CSRC

Active Matter: Interfaces and Boundaries

Workshop Program

April 24-26, 2024

Beijing China

Active Matter: Interfaces and Boundaries

April 24-26, 2024 Beijing CSRC

Organizers

Hugues Chaté, Beijing Computational Science Research Center & CEA Saclay

Jure Dobnikar, IOP/CAS

Ignacio Pagonabarraga, University of Barcelona

Contact Information

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Usefull Information

For your convenience, here are ***Some Important Tips***:

1.Workshop Date: April 24-26, 2024

2. Onsite Registration

- ✧ Time: 08:00-08:50 (April 24, Wednesday)
- ✧ Place: Conference Room I

3. CSRC Address: Beijing Computational Science Research Center, Building No.9, No. 10 East Xibeiwang Road, Haidian District, Beijing, China

(北京市海淀区西北旺东路10号院东区9号楼，北京计算科学研究中心)

4.Venue

- ✧ **Tutorial/Workshop venue:** Conference Room I, 1st Floor (一楼第一会议室)
- ✧ **Lunch & Dinner Place:** Canteen, B1 Floor (中心地下一层餐厅)

5. WIFI: csrc_guest, password: csrc20150308

6. Recommended Route

- ✧ **Taxi:**

(1) From Capital International Airport (首都国际机场): the cost is about 130 RMB (50mins).

(2) From Beijing Daxing International Airport (北京大兴机场): the cost is about 300 RMB (80mins).

(3) From Beijing Railway Station (北京站): the cost is about 100 RMB (80 mins).

(4) From Beijing West Railway Station (北京西站): the cost is about 70 RMB (60mins).

(5) From Beijing South Railway Station (北京南站): the cost is about 105 RMB (90mins).

✧ **Local Bus:**

(1) Bus #495/#909 (Software Park West Stop/软件园西区站)

(2) Bus #333 (Software Park North Stop/r 软件园北站)

(3) Bus #963/#982 (Dongbeiwang West Road North Stop/东北旺西路北口站)

✧ **Subway:**

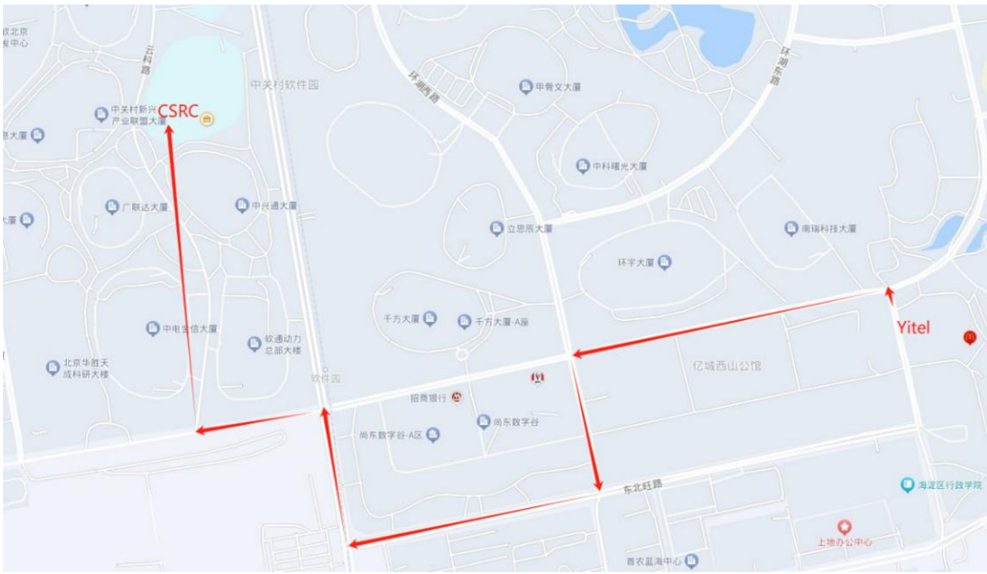
(1) Take Subway Line 13 to "**SHANG DI Station(上地站)**", take Exit A to catch Bus #909 to "**Software Park West Stop(软件园西区站)**". Cross the road, enter the park, then take the first road to the right and proceed in the north direction, CSRC will be to your right in 400 meters.

(2) Take Subway Line 13 to "**Qing He Station(清河站)**", take Exit A to catch Bus #495 to "**Software Park West Stop(软件园西区站)**". Cross the road, enter the park, then take the first road to the right and proceed in the north direction, CSRC will be to your right in 400 meters.

7.Recommended Hotels

✧ **Yitel (和颐酒店) :**

ZPark Building 9, No. 8 West Dongbeiwang Road, Haidian District, Beijing, 100094, China 北京市海淀区东北旺西路 8 号中关村软件园 9 号楼 (中关村软件园南门)



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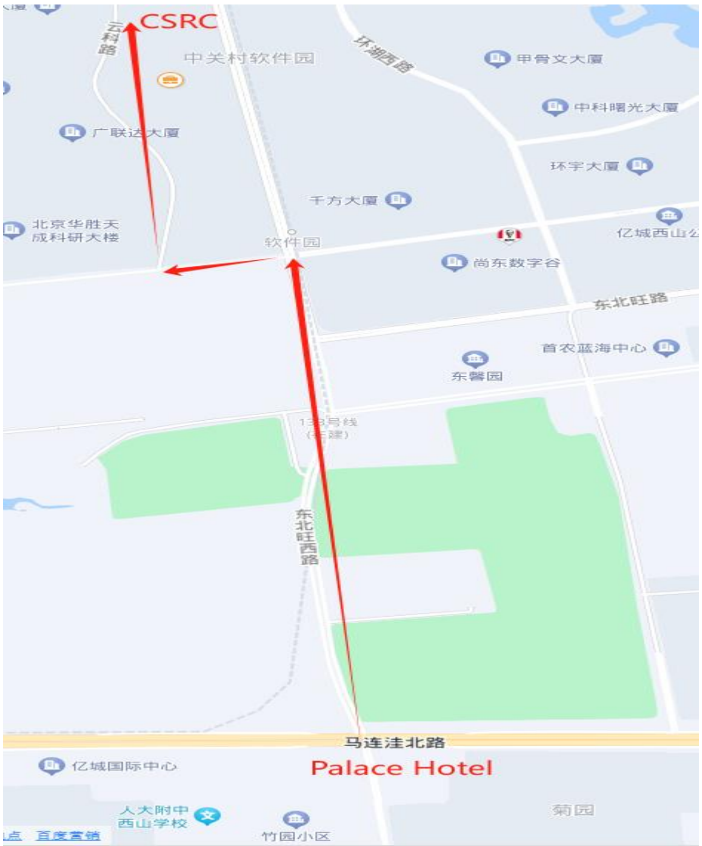
✧ **Palace Hotels 朗丽兹酒店**

北京市海淀区竹园东街与马连洼北路交叉口西南侧约 50 米 (竹园小区北侧商服楼一层 111 号)



Invited Speakers

Francesco Ginelli	Universita degli Studi dell'Insubria, Italy
Isabella Guido	University of Surrey, UK
Silke Henkes	Leiden University, The Netherlands
Benoît Mahault	Max Planck Institute for Dynamics and Self-Organization, Germany
Fanlong Meng	Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing
Yi Peng	Institute of Physics, Chinese Academy of Sciences, Beijing
Sunghan Ro	MIT, USA
Masaki Sano	Shanghai Jiao Tong University, Shanghai
Xiaqing Shi	Soochow University, Suzhou
Alexandre Solon	Sorbonne Université, France
Anton Souslov	University of Cambridge, UK
Thomas Speck	University of Stuttgart, Germany
Julien Tailleur	MIT, USA
Andrej Vilfan	J. Stefan Institute, Slovenia
Xinliang Xu	Beijing Computational Science Research Center, Beijing
Mingcheng Yang	Institute of Physics, Chinese Academy of Sciences, Beijing
Fangfu Ye	Wenzhou Institute, University of Chinese Academy of Sciences, Wenzhou
Zhihong You	Xiamen University, Xiamen
Hepeng Zhang	Shanghai Jiao Tong University, Shanghai
Jie Zhang	University of Science and Technology of China, Hefei
Kun Zhao	University of Electronic Science and Technology of China, Chengdu
Yongfeng Zhao	Soochow University, Suzhou

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Workshop Schedule

April 24, 2024 (Wednesday)

Registration	**April 24 08:00-08:50**
08:50-09:30	Julien Tailleur **From pressure to surface tension, the anomalous mechanical properties of active particles**
09:30-10:10	Yongfeng Zhao **Active Young-Dupré's equation**
10:10-10:40	Group Photo (Lobby, 1st Floor) & Coffee Break
10:40-11:20	Thomas Speck **Active Brownian particles under hard and soft confinement**
11:20-12:00	Zhihong You **Liquid-liquid phase separation driven by active flow**
12:00-13:00	Lunch (*CSRC Canteen, B1 Floor*)
13:00-14:00	Coffee & Discussions
14:00-14:40	Francesco Ginelli **Flocking under confinement: Boundary induced symmetry breaking and Casimir-like forces**
14:40-15:20	Alexandre Solon **The fragility of collective motion**
15:20-16:00	Tea & Discussions
16:00-16:40	Jie Zhang **Experimental observation of anomalous giant number fluctuations in homogeneous active liquid**
16:40-17:20	Sunghan Ro **Far-reaching impact of boundaries and disorder on scalar active matter**
17:20	Dinner (*CSRC Canteen, B1 Floor*)

April 25, 2024 (Thursday)

08:50-09:30	Isabella Guido **Mechanical instability in living materials**
09:30-10:10	Silke Henkes **Emergent mesoscale correlations in active solids**
10:10-10:40	Coffee Break
10:40-11:20	Xiaqing Shi **Deformations of 2D crystalline boundaries in active bath: effect of persistent noise**
11:20-12:00	Xinliang Xu **Sticky bacteria are hot**
12:00-13:00	Lunch (*CSRC Canteen, B1 Floor*)
13:00-14:00	Coffee & Discussions
14:00-14:40	Yi Peng **Bacterial turbulence from two to three dimensions**
14:40-15:20	Anton Souslov **Optimal design and pattern formation in robotic active matter**
15:20-16:00	Tea & Discussions
16:00-16:40	Kun Zhao **The role of Type IV Pili in Cyanobacterium Synechococcus elongatus PCC7942**
16:40-17:00	Final Discussions
17:00	Dinner (*CSRC Canteen, B1 Floor*)

April 26, 2024 (Friday)

08:50-09:30	Benoît Mahault **Collective self-caging of active filaments by virtual confinement**
09:30-10:10	Fanlong Meng **Cilia beating in presence of a wall**
10:10-10:40	Coffee Break
10:40-11:20	Andrej Vilfani **Order from a border: hydrodynamic synchronization of cilia in finite systems**
11:20-12:00	Mingcheng Yang **Biomimetic Synchronization in biciliated robots**
12:00-13:00	Lunch (*CSRC Canteen, B1 Floor*)
13:00-14:00	Coffee & Discussions
14:00-14:40	Hepeng Zhang **Measuring attractive interaction between a self-electrophoretic micromotor and a wall**
14:40-15:20	Masaki Sano **Active Fluid Experiments in Confined Geometries**
15:20-16:00	Tea & Discussions
16:00-16:40	Fangfu Ye **Collective dynamics of cell migration**
16:40-17:00	Farewell
17:00	Dinner (*CSRC Canteen, B1 Floor*)

Flocking under confinement: Boundary induced symmetry breaking and Casimir-like forces

Francesco Ginelli

Dipartimento di Scienza e Alta Tecnologia and Center for Nonlinear and Complex Systems, Università degli Studi dell'Insubria, Como, Italy

Confining in space the equilibrium fluctuations of statistical systems with long-ranged correlations is known to result into effective forces on the boundaries. Here we demonstrate the occurrence of Casimir-like forces in the non-equilibrium context provided by flocking active matter. In particular, we consider a system of aligning self-propelled particles in two spatial dimensions, which are transversally confined by reflecting or partially reflecting walls. We discuss how bulk correlations are affected by such boundaries and show that the confined active vectorial fluid is characterized by extensive boundary layers, as opposed to the finite ones usually observed in confined scalar active matter. Moreover, a finite-size, fluctuation-induced contribution to the pressure on the wall emerges, which decays slowly and algebraically upon increasing the distance between the walls. We explain our findings – which display a certain degree of universality – within a hydrodynamic description of the density and velocity fields.

Mechanical instability in living materials

Isabella Guido

University of Surrey, Guildford, UK

Cytoskeletal networks such as microtubules and motor proteins drive vital cellular processes that, together with cargo delivery and cell division, also include providing mechanical stability when cells are exposed to external stresses. However, how the cytoskeleton orchestrates its components to respond to external environment is not still clear.

Here we show a bioinspired system resembling a cytoskeletal networks and characterize its activity under the influence of external mechanical stimulation. We observe the emergent behavior in compartments of various nature and size, exploring how environmental dynamics influence system dynamics.

By analysing such non-equilibrium systems, our study contributes to elucidating how biological structures respond to mechanical cues commonly encountered in the environment of living organisms.

Emergent mesoscale correlations in active solids

Silke Henkes

Lorentz Institute for Theoretical Physics, Leiden University, The Netherlands

In soft active matter, such as crawling and swimming cells, or active colloids and polymers, active driving interacts with the mechanical properties of the material to form active solids, liquids and everything in between.

Here I will present how a generic mesoscopic correlation length emerges from the coupling of uncorrelated but persistent self-propulsion to the elasticity of the underlying material in overdamped dynamics. It can be applied it to an intriguing system of travelling strings made of active colloids, where it explains string propulsion and emergent tangent-tangent corrleations seen in simulation and experiment.

Within this framework, we can model epithelial cell sheets with active Brownian dynamics and soft repulsive interactions, and also as a self-propelled Voronoi model. Then uncoordinated cell crawling interacting with mechanics produces characteristic 'swirly' motion with strong spatiotemporal correlations. We are able to quantitatively match simulations and in-vitro cell sheets made of corneal epithelial cells and MDCK cells. We can also show that these emergent correlations are a good model for the fingering instability at the edge of these sheets. I will conclude with recent results that consider uncorrelated activity that takes the form of internal stresses in the system, which are a frequent feature in morphogenesis.

Collective self-caging of active filaments by virtual confinement

Benoît Mahault

Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

The coupling of motility with active responses to environmental cues is essential for many microorganisms to seek and establish appropriate habitats, and offers new strategies to control biological and synthetic active systems. One of the simplest possible responses, reversals of the direction of motion, is believed to enable filamentous cyanobacteria to form stable aggregates or accumulate in suitable light conditions. By subjecting ensembles of gliding cyanobacteria to disk illumination patterns, we demonstrate that filamentous morphology in combination with reversals has consequences far beyond simple accumulation: ring-like nematically ordered aggregates form at the edges of the illuminated region. Varying the size and shape of the light pattern, we explore how boundary curvature impacts aggregation. A minimal mechanistic model of active flexible filaments qualitatively replicates the experimental findings, and reveals the generic and emergent character of this phenomenology by showing that it arises despite the absence of explicit alignment with the illumination edge.

Cilia beating in presence of a wall

Fanlong Meng

Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing

Cilia can beat collectively in the form of the metachronal wave, and we investigate how near field hydrodynamic interactions between cilia can influence the collective response of the beating cilia. We find that the first harmonic mode in the driving force acting on each individual cilium can determine the direction of the metachronal wave after considering the finite size of the beating trajectories, identified by our agent-based numerical simulations. The stable wave patterns, e.g., the travelling direction, can be controlled by the driving forces acting on the cilia, based on which one can change the flow field generated by the cilia. This work can help to understand the role of the hydrodynamic interactions in the collective behaviours of cilia, and may also guide future fabrications of artificial cilia beating in the desired dynamic mode.

References: [1] Z. Cheng, A. Vilfan, Y. Wang, R. Golestanian, F. Meng, to be submitted (2024); [2] F. Meng, R. Bennett, N. Uchida, R. Golestanian, Proceedings of the National Academy of Sciences 118, e2102828118 (2021).

Bacterial turbulence from two to three dimensions

Yi Peng

Institute of Physics, Chinese Academy of Sciences, Beijing

Turbulent flows are observed in low-Reynolds active fluids, which are intrinsically different from inertial turbulence featured by Kolmogorov's universal -5/3 scaling in kinetic energy spectra. Understanding the scaling behaviors of this new type of turbulence and their dependence on the system dimensionality is a fundamental challenge in non-equilibrium physics. We experimentally measure flow structures and energy spectra of bacterial turbulence between two large parallel plates spaced by different heights H. The turbulence exhibits three regimes as H increases, resulting from the competition of bacterial length, vortex size and H. The spectra display distinct universal scaling laws in two-dimensional (2D) and three-dimensional (3D) regimes, independent of bacterial activity, length and H, whereas scaling exponents exhibit transitions in the crossover. To understand the scaling laws, we develop a hydrodynamic model using image systems to represent the effect of no-slip confining boundaries. This model predicts universal 1 and -4 scaling on large and small length limits, respectively, and -2 and -1 on intermediate length scales in 2D and 3D, respectively, which are consistent with the experimental results. Our study suggests a framework for investigating the effect of dimensionality on non-equilibrium self-organized systems.

Far-reaching impact of boundaries and disorder on scalar active matter

Sunghan Ro

Department of Physics, MIT, USA

The motion of active systems is distinguishable from its time-reversed counterpart, setting it apart from equilibrium systems. As a result, the responses of active systems to forces exerted by inclusions exhibit characteristics unmatched by equilibrium systems. Notably, asymmetric inclusions can induce steady-state currents and corresponding long-range density modulations. In this talk, based on a recent review [1] and studies [2,3], I will discuss the mechanical responses of scalar active matter to weak potential forces and show how they can alter the macroscopic phases of the systems.

[1] O. Granek, Y. Kafri, M. Kardar, S. Ro, J. Tailleur, and A. Solon, ``Colloquium: Inclusions, boundaries, and disorder in scalar active matter", Rev. Mod. Phys. (accepted in March 2024)

[2] Y. Ben Dor, S. Ro, Y. Kafri, M. Kardar, and J. Tailleur, ``Disordered boundaries destroy bulk phase separation in scalar active matter", Phys. Rev. E 105, 044603 (2022)

[3] S. Ro, Y. Kafri, M. Kardar, J. Tailleur, ``Disorder-induced long-ranged correlations in scalar active matter", Phys. Rev. Lett. 126, 048003 (2021)

Active Fluid Experiments in Confined Geometries

Masaki Sano

Institute of natural Sciences & School of Physics and Astronomy, Shanghai Jiao Tong University & Universal Biology Institute, The University of Tokyo

Fluid motion is a fascinating phenomenon, and even though the world has entered the age of quantum and AI, there are still many unsolved problems. Unlike the phase transition problem in equilibrium statistical mechanics, which is always considered in an ideally infinite system at thermal equilibrium, fluid motion is highly dependent on the geometry and driving condition at the boundaries. Collection of self-driven elements create active fluids that spontaneously flow with no external force or pressure gradient. In fluid dynamics, thanks to many years of accumulated experience, there is a list of solved and unsolved problems. However, our understanding of active fluids has only just begun. Therefore, the study of active fluid dynamics in confined geometries and with different boundary conditions offers many opportunities for exploration. Here, we demonstrate that confinement of active fluids consisting of motile many biological cells crawling on the substrate can create spontaneous flows in confined geometries. We report interesting phenomena such as directional flow, chiral edge flow, accumulation and depletion phenomena depending on the shape of the walls or the weak local induction patterns present on the substrates.

Deformations of 2D crystalline boundaries in active bath: effect of persistent noise

Xiaqing Shi

Center for Soft Condensed Matter Physics and Interdisciplinary Research, School of Physical Science and Technology, Soochow University, Suzhou

Two-dimensional (2D) crystals made of active particles were shown recently to be able to experience extremely large spontaneous deformations without melting. The root of this phenomenon was argued to lie in the time-persistence of the orientation of the intrinsic axes of particles. Here, we pursue this idea and consider passive systems subjected to time-persistent external perturbations. We study a simple model of a passive 2D crystal immersed in a bath of active particles, and show that it can sustain large deformations without melting. We then show its connections to active crystals formed by active Brownian particles and a 2D XY model subjected to time-correlated noise.

The fragility of collective motion

Alexandre Solon

LPTMC, Sorbonne Université, Paris, France

Understanding the collective motion of self-propelling particles, such as flocking birds, is a problem that is almost 30 years old but remains topical. Considering minimal flocking models (the Vicsek model and its variants) I will present several results that tend to show the fragility of the polar ordered phases of collective motion. First, any amount of spatial anisotropy destroys the long-range correlations and giant density fluctuations characteristic of these states. Moreover, in several models, the ordered state is actually unstable to the nucleation of defects.

Optimal design and pattern formation in robotic active matter

Anton Souslov

DAMTP, University of Cambridge, UK

Active solids consume energy to allow for actuation and shape change not possible in equilibrium. I will focus on design principles for active materials with so-called odd elastic moduli, which are composed of non-reciprocal springs. For example, we find that in floppy lattices, zero modes couple to microscopic non-reciprocity, destroying odd moduli entirely. Instead, an optimal odd lattice with be sufficiently soft to activate elastic deformations, but not too soft. I will then discuss how inertia and odd elasticity conspire and give rise to new varieties of pattern formation at the continuum scale. These results provide a theoretical underpinning for recent experiments and point to the design of novel soft machines.

Active Brownian particles under hard and soft confinement

Thomas Speck

Institute for Theoretical Physics IV, University of Stuttgart, Germany

I will present recent and ongoing work to characterize the behavior of active particles under confinement combining experiments using colloidal particles with simulations and dynamic mean-field theory. First, I will discuss how active particles modulate forces between a hard wall and a trapped probe particle [1], opening strategies for microrheological investigations of active media. In contrast to passive suspensions, such active depletants imply large repulsive forces governed by a pronounced local structure. We supplement these observations by an adiabatic elimination of the active particles, leading to an effective evolution equation for the probe particle [2]. In the second part, I will discuss our recent results for the behavior of active particles if confined to a channel or annulus by soft forces [3] as relevant for many biological situations in which confinement is rather soft and flexible. Varying the propulsion speed and confinement strength, we observe the formation of dynamic clusters and a reentrant transition into a uniform gas-like phase.

[1] S Paul, A Jayaram, N Narinder, T Speck, C Bechinger, PRL 129, 058001 (2022)

[2] A Jayaram, T Speck, EPL 143, 17005 (2023)

[3] T Knippenberg, A Jayaram, T Speck, C Bechinger, arXiv:2310.16814

From pressure to surface tension, the anomalous mechanical properties of active particles

Julien Tailleur

Department of Physics, MIT, Cambridge, USA

Active particles dissipate energy to exert self-propelling forces on their environment. This microscopic drive out of equilibrium leads to rich behaviors, from the flocking of birds to the motility-induced phase separation of self-propelled colloids or bacteria, that have attracted a lot of attention in the past. This exchange of momentum with the environment also impacts their collective mechanical properties, a topic which has been much less studied. In this talk, I will review recent developments concerning the mechanical pressure and the surface tension of active systems and show how statistics and mechanics decouple in these non-equilibrium systems, leading to surprising properties.

References:

A. P. Solon, Y. Fily, A. Baskaran, M. E. Cates, Y. Kafri, M. Kardar, J. Tailleur, "Pressure is not a state function for generic active fluids", Nature Physics 11, 673-678 (2015)

N. Nikola, A. P. Solon, Y. Kafri, M. Kardar, J. Tailleur, R. Voituriez , "Active particles on curved surfaces: Equation of state, ratchets, and instabilities", Phys. Rev. Lett. 117, 098001 (2016)

R. Zakine, Y. Zhao, M. Knezevic, A. Daerr, Y. Kafri, J. Tailleur, F. van Wijland, "Surface Tensions between Active Fluids and Solid Interfaces: Bare vs Dressed", Physical Review Letters 124, 248003 (2020)

Order from a border: hydrodynamic synchronization of cilia in finite systems

Andrej Vilfan

J. Stefan Institute, Ljubljana, Slovenia

When many cilia are located on the surface of a microorganism, their beating can synchronise such that their phases form metachronal waves. To understand the process of synchronisation, we study a model where each cilium is represented as a spherical particle, moving along

a tilted trajectory with a position-dependent active driving force and a position-dependent internal drag coefficient. The model thus takes into account all the essential broken symmetries of the ciliary beat. We show that taking into account the near-field hydrodynamic

interactions, the effective coupling between cilia can become nonreciprocal: the phase of a cilium is more strongly affected by an adjacent cilium on one side than by a cilium at the same distance in the opposite direction. As a result, synchronisation starts from a seed at the edge of a group of cilia and propagates rapidly across the system, leading to a synchronisation time that scales proportionally to the linear dimension of the system. A ciliated surface is thus

characterised by three different velocities: the velocity of fluid transport, the phase velocity of metachronal waves and the group velocity of order propagation. Unlike in systems with reciprocal coupling, boundary effects are not detrimental for synchronisation, but rather help to initiate the wave.

[1] D. Hickey, R. Golestanian and A. Vilfan, Proc. Natl. Acad. Sci. USA 120, e2307279120 (2023).

Sticky bacteria are hot

Xinliang Xu

Complex Systems Division, Beijing Computational Science Research Center

The entrapment of bacteria near boundary surfaces is of biological and practical importance, yet the underlying physics is not well understood. We demonstrate that it is crucial to include a commonly neglected entropic effect related to the spatial variation of hydrodynamic interactions, through a model that provides analytic explanation of bacterial entrapment in two dimensionless parameters: α_1 the ratio of thermal energy to self-propulsion, and α_2 an intrinsic shape factor. For α_1 and α_2 that match an Escherichia coli at room temperature, our model quantitatively reproduces existing experimental observations, including two key features that have not been previously resolved: The bacterial "nose-down" configuration, and the anticorrelation between the pitch angle and the wobbling angle. Furthermore, our model analytically predicts the existence of an entrapment zone in the parameter space defined by $\{\alpha_1, \alpha_2\}$.

Biomimetic Synchronization in biciliated robots

Mingcheng Yang

Institute of Physics, Chinese Academy of Sciences, Beijing

Direct mechanical coupling is known to be critical for establishing synchronization among cilia. However, the actual role of the connections is still elusive - partly because controlled experiments in live samples are challenging. Here, we employ an artificial ciliary system to address this issue. Two cilia are formed by chains of self-propelling robots and anchored to a shared base so that they are purely mechanically-coupled. The system mimics biological ciliary beating but allows fine control over the beating dynamics. We find that the artificial cilia exhibit rich motion behaviors, depending on the mechanical coupling scheme. Particularly, their synchronous beating display two distinct modes - analogous to those observed in C. reinhardtii, the biciliated model organism for studying synchronization. Close examination suggests that the system evolves towards the most dissipative mode. Using this guideline in both simulations and experiments, we are able to direct the system into a desired state by altering the modes' respective dissipation. Our results have implications in understanding the synchronization of cilia.

Collective dynamics of cell migration

Fangfu Ye

Wenzhou Institute, University of Chinese Academy of Sciences

TBA

Liquid-liquid phase separation driven by active flow

Zhihong You

Department of Physics, Xiamen University

Liquid-liquid phase separation (LLPS) plays a crucial role in various processes such as cell signaling, protein aggregation, and the formation of complex materials. In this talk, I will demonstrate how active flow can be used to control LLPS, allowing us to manipulate the physical properties of liquid droplets including the shape, topology, and size distribution.

Measuring attractive interaction between a self-electrophoretic micromotor and a wall

Hepeng Zhang

School of Physics and Astronomy & Institute of Natural Sciences, Shanghai Jiao Tong University

Chemically driven micromotors interact strongly with nearby walls. However, the strength of the motor-wall interaction has not been experimentally quantified. Here, we apply an external force to a self-electrophoretic micromotor which slides along a wall and measure the force required to lift the motor off the wall. Our experiments show that the required lift force increases with the strength of chemical driving and can be significantly larger than motor's effective gravity and propulsive force. Experimental results are reproduced by an electro-kinetic numerical model which includes fully resolved Debye layers. The model shows that the attractive force arises from the accumulation of excessive Hydrogen ions between the motor and wall, revealing a non-equilibrium mechanism to generate attractive interactions between like-charge objects.

Experimental observation of anomalous giant number fluctuations in homogeneous active liquid

Jie Zhang

University of Science and Technology of China, Hefei

Giant number fluctuations, universally observed in active fluids exhibiting polar or nematic order, stand out as a distinct anomaly. In active Brownian particles without polar order, however, motility induced phase separations are usually inevitable. Although inertia can be turned on in physical models to avoid motility induced phase separations, and simulations suggest ubiquitous anomalous fluctuations even in disordered homogeneous fluid phase, such phenomena have never been observed experimentally. In this talk, we will show that GNF arise in the fluid phase of active Brownian particles, where the polar order and motility induced phase separation are absent. GNF in ABP extends over a large but finite length which characterizes the growing velocity correlations.

The role of Type IV Pili in Cyanobacterium Synechococcus elongatus PCC7942

Kun Zhao

University of Electronic Science and Technology of China, Chengdu

Type IV pili (TFP) are bacterial surface appendages that are closely related to a variety of cell activities including cell motilities and natural transformation. However, for photosynthetic cyanobacteria with unique circadian rhythm that play important roles in global carbon cycling, the molecular and ecological functions of their TFP have rarely been reported. In this talk, firstly, I will show that by establishing a method of fluorescently labeling pili in cyanobacterium Synechococcus elongatus PCC 7942 (Syn7942), we have quantitatively characterized the TFP and its-driven twitching motility in situ at the single-cell level. With this technique, we have discovered an oscillating pattern of TFP in accordance with the light and dark periods during light-dark cycles, suggesting a circadian rhythmic regulation of TFP activities. Finally, I will briefly discuss the fluid dynamics associated with TFP activities and its role in controlling cell positions in water columns.

Active Young-Dupré's equation

Yongfeng Zhao

Center for Soft Condensed Matter Physics and Interdisciplinary Research, School of Physical Science and Technology, Soochow University, Suzhou, China

Active particles can form liquid droplets that exhibit rich wetting phenomena on solid surfaces. Surface tensions are state variables that are expected to control the wetting phenomena in equilibrium systems. However, in active systems, the surface tensions between the three phases (liquid, gas, and solid) involved are not well understood, especially when the liquid-gas surface tension is argued to be negative [1]. In this talk, we provide mechanical justifications for the negative liquid-gas surface tension. Then we show how the force balance among the three surface tensions at the contact angle is disrupted by self-organized non-equilibrium particle currents. This leads to an active Young-Dupré's equation that successfully predicts both the contact angles and the shapes of the liquid-gas interfaces [2].

References

1. Julian Bialke, Jonathan T. Siebert, Hartmut Lowen, and Thomas Speck, ”Negative Interfacial Tension in Phase-Separated Active Brownian Particles”, Phys. Rev. Lett. 115, 098301 (2015)

2. Yongfeng Zhao, Ruben Zakine, Adrian Daerr, Yariv Kafri, Julien Tailleur, and Frederic van Wijland, “Active Young-Dupré's Equation: How Self-organized Currents Stabilize Partial Wetting”, in prepare.