynamical phase transitions. In this context, the larger the system, the smaller are the fluctuations. It remains however challenging to control these phases and turn them into functional materials. In this talk I will discuss a possible path along which these two fields of research could cross-fertilize. More specifically, I will present experiments, simulations and theoretical approaches to study how social learning distributed in a swarm of robots, can drive collective task-achievement without external control. In particular, I will introduce and discuss recent progress, which we could make deriving hydrodynamic equations for fluids of learning robots.

Kabir Husain
University College London

The Evolution of Non-equilibrium Error-correction

Abstract:

Since at least Schrodinger, life has been seen as a non-equilibrium process that has successfully evaded the second law of thermodynamics: maintaining order for four billion years. Yet, while we understand how extant biomolecular Maxwell Demons work, much less is known about how such they come into existence in the first place. Here, combining experimental and theoretical work on proofreading DNA polymerases, we suggest that surprisingly little might be needed. We find that complex, non-equilibrium error-correcting machinery such as kinetic proofreading can arise through selection for speed alone, without any selection for higher accuracy. Our results rely on a memory effect intrinsic to the biophysics of templated copying – namely, stalling due to misincorporations. We describe progress towards an experimental test of the hypothesis: developing a massively multiplexed Luria-Delbruck assay capable of measuring the fidelity and speed of thousands of polymerases in a single experiment. Our work sheds light on the origins of fidelity in biomolecular processes, and suggests a minimal scenario for the origins of non-equilibrium order in biology.

Xinpeng Xu
Guangdong Technion-Israel Institute of Technology

Deep Learning-based Statistical Inference of Stochastic Cell Migration in a Complex Microenvironment

Abstract:
Cell migration drives embryonic development, wound healing, immune surveillance, and cancer metastasis. Cell-scale motion emerges from coupled cytoskeletal, adhesive, and signaling processes acting within heterogeneous biochemical, mechanical, and geometric microenvironments. Yet most experiments record only low-dimensional tracks, typically the cell centroid and, at best, a polarity/orientation. These observables do not uniquely constrain detailed bottom-up models with many latent internal variables and parameters, motivating inference of an effective stochastic equation of motion directly from trajectories. We introduce a Generic Cell Locomotion Model (GCLM): a Markovian stochastic differential equation for cell position and orientation with state-dependent (multiplicative) Gaussian white noise. GCLM decomposes migration into an effective spatio-orientational potential that generates conservative drift. It further includes a nonconservative self-propulsion speed landscape and an anisotropic diffusion tensor that captures direction- and state-dependent fluctuations. To infer these fields from discretely sampled trajectories, we maximize an Onsager–Machlup path likelihood using a physics-informed neural parameterization (Deep Onsager–Machlup method, DOMM). On synthetic Brownian and active Brownian particle data with fully observed position and orientation, DOMM accurately recovers the planted drift, propulsion, and diffusion. The inferred decomposition provides an interpretable “effective migration phenotype” that can be compared across microenvironments, drugs, or genetic perturbations to localize which physical component changes and to generate testable mechanistic hypotheses. This proof of principle sets the stage for extensions to partial observability and measurement noise via latent-state inference.

Junhua Yuan

University of Science and Technology of China

Hydrodynamic Phase Entrainment Drives Synchronization of Sperm Flagella

Abstract:

Synchronization of sperm flagella may enhance reproductive fitness and offers an accessible model for studying biological coordination. However, a fundamental debate persists: while hydrodynamic models predict that fluid coupling alone can synchronize adjacent flagella, experiments on freely swimming sperm suggest that direct mechanical contact is required. This discrepancy likely reflects both idealized theoretical assumptions that neglect physiological heterogeneity and experimental limitations that preclude isolation of the hydrodynamic contribution. To resolve this, we developed a microfluidic trap array that immobilizes pairs of sperm cells while preserving their natural flagellar beating, enabling long-duration, high -precision measurements of phase dynamics under controlled hydrodynamic conditions. By analyzing the synchronization dynamics through the Adler equation—which accommodates the intrinsic frequency detuning of biological oscillators—we reveal that under head-fix ed conditions, pure hydrodynamic coupling is sufficient to drive robust flagellar synchronization. Furthermore, we find that the coupling strength decays approximately linearly with interflagellar distance over physiologically relevant scales, and that flagellar phase fluctuations are dominated by low- frequency colored noise, challenging the ubiquitous white- noise approximation in active matter models. Going beyond the conventional phenomenological use of the Adler equation, we derive a phase–response function that traces its coupling term directly to the measured hydrodynamic flow field, thereby grounding the abstract phase dynamics in its physical basis in fluid mechanics. These results reconcile the theoretical–experimental divide regarding flagellar synchronization and establish a transferable framework for investigating collective behavior in diverse systems of nonidentical biological oscillators.

Kai Qi
Shanghai Institute of Microsystem and Information Technology

Hydrodynamic Simulations of Microswimmers in Complex Fluids

Abstract:
Microswimmers move through complex environments such as viscoelastic fluids, biological gels, and porous media, where their dynamics are strongly coupled to the surrounding medium. Using lattice-Boltzmann simulations coupled with the squirmer model, we investigate microswimmer dynamics in polymer solutions and porous confinement. For a single swimmer, we introduce a characteristic flow-decay length to map swimmer propulsion onto oscillatory-shear rheology, allowing the local viscoelastic response to be characterized by effective storage and loss moduli. Over the parameter range studied, the response is predominantly dissipative. In many-swimmer systems, polymers strongly enhance orientational order through hydrodynamic feedback: swimmer-generated flows stretch and align polymers, while the resulting polymer organization reinforces swimmer alignment, enhancing polarization by up to 26-fold. In interconnected spherical cavities, concave boundaries induce swimmer-type-dependent trapping: pushers follow persistent tangential orbits, pullers are locked in wall-normal states, while neutral swimmers explore the boundary more broadly. At higher swimmer numbers, interparticle collisions disrupt trapped states and promote inter-cavity transport, particularly for pushers. These results reveal how complex fluids and confinement regulate microswimmer dynamics from individual propulsion to collective transport.

Chenxu Wu
Xiamen University

Dynamics of microvesicle formation driven by glycocalyx

Ke Xiao, and Chen-Xu Wu

Abstract:
Microvesicles (MVs), a type of cell-secreted extracellular vesicle (EV), are essential for various biological processes. Recent evidence suggests that overexpression of MUC1 glycoproteins facilitates MV formation on the cell membrane, but the mechanism underlying this nonequilibrium process remains unknown. Here, the kinetics of glycocalyx-driven MV formation is studied in the framework of Onsager's variational principle. Using this deterministic theory, we first show that the process of MV formation is accelerated for the denser and thicker glycocalyx-grafted cell membrane and can be improved by reducing the ionic strength or enhancing the degree of glycocalyx ionization. Intriguingly, we further discover that there exists an optimal glycocalyx coverage for the fastest formation of MVs. We then investigated the process of MV formation using a stochastic approach.
Our results suggest that the diffusion coefficient is not constant, leading to the prediction of a shorter formation time compared to the deterministic approach.

Shoichi Toyabe
Tohoku University

Efficient transport of thermal and active systems in experiments

Abstract:
Nonequilibrium thermodynamics has successfully characterized a wide range of physical, chemical, and biological processes that occur far from equilibrium. It provides a framework for understanding how systems evolve over time in terms of entropy production and related quantities. However, the controllability of nonequilibrium systems remains largely unexplored. Here, we experimentally investigate efficient or optimal control in three distinct systems. First, we realize the "optimal transport" of a passive Brownian particle following established optimal transport theory. Second, we present our recent experiments on the efficient control of the rotary molecular motor F1-ATPase. Finally, we introduce preliminary experiments on transport in, and of, active bacterial suspensions.

Kento Yasuda
Nihon University

Extended Onsager's Variational Principle for Active Matter

Abstract:
Onsager's variational principle provides a systematic framework for deriving dynamical equations in soft and active matter. By reformulating the time-global Onsager-Machlup variational principle (OMVP), we propose a novel statistical method to incorporate thermal fluctuations [Phys. Rev. E 110, 044104]. To demonstrate the utility of this formulation, we first derive the diffusion constant of a Brownian particle in a viscous fluid by maximizing the modified Onsager-Machlup integral for the surrounding medium. Building on this, we develop the informational Onsager-Machlup principle [arXiv:2510.13145], a generalized framework that unifies dissipative and informational contributions within a single formalism. This approach introduces a conditioned Onsager-Machlup integral to quantify path entropy under specific memory states, enabling the derivation of cumulant generating functions for observables in systems governed by measurement and feedback. We apply this principle to a minimal model of an information-driven swimmer, where feedback adaptively modulates viscous drag based on velocity measurements, to obtain analytical expressions for the mean velocity and higher-order cumulants. Finally, we discuss potential extensions of this formulation to various active systems.

Wei Wang
Harbin Institute of Technology, Shenzhen

New observations of Quincke roller collective behaviors

Abstract:
Quincke rollers are dielectric spheres that roll in response to direct current electric fields. They are known to exhibit collective motion, such as travelling bands, vortices and moving clusters, through electrical dipolar interactions and hydrodynamic alignments. However, less is known about how these behaviors, both individual and collective, vary in a changing environment beyond electric fields.

In this talk, I present two recent observations in this area. First, we report the somewhat surprising transition in the collective motion of Quincke rollers when the environmental temperature or relative humidity is increased, whereby large vortices transform into polar clusters, rotating clusters and finally active crystals. This transition occurs due to an increase in the electrical conductivity of the surrounding medium (hexadecane + AOT), which shifts the pairwise interaction between the rollers from repulsion to anisotropic attraction and finally to isotropic repulsion as the temperature or humidity increases. Secondly, I demonstrate that magnetic microspheres form vortices in the absence of magnetic fields but form alternating lanes when a magnetic field is applied vertically to the plane on which the rollers move. We propose a phenomenological model that qualitatively explains the formation of lanes and the scaling of lane width with magnetic field strength.

These observations demonstrate that the external environment plays a pivotal role in determining how Quincke rollers interact with each other, as well as in the emergence and evolution of their collective behaviors. From a practical point of view, these findings suggest that temperature, humidity, and magnetic fields can be used to control the spatiotemporal organization of active colloids for various potential applications.

Cathy McNamee
Kyoto University

Changing the Forces between Materials in Aqueous Solutions with Audible Sounds

Abstract:
The forces acting between materials in aqueous solutions help determine their organization ability. Attractive forces promote aggregation and repulsive forces promote dispersion. The forces can be changed from repulsions to attractions by adsorbing chemicals to the surface of the materials. However, the presence of such chemicals can adversely affect the applications of the systems. Forces can be changed without the addition of chemicals, if the electrical double layer (EDL) around the charged surfaces is modified by external stimuli. Sound waves have been theoretically predicted to periodically polarize the ionic atmospheres around charged particles in aqueous solutions, thus causing an EDL change [1]. However, studies are lacking on the effect of audible sounds on the EDL, in spite of audible sound being readily available at a low cost. In this study, we used the Atomic Force Microscope to determine how audible sound can modify the forces acting between a negatively charged silica particle (probe) and silicon wafer in water and in aqueous salt solutions. Information on the EDL thickness (Debye length) and surface potential was obtained from force-distance curves. The effect of the sound frequency, mobility of the ions in the EDL, and the EDL compressibility on the change in the force curves by sound was determined [2,3]. Sound was shown to be capable of changing the EDL and forces acting between charged surfaces in aqueous solutions, if a compressible system composed of ions with a low mobility is used. The degree of this change increased with the sound frequency.

References: 1) Dukhin S.S. Adv. Colloid Interface Sci. 1993, 44, 1-134; 2) McNamee, C.E.; Tokuyama, M.; Yamamoto, S. Langmuir 2024, 40, 2, 1177–1184; 3) McNamee, C.E.; Yamamoto, S. Langmuir 2025, 41, 9434-9443.
Our results suggest that the diffusion coefficient is not constant, leading to the prediction of a shorter formation time compared to the deterministic approach.

Azam Gholami
New York University, Abu Dhabi, UAE

Spontaneous Flows and Interfacial Instabilities in Oxygen-sensitive Living Active Matter

Abstract:
Active fluids generate motion and stress internally, but in living systems this activity is often regulated by environmental fields that the organisms consume or produce. Here we show that oxygen gradients organise dense suspensions of the flagellated microswimmer Euglena gracilis and trigger an active interfacial instability. In circular chambers open to air at the periphery, oxygen exchange and cellular consumption generate a radial chemical gradient. Starting from an initially homogeneous suspension, cells spontaneously localise into a dense annular band through oxygen-dependent motility and bidirectional oxytaxis. This oxytactically formed ring then deforms and undergoes collective azimuthal motion, rotating as a long-lived corona of protrusions. We reproduce this sequence with an oxygen-coupled polar active-fluid model in which oxygen regulates both cell reorientation and motility, while dipolar active stresses drive the deformation and flow of the dense interface. The simulations show that oxygen taxis creates and positions the annular active interface, whereas the subsequent corona is an activity-driven interfacial instability. Our results reveal how a self-generated chemical gradient can position and activate a living fluid, providing a route to environmental control of active-matter flows and interfaces.

Daniel Pearce
University of Geneva

Scale and Order in Active Nematics

Abstract:
Hydrodynamic theories of active matter have provided an incredibly effective tool in the description of many phenomena in living organisms, from flocks of birds to migration of epithelial cells. Here we present a thorough analysis of the dynamics of chaotic flows in active nematics and demonstrate that energy transfer between scales is observed even at zero Reynolds number. We then show that this results directly from the generation of topological defects in active fluids. Finally we identify a completely new regime of active nematics in which the system form long range bend walls as opposed to topological defects.

Hiroshi Kori
University of Tokyo

Data, Dynamics, and Networks: Insights from Synchronization Theory

Abstract:
Data-driven approaches are becoming increasingly important across many areas of physics, yet they face significant challenges such as noise, limited observability, and model interpretability. In this talk, I discuss data-driven studies of synchronization phenomena, a field to which I have contributed, as a simplified setting compared to active matter. Synchronization systems typically assume fixed interaction networks, offering a clearer framework to infer interaction structures and collective dynamics from data. I will introduce several examples of such approaches and highlight both their potential and limitations. I hope that insights gained from these simpler systems can provide useful perspectives for the further development of data-driven theories of active matter.

Yi Peng
Institute of Physics, CAS

Flocking Phase Separation and the Collective Modes in Inertial Active Matter

Abstract:
Collective motion is a ubiquitous phenomenon in active matter systems ranging from bacterial suspensions to animal groups and robotic swarms. Here we investigate the collective dynamics of inertia-dominated active agents using a model system of millimeter-scale magnetic rollers whose motility can be tuned by external magnetic fields. At sufficiently high density, the system exhibits a striking nonequilibrium phase coexistence: a coherently moving flock propagates through a dilute, disordered gaseous phase. This transition displays characteristics of a first-order flocking phase separation. The two coexisting phases show distinct particle exchange dynamics and maintain different effective temperatures, a hallmark of strongly nonequilibrium behavior. By combining experiments, agent-based simulations, and phenomenological modeling, we show that inelastic collisions between inertial, externally driven rollers generate a positive feedback between local density and polar alignment, which stabilizes the propagating flock. These results identify a new mechanism for phase separation in inertial active matter and provide a controllable platform for exploring collective motion relevant to biological flocks and engineered active systems.

Mingcheng Yang
Institute of Physics, CAS

Surface Tension between Coexisting Phases of Active Particles

Abstract:
Surface tension plays a pivotal role in interfacial phenomena and typically exhibits a positive value for interfaces of stable phase-separated systems. However, for motility-induced phase separation (MIPS) of active Brownian particles, the active surface tension, determined through active pressure, is surprisingly negative. This counterintuitive active surface tension has caused considerable debate over its interpretation and proper formulation. To address this challenge, we derive the active surface tension from its mechanical definition based on the conventional intrinsic pressure framework. The derived expression yields a markedly positive surface tension for the MIPS, aligning with direct mechanical stability analysis of active interfaces. These findings significantly advance the understanding of active surface tension and pave the way for exploring complex active interfacial phenomena.

Kazuaki Takasan
University of Tokyo

Quantum Active Matter

Abstract:
Active matter is an ensemble of self-propelled entities, such as flocks of birds and schools of fish, that has attracted much attention because of phase transitions and pattern formation not present in equilibrium systems. While most studies have been limited to classical systems, recent developments in atomic, molecular, and optical systems suggest that it may be possible to design quantum many-body systems that behave like active matter. In this talk, I will present our work on two-component hard-core bosons with spin-dependent asymmetric (non-Hermitian) hopping, corresponding to the motility of each active particle. We have shown that this model can be regarded as a quantum generalization of classical active-matter models defined on a lattice and that it exhibits motility-induced phase separation. More recently, we have shown, based on both numerical and analytical analyses, that the combination of activity and repulsive interactions induces ferromagnetism. This activity-induced ferromagnetism can be considered as a quantum counterpart

Suropriya Saha
Max Planck Institute for Dynamics and Self-Organization

Spinning Mixtures: Nonreciprocity Transfers Chirality across Scales in Scalar Densities

Abstract:
Mixtures of chiral active particles provide a minimal setting where nonreciprocity and chirality intertwine to shape collective dynamics. Here we show that nonreciprocal interactions can generate and transfer chirality across scales even in theories formulated solely in terms of scalar number densities. We introduce a minimal two-species continuum model, which we call $\NRCHs$, in which nonreciprocity and chirality enter through local and nonlocal parts of the chemical potential—both contributions equally relevant in terms of the number of spatial gradients involved. At the coarse-grained level, chirality manifests as localized domains (called charges) with a finite curl of the interspecies nonreciprocal current. These chiral charges actively redistribute particles, strongly modifying the underlying nonreciprocal dynamics. Their interplay gives rise to distinct nonequilibrium steady states, including phase separation with persistent edge currents and a spatiotemporally disordered phase combining chiral and nonreciprocal signatures. Our results establish nonreciprocity as a generic mechanism for generating chiral dynamics in scalar mixtures.

Sifan Yin
Max Planck Institute for the Physics of Complex Systems

Developmental mechanics of divergent buckling patterns in chick gut

Abstract:
Tissue buckling is an increasingly appreciated mode of morphogenesis in the embryo, but it is often unclear how geometric and material parameters are molecularly determined during development to generate diverse functional patterns. Here, we study the link between mechanical properties and the morphogenesis of the intestinal tract, the esophagus, small and large intestine. These regions originate from a simple, common tube but adopt unique forms. Using measured data from the developing chick gut coupled with a minimal theory and simulations of differential growth, we investigate divergent lumen morphologies along the entire early gut and demonstrate that spatiotemporal geometries, moduli, and growth rates control the segment-specific patterns of mucosal buckling. Primary buckling into wrinkles, folds, and creases, as well as secondary period-doubling in the foregut and multiscale creasing-wrinkling in the hindgut, are captured and well explained by mechanical models. This study advances our existing knowledge of how identity leads to form in these regions, laying the foundation for future work uncovering the relationship between molecules and mechanics in gut morphological regionalization.