國科溫州研究院
Wenzhou Institute UCAS

Active Matter c2c

Advanced core-to-core network for the physics of self-organizing active matter

Wenzhou Institute
University of Chinese Academy of Sciences

国科温州研究院

January 29th - 30th, 2024

PROGRAM BOOK

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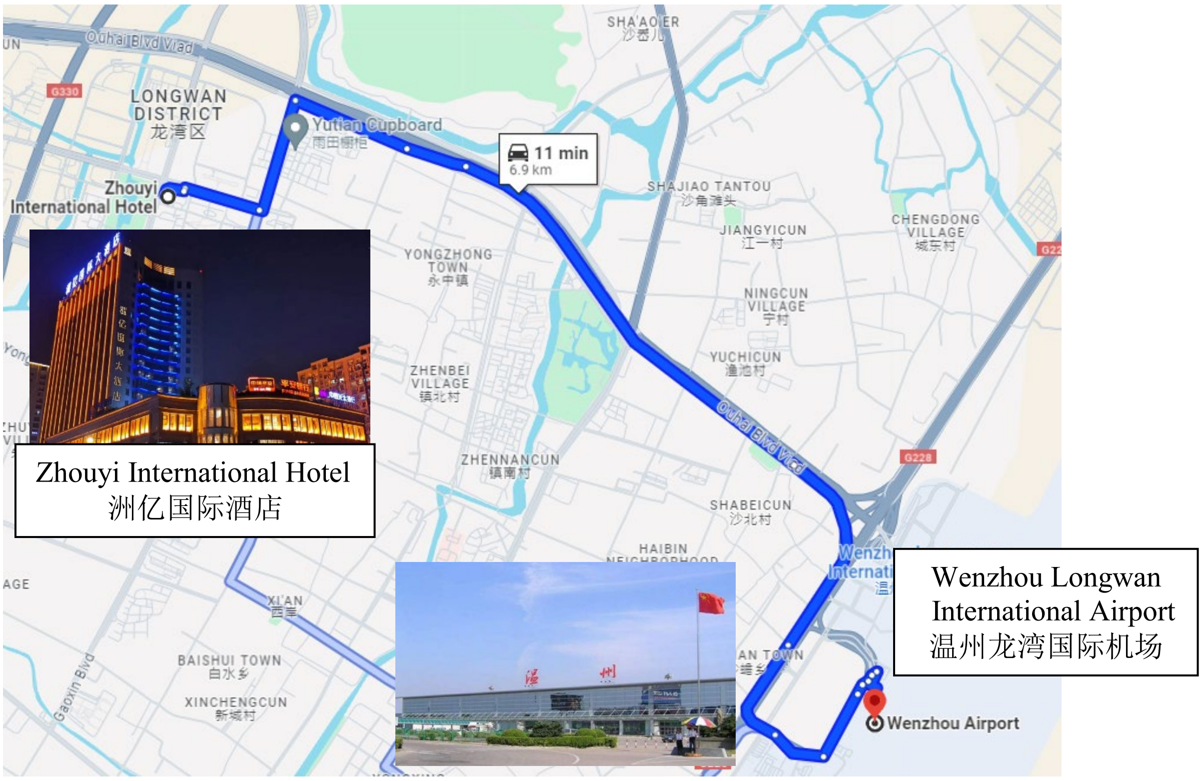
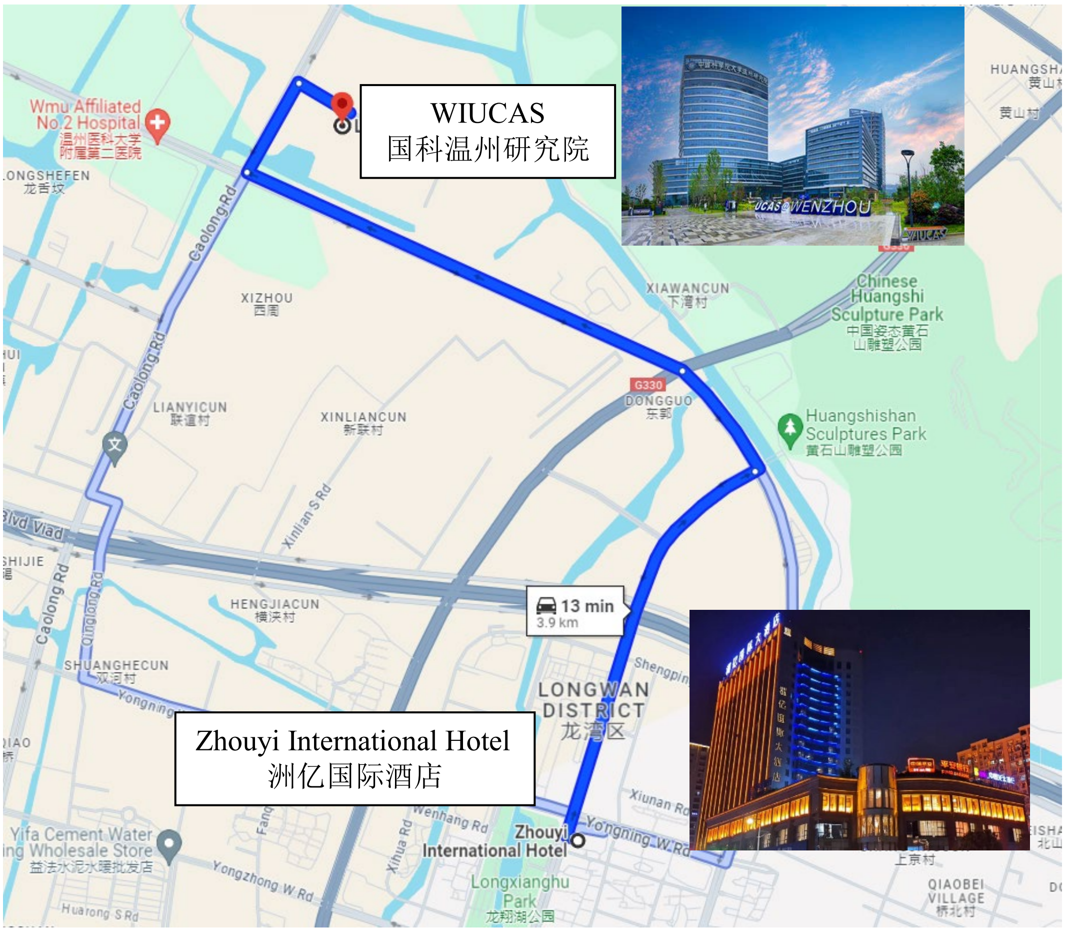
Map of Wenzhou





PROGRAM

Jan. 29	Meeting Room, 4th Floor, Building #3, Wenzhou Institute, UCAS		
Chair: Shigeyuki Komura (WIUCAS)			
8:50-9:00	Opening		
9:00-9:25	Fangfu Ye 叶方富	Wenzhou Institute, UCAS 国科温州研究院	ECM-mediated cell dynamics
9:25-9:50	Xinpeng Xu 徐新鹏	Guangdong Technion – Israel Institute of Technology 广东以色列理工学院	Lorentz reciprocal relations in dry active fluid
9:50-10:15	Masaki Sano 佐野雅己	Shanghai Jiao Tong University 上海交通大学	Integer topological defects reveal hidden nonlinear active forces in active nematics
Break			
Chair: Yujie Jiang (WIUCAS)			
10:35-11:00	Yongfeng Zhao 赵永峰	Soochow University 苏州大学	Characterization and control of the run-and-tumble dynamics of Escherichia coli
11:00-11:25	Daiki Nishiguchi 西口大貴	The University of Tokyo 东京大学	Vortex reversal as a precursor of active turbulence
11:25-11:40	Haiqin Wang 王海钦	Technion – Israel Institute of Technology 以色列理工学院	Persistent random walk: A phenomenological paradigm for cell migration on solid substrates
Lunch @ WIUCAS			
Chair: Ziluo Zhang (WIUCAS)			
14:00-14:25	Rosalba García Millán	King's College London 伦敦国王学院	Microscopics of motility-induced phase separation
14:25-14:50	Fanlong Meng 孟凡龙	Institute of Theoretical Physics, CAS 中国科学院理论物理所	Modelling multiflagellate swimming controlled by interflagella hydrodynamic interactions
14:50-15:15	Yi Peng 彭毅	Institute of Physics, CAS 中国科学院物理研究所	Hydrodynamics-induced interaction between parallel plates immersed in bacterial baths
Break			
Chair: Bin Zheng (WIUCAS)			
15:35-16:00	David Dean	University of Bordeaux 波尔多大学	Self phoretic motion of a trapped colloid
16:00-16:25	Hepeng Zhang 张何朋	Shanghai Jiao Tong University 上海交通大学	Collective phenomena of chiral swimming microorganisms
16:25-16:50	Rui Ma 马锐	Xiamen University 厦门大学	Active matter on a deformable surface
16:50-17:05	Binze Tang 唐宾泽	Peking University 北京大学	Phase separation of transcription proteins on DNA with dispersed binding motif
Dinner @ Zhouyi International Hotel			

Jan. 30	Meeting Room, 4th Floor, Building #3, Wenzhou Institute, UCAS		
Chair: Ryohei Seto (WIUCAS)			
9:00-9:25	Ryoichi Yamamoto 山本量一	Kyoto University 京都大学	Direct numerical simulations of active particles with fully resolved hydrodynamics
9:25-9:50	Mingcheng Yang 杨明成	Institute of Physics, CAS 中国科学院物理研究所	Biomimetic Synchronization in biciliated robots
9:50-10:15	Qiang He 贺强	Harbin Institute of Technology 哈尔滨工业大学	Insights into chemically-driven colloidal motors
Break			
Chair: Zhongqiang Xiong (WIUCAS)			
10:35-11:00	Guangyin Jing 经光银	Northwest University 西北大学	Bacterial rheotaxis in complex fluids
11:00-11:25	Kenta Ishimoto 石本健太	Kyoto University 京都大学	Hydrodynamic shape theory for active particles in fluid flow
11:25-11:40	Yanan Liu 刘亚楠	Northwest University 西北大学	Circular motion of bacteria on complex interface
Lunch @ WIUCAS			
13:00-15:00	Poster Session		
Chair: Zhiyuan Zhao (WIUCAS)			
15:00-15:25	Hugues Chaté	Beijing Computational Science Research Center 北京计算科学研究中心	Metastability of polar flocks
15:25-15:50	Xiaqing Shi 施夏清	Soochow University 苏州大学	Extreme spontaneous deformations of active crystals
Break			
Chair: Zhanglin Hou (WIUCAS)			
16:10-16:35	Zhihong You 游智鸿	Xiamen University 厦门大学	Mechanical and geometrical control of active vortex condensation
16:35-17:00	Hiroyuki Kitahata 北畑裕之	Chiba University 千叶大学	Motion coupled with a shape in a particle and a droplet driven by surface tension gradient
17:00-17:10	Closing		

POSTERS

Number	Name	Title
P01	Haiqin Wang (Technion)	Variational methods and deep learning-based methods for soft and active matter physics
P02	Siyuan Yang (SJTU)	Non-reciprocal collective motion of AC Quincke rollers
P03	Yisong Yao (SJTU)	Directed motion of neural progenitor cells under splay guidance
P04	Zihui Zhao (SJTU)	Topological defects, asters, spirals and circles, induce consistent accumulation of neural progenitor cells
P05	Zhanglin Hou (WIUCAS)	Informational active Ornstein-Uhlenbeck particle
P06	Yujie Jiang (WIUCAS)	Activity-modulated particulate gels
P07	Ryohei Seto (WIUCAS)	A CFD-DEM simulation with locally-averaged equations of motion for dense suspension flows
P08	Yanwen Zhu WIUCAS)	Hard disk with Brownian inertial core
P09	Jun Li (WIUCAS)	Odd elasticity of a thermal microswimmer
P10	Zhongqiang Xiong (WIUCAS)	Ridge instability in dense suspensions caused by the second normal stress difference
P11	Zhiyuan Zhao (WIUCAS)	Phase separation of counter-spinning particles under simple shear flows
P12	Shenhua Jiang (WIUCAS)	5 scenarios of two-dimensional melting revealed by hard truncated rhombs
P13	Fei Liu, Jin Wang (WIUCAS)	ATP acts as a hydrotrope to regulate the phase separation of NBDY clusters
P14	Ziluo Zhang (WIUCAS)	Field theory of run and tumble particles in d dimensions
P15	Bin Zheng (WIUCAS)	Charge regulation of polyelectrolyte gels: Swelling transition
P16	Shigeyuki Komura (WIUCAS)	Emergence of odd elasticity in a microswimmer using deep reinforcement learning
P17	Shurui Yuan (WIUCAS)	Ultrasmall Pt NPs-modified flasklike colloidal motors with high mobility and enhanced ion tolerance
P18	Yang Huang (WIUCAS)	Directional and reconfigurable assembly of active colloidal motors triggered by chemical communications
P19	Yuta Tateyama, Hiroyuki Kitahata (Chiba U)	Analysis of spatio-temporal dynamics described by nonreciprocal Swift-Hohenberg equation
P20	Erdal C. Oğuz (IOP, CAS)	Structural studies of local environments in high-symmetry quasicrystals

ABSTRACTS

ECM-mediated cell dynamics

Fangfu Ye（叶方富）

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The migration dynamics of cells are influenced by various factors in the microenvironment. In addition to the widely studied biochemical molecular signaling pathways, physical factors in the microenvironment have also been shown to play a crucial role in regulating cell migration dynamics. We constructed an in vivo-like extracellular matrix (ECM), by using collagen with tunable stiffness, to partly mimic the microenvironment of cells, and investigated influences of ECM's physical properties on individual and collective cell dynamics and on cell communication. This talk will briefly report our recent results from these experimental and theoretical investigations on various types of cells.

Self-introduction

Prof. Fangfu Ye received his Ph.D. in Physics in 2007 from University of Pennsylvania, and later worked as a postdoctoral research associate at the Liquid Crystal Institute of Kent State University, the department of physics of University of Illinois at Urbana-Champaign, and the school of physics of Georgia Institute of Technology, successively. He joined the Institute of Physics of Chinese Academy of Sciences in 2013. His research interests span the fields of soft condensed matter physics, biological physics, and biomedical engineering, with focuses on active matter, cell behavior regulation, and properties of biological materials.

Lorentz reciprocal relations in dry active fluid

Zhihao Li[1]（李智豪）, Yongfeng Zhao[2]（赵永峰）, Xinpeng Xu[1]（徐新鹏）

[1] Physics program, Guangdong Technion – Israel Institute of Technology, Shantou, Guangdong, 515063, China

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The Lorentz reciprocal relation (LRR) derived by Lorentz in 1896 is a highly non-trivial hydrodynamic reciprocal relation, which asserts that the friction matrix of an anisotropic object in slow viscous flows is symmetric. The LRR has been proved by different ways based either on hydrodynamic theory or on Brownian motion theory. LRR can be regarded as a special case of the more fundamental Onsager reciprocal relation (ORR) that is formulated by Onsager in 1931 for linear irreversible processes. One of the major assumptions underlying the proof of ORR is the time-reversal symmetry. Here we investigate the validity of LRR for a passive rod moving in dry active fluids where time-reversal symmetry is broken. Three different types of dry active particles have been considered: active Brown particles, chiral active (self-propelled) particles, and active chiral particles. We find that the LRR is obeyed in linear regime when the passive rod is moving in active fluids composed of active Brown particles or chiral active particles. However, the LRR is broken even in linear regime when the rod is moving in active chiral particle fluids where odd viscosity emerges. Our work provides a direct, numerical illustration of the validity of the LRR as a special case of ORR outside their original range of application and uncovers the mechanisms for their broken.

Self-introduction

Dr. Xinpeng Xu received his B.S. in physics from the Wuhan University in 2008 and Ph.D. in Nano Science and Technology from the Hong Kong University of Science and Technology (HKUST) in 2012. After five years of post-doctor experiences at HKUST, Weizmann Institute of Science, and Technion-Israel, he joined the Physics program at GTIIT in 2017 as an assistant professor and became associate professor in 2023. His main research interests are in the theory of soft matter and biological systems in close collaboration with experiments.

Integer topological defects reveal hidden nonlinear active forces in active nematics

Masaki Sano（佐野雅己）

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Neural progenitor cells (NPC) are known to accumulate at +1/2 topological defects as a generic property of extensile active nematics [1]. Collective behavior around integer defects has not been well studied. Existing theories predict that cells will be attracted to aster type defect but will escape from circular defect for extensile systems. We performed experiment by inducing different types of +1 integer topological defects (aster, spiral, circle) in the monolayer of NPCs and found that cells are consistently attracted to the core of +1 defects regardless of defect type. This contradicts to existing theory. To describe these counterintuitive behaviors, we consider a particle model that could reproduce the observed behavior. Based on the successful particle model, we derived a hydrodynamic model using a Boltzmann-type approach. We elucidated that the accumulation or depletion behavior at the core of +1 defects is governed by the nonlinear active force terms, which have not been considered previously.

References

[1] K Kawaguchi, R. Kageyama, M. Sano, Nature (2018).
[2] Z. Zhao, H. Li, Y. Yao, Y. Zhao, H. Zhang, H. Chate, M. Sano in preparation.

Self-introduction

Prof. Masaki Sano is currently a chair professor at the Institute of Natural Sciences, Shanghai Jiao Tong University. His research has focused on nonlinear dynamics, fluid dynamics, and biophysics from the perspective of nonequilibrium statistical physics. Since about 1995, he has been working on problems related to living systems and experiments on active matter, with an emphasis on soft matter.

Characterization and control of the run-and-tumble dynamics of Escherichia coli

Yongfeng Zhao（赵永峰）

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The molecular basis of the run-and-tumble motility of Escherichia coli has been studied extensively. However, the quantitative spatiotemporal characterization of a swimming population remains challenging because of the broad range of relevant length and time scales. We show how this challenge can be met by using renewal processes to analyze measurements of the intermediate scattering function over length scales from ~10^0 – 10^2 μm. This allows us to demonstrate quantitatively how the persistence length of an engineered strain can be controlled by a chemical inducer and to characterize a transition from perpetual tumbling to smooth swimming. For wild-type *E. coli*, we quantitatively bridge for the first time small-scale directed swimming and large-scale diffusion, hence measuring simultaneously motility parameters and the effective diffusivity.

References

[1] Christina Kurzthaler*, Yongfeng Zhao*, Nan Zhou, Jana Schwarz-Linek, Clemence Devailly, Jochen Arlt, Jian-Dong Huang, Wilson C. K. Poon, Thomas Franosch, Julien Tailleur, and Vincent A. Martinez, Phys. Rev. Lett. 132, 038302 (2024).

[2] Yongfeng Zhao*, Christina Kurzthaler*, Nan Zhou, Jana Schwarz-Linek, Clemence Devailly, Jochen Arlt, Jian-Dong Huang, Wilson C. K. Poon, Thomas Franosch, and Vincent A. Martinez, Julien Tailleur, Phys. Rev. E 109, 014612 (2024).

Self-introduction

Dr. Yongfeng Zhao is now an associate professor in Center for Soft Condensed Matter Physics and Interdisciplinary Research, Soochow University. He obtained his BSc in Peking University and his PhD in the University of Hong Kong. Before joining Soochow University, he worked in Université Paris and Shanghai Jiao Tong University as a postdoc researcher. His research interests are on theoretical problems in active matter, non-equilibrium statistical physics, and biophysics. He works on interfacial phenomena in scalar active systems, active mixtures, and characterization of the microscopic dynamics of micro-swimmers.

Vortex reversal as a precursor of active turbulence

Daiki Nishiguchi（西口大貴）

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Active matter systems often exhibit active turbulence at low Reynolds numbers [1]. It self-organizes into stable vortices when confined in circular geometries or in the presence of periodic obstacles [2,3]. We found that a stabilized single-vortex state of bacterial turbulence under circular confinement transits to bulk turbulence via reversals of rotational directions when loosening the confinement [4]. Our numerical simulations reproduced oscillatory vortices with reversals, which we characterized as a limit cycle analytically. Combining experiments, simulations and analytical calculations, we have identified these reversals and oscillations as a precursor of active turbulence [5].

References

[1] D. Nishiguchi, J. Phys. Soc. Jpn. **92**, 121007 (2023).
[2] D. Nishiguchi, I.S. Aranson et al, Nat. Comm. **9**, 4486 (2018).
[3] H. Reinken, D. Nishiguchi et al, Comm. Phys. **3**, 76 (2020).
[4] S. Shiratani, K.A. Takeuchi and D. Nishiguchi, arXiv: 2304.03306 (2023).
[5] D. Nishiguchi, S. Shiratani, I.S. Aranson and K.A. Takeuchi, in preparation.

Self-introduction

Daiki Nishiguchi is currently an Assistant Professor at The University of Tokyo. He earned his Ph.D. in physics from The University of Tokyo in 2017, and then pursued postdoctoral research at CEA-Saclay and Pasteur Institute in Paris, France, before starting his current position in 2019. He enjoys active matter experiments both in biological and artificial systems under a microscope, with a particular focus on uncovering their universal laws and their ways of life. He has a keen interest in science communication and has been involved in diverse outreach activities. He received the Young Scientist Award of the Physical Society of Japan (2020). For more detailed information, please visit: https://sites.google.com/site/daikinishiguchi/home-english/

Persistent random walk: a phenomenological paradigm for cell migration on solid substrates

Haiqin Wang[1,2]（王海钦）and Xinpeng Xu[2,1]（徐新鹏）

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Cell migration is crucial to many biological processes, including embryonic morphogenesis, tissue repair, immune response, and cancer progression. Understanding how cells respond to external stimuli (chemical, geometrical, and physical signals) is a major challenge for cell migration. These responses involve movement toward or away from a stimulus, which is called a taxis. We propose the persistent random walk model, in which active randomness are described by persistent random motion and the taxis is included into some “potentials”, provide a phenomenological paradigm for quantifying cellular taxis, such as haptotaxis on substrates with fibronectin gradients, curvotaxis on stiff cylinders [1], and durotaxis on substrates with stiffness gradients [2].

References

[1] X. Yu, H. Wang, F. Ye, X. Wang, Q. Fan, X. Xu, bioRxiv:2022.12.30.522287.
[2] S. Bose, H. Wang, X. Xu, A. Gopinath, and K. Dasbiswas, in preparation.

Self-introduction

Ms. Haiqin Wang is currently a PhD student under the co-supervision of Prof. Yariv Kafri in the Department of Physics at the Technion – Israel Institute of Technology in Israel, and Prof. Xinpeng Xu in the Physics Program at the Guangdong Technion – Israel Institute of Technology in China. She received her BSc degree in Physics at Capital Normal University in China and MSc degree in Physics at the Beijing Normal University. Her research focuses on the theoretical modeling of mechanical interactions between adherent cells and their surrounding matrix.

Microscopics of motility-induced phase separation

R. García Millán [1,2,3], **M. Bothe**[4], **L. Chen**[4], **L. Cocconi**[4], **Z. Zhang**[4], **Z. Zhen**[4], **and G. Pruessner**[4]

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Numerical and experimental evidence shows that self-propelled particles that interact repulsively tend to form condensates, a phenomenon known as motility-induced phase separation (MIPS) that is unique to systems out of equilibrium. Active particles tend to accumulate where they move more slowly, and they tend to move slowly where they accumulate, giving rise to a positive feedback that reinforces the formation of dense and dilute regions [1, 2, 3]. The microscopic details of this mechanism and the role of the activity, however, remain elusive.

In recent work, we have studied in a many body field theory interacting run-and-tumble particles, that move at constant speed w, tumble with rate α and diffuse with constant D. Particles interact with strength ν and characteristic interaction length ξ [4, 5, 6]. Our exact results establish the link between their microscopic dynamics and the emergent effective attraction between them, as illustrated by the two-point correlation function shown in Fig. 1. In this talk I will present the key field theoretic aspects of this active system and the physical insights gained from a microscopic approach [7].

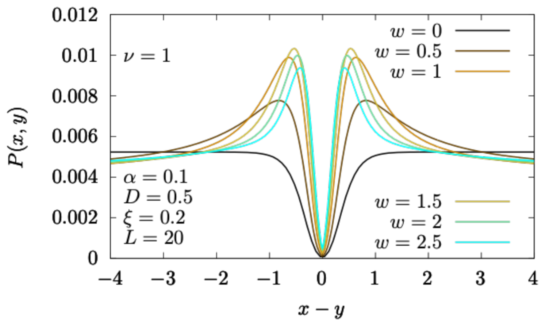

Figure 1: Two-point correlation function between interacting run-and-tumble particles for increasing self-propulsion speed.

References

[1] M. E. Cates, and J. Tailleur, *Annu. Rev. Condens. Matter Phys.* 6, 219–244 (2015).
[2] A. Slowman, M. Evans, and R. Blythe, *Phys. Rev. Lett.* 116, 218101 (2016).
[3] Y. I. Li, R. Garcia-Millan, M. E. Cates and E. Fodor, arXiv:2301.12155 (2023).
[4] R. Garcia-Millan and G. Pruessner, J. Stat. Mech. 2021 063203 (2021).
[5] G. Pruessner and R. Garcia-Millan, arXiv:2211.11906 (2022).
[6] Z. Zhang and R. Garcia-Millan, arXiv:2209.09721 (2022).
[7] R. Garcia-Millan et al., in preparation.

Self-introduction

Dr Rosalba García Millán is Lecturer in Disordered Systems at King's College London. Her research focus is on active matter, biological physics, complex systems and self-organised criticality. Using field theory, she has characterised run-and-tumble motion in a confining potential, developed a framework to calculate entropy production of active particle systems, studied non-reciprocal interactions, and branching processes and various of their applications. On the experimental side of her research, she has studied the spatial organisation of DNA inside the cell nucleus.

Modelling multiflagellate swimming controlled by interflagella hydrodynamic interactions

Fanlong Meng（孟凡龙）

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We investigate the effects of interflagella hydrodynamic interactions (iHIs) on the swimming performance of a three-dimensional multiflagellate microswimmers. When the flagella are actuated synchronously, the swimming efficiency can be either enhanced or reduced, which is determined by the intrinsic tilting angle and the number of flagella. When the flagella are actuated asynchronously with a phase difference between neighboring flagella-resembling the microalga Pyramimomas, the microswimmer can swim more efficiently by utilizing the iHIs and basal mechanical coupling. We further demonstrate that an optimal number of flagella could arise when the microswimmer is loaded with a finite-sized swimmer body. Apart from understanding the role of iHIs in multiflagellate swimming, this work could also guide laboratory fabrications of microswimmers with desired swimming performance.

Reference

[1] S. Hu and F. Meng, arXiv:2310.10189 (2023).

Self-introduction

Fanlong Meng is now a full professor at Institute of Theoretical Physics, Chinese Academy of Sciences. He obtained his Bachelor degree from University of Science and Technology of China in 2010, and then his PhD degree from Institute of Theoretical Physics, Chinese Academy of Sciences in 2015. After obtaining the PhD degree, he conducted the postdoctoral research at University of Cambridge, University of Oxford and Max Planck Institute for Dynamics and Self-Organization. In 2019, he joined Institute of Theoretical Physics, Chinese Academy of Sciences as an associate professor, and then got promoted to be a full professor in 2023. Webpage: http://lib.itp.ac.cn/html/meng.

Hydrodynamics-induced interaction between parallel plates immersed in bacterial baths

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Interaction between colloidal particles are crucial for the phase behaviors and rheology of colloidal suspensions. We employ optical-tweezers to measure the effective interactions between two parallel plates immersed in bacterial suspensions. The plates are found to experience a long-range attraction, which increases linearly with bacterial density and decreases with plate separation. The higher bacterial density and orientation order between plates observed in the experiments imply that the long-range effective attraction mainly arises from the bacterial flow field, instead of the direct bacterium-plate collisions, which is confirmed by the simulations. Furthermore, the hydrodynamic contribution is inversely proportional to the squared interplate separation in the far field. Our findings highlight the importance of hydrodynamics on the effective forces between passive objects in active baths, providing new possibilities to control activity-directed assembly.

Reference

[1] Luhui Ning, Xin Lou, Qili Ma, Yaochen Yang, Nan Luo, Ke Chen, Xin Zhou, Fanlong Meng, Mingcheng Yang, Yi Peng, Phys. Rev. Lett. 131, 158301(2023).

Self-introduction

Prof. Yi Peng is currently at Institute of Physics, Chinese Academy of Sciences. He got PhD degree in Hong Kong University of Science and Technology in 2008. His research interest is to employ advanced microscopic imaging techniques and manipulation methods to study phase transitions in colloidal crystals and collective dynamics in active matter.

Self phoretic motion of a trapped colloid

David Dean

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We consider a class of problems where a colloid interacts with its past trajectory due to interaction with a chemical gradient or temperature gradient for which the particle itself is the source. Previous studies have shown that in one dimension (in the absence of thermal noise) particles exhibit a phase transition where they exhibit a steady state where they move at a constant velocity when the self phoretic effect is sufficient strong and repulsive (negative chemophoresis or thermophoresis). Here we consider what happens when the colloid is trapped in a harmonic potential. As the phoresis strength is increased the particle leaves an inactive state and starts to oscillate under the phoretic effect. We show that this dynamical transition is continuous and identify the phase diagram as a function of the particle's friction coefficient, the strength of the trap and the phoretic constant. Near the transition a mode of frequency becomes excited and as the phoretic constant is increased this mode then generates modes of frequency etc.

Self-introduction

Prof. David Dean is professor of theoretical physics at the Laboratoire d'ondes et matière d'Aquitaine, University of Bordeaux. He works on problems of out of equilibrium statistical physics, disordered systems, random matrix theory, stochastic processes and the Casimir effect. He has published 160 papers in these areas.

Collective phenomena of chiral swimming microorganisms

Hepeng Zhang（张何朋）

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Swimming microorganisms can develop collective phenomena with extended spatiotemporal coherence through interactions between individual cells. In this talk, I will discuss two recent studies on this subject. First, we carried out experiments with marine algae (Effrenium voratum), which swim in circles at the air-liquid interface, and discovered that effective hydrodynamic repulsion between cells in the far field suppresses density fluctuations and generates disordered hyperuniform states under a wide range of density conditions. The second study focused on bacteria (Paenibacillus vortex) colonies growing on agar plates. In this system, while active turbulence without manifest chirality takes place in the bulk, cells self-organize into a wide, clockwise (viewed from the air side) flow all along the typically tortuous centimeter-scale external boundary. We traced the origin of these robust edge flows back to a weak chiral symmetry breaking mechanism at the individual level. Experimental results in both studies were quantitatively reproduced in simple particle models with hydrodynamic and excluded-volume interactions.

Self-introduction

Hepeng Zhang received his BS from Fudan University, Shanghai, China in 2000 and his PhD degree from the City University of New York, New York, United States, in 2004. He joined the University of Texas at Austin and worked as a postdoctoral researcher from 2004 to 2010. In 2010, he moved to Shanghai Jiao Tong University, where he is currently a distinguished professor. His current research interests include active matter, biophysics, fluid dynamics and statistical physics.

Active matter on a deformable surface

Rui Ma（马锐）

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The cell cortex is a thin layer of actin network that is assembled and tethered under the cell membrane. As a result of the active stresses produced by molecular motors within the actin network, the cell cortex is able to transform into various shapes. In this talk, I will present two models to describe the morphology of a cell cortex using a theory of active fluid dynamics on deformable surfaces. In the first model, we assume the active stresses produced by molecular motors are curvature-dependent. Both symmetric and asymmetric cell division can emerge from the model dynamics. In the second model, we introduce a nematic order parameter to describe the orientation of actin filaments and the active stresses are anisotropic. A spontaneous chiral symmetry breaking can occur such that actin flows in the two hemispheres are oriented in opposite directions.

Self-introduction

Prof. Rui Ma received his bachelor's degree from Jilin University in 2008, and his doctorate from Tsinghua University in 2014. He did a postdoc at MPI-PKS in Germany and Yale University in America. In September 2020, he was enrolled as a Nanqiang Scholar of Xiamen University and joined the College of Physical Science and Technology as an associate professor. His research interests are mainly in the mechanics of cell membrane and has more than 20 publications in scientific journals such as PRL, PRE and Biophysical Journal.

Phase separation of transcription proteins on DNA with dispersed binding motif

Binze Tang[1]（唐宾泽）, Jun Cheng[2]（程军）, Zhi Qi[2]（齐志）and Limei Xu[1]（徐莉梅）

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Emergent evidence indicate that proteins can assembly to membraneless compartment via liquid-liquid phase separation (LLPS). Not only do proteins like P granules and stress granules form droplet in bulk solution, protein such as transcriptional pieces of machinery can form condensate on DNA. The underlying physics of protein condensates forming on DNA is still not fully explored. Here we investigate the LLPS of FUS/EWS/TAF15 (FET) fusion oncoproteins on DNA via single-molecule assay[1]. Our observations reveal that FET undergoes LLPS not only at continuous target binding motifs (CBM) but also at dispersed binding motifs (DBM), where regions are interspersed with unbinding segments. Employing 3D lattice model, we demonstrate that both CBM and DBM effectively reduce the nucleation barrier of LLPS and induce morphology transitions of the condensate. As the concentration increases, FET undergoes pre-wetting/wetting transitions and LLPS orderly at CBM. However, the pre-wetting/wetting transition can be suppressed when the length of CBM is small. More complicated, at DBM, the pre-wetting/wetting transition is less pronounced and the behavior of LLPS are modulated by the length of DBM, density, and arrangement of the binding motifs. Notably, relying solely on DNA sequence information, we successfully predict protein condensation probabilities along the sequence aligning closely with experimental observations. This study provides a simple but extensible tool to understand the intricate interplay between biomolecules and surface from microscopic aspect, advancing the understanding of biophysical phase separation [2].

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Self-introduction

Binze Tang is a PhD student of Department of Physics, Peking University. He joined Prof. Limei Xu's group in 2019. His research interests are focused on employing multiscale simulations, machine learning and statistical thermodynamics to understand the liquid structure and phase behavior on interface.

Direct numerical simulations of active particles with fully resolved hydrodynamics

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We have developed a unique numerical scheme, the smoothed profile (SP) method, to perform direct numerical simulations (DNS) for various passive and active particle systems [1] and applied it to several systems of active particles, including microswimmer in viscoelastic media [2], Quincke roller dispersions [3], and smart navigating particle in complex flow [4]. Here, we report on our recent results on the applications of the SP method to the systems of catalytic micromotor, which propels using chemical reactions taking place on the particle's surface (Fig.1). The details will be reported in the presentation.

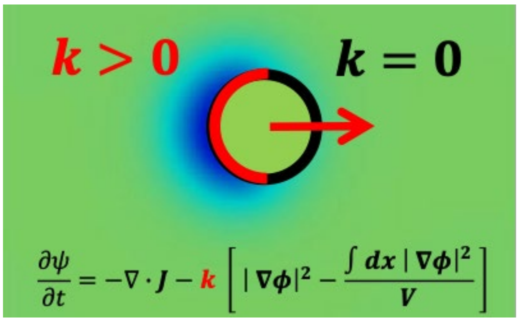

Fig.1 Schematic illustration of the catalytic micromotor.

Acknowledgments

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Self-introduction

Prof. Ryoichi Yamamoto is currently a PI at Department of Chemical Engineering, Kyoto University. He has been working on various theoretical studies on soft and active matters by using computer simulations, such as direct numerical simulations for dispersions of colloidal particles and micro swimmers, multi-scale simulations for soft matters, and modeling of biological tissues including cell division and apotheosis. More detailed information can be seen at: https://sm.cheme.kyoto-u.ac.jp/.

Biomimetic Synchronization in biciliated robots

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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 significant implications in understanding the synchronization of cilia.

Self-introduction

Prof. Mingcheng Yang obtained his Ph.D. in physics from Shanghai Jiao Tong University, China in 2008, after which he did a postdoc in Juelich research center, Germany. Since 2013, he has been working in Institute of Physics, Chinese Academy of Sciences. His research interests include active matter, soft matter, mesoscale simulations, nonequilibrium physics.

Insights into chemically-driven colloidal motors

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We discuss the synergistic or competitive manner in which all reactant and product gradients jointly propel the motion of the chemically-driven colloidal motors based on a well-known H_2O_2-fueled Janus Pt-SiO_2 colloidal motor as an example. By varying the hydroxyl-to-carbon ratio on the SiO_2 inert face, we observe complex motion behavior in the system of Pt-SiO_2 colloidal motor, characterized by varying velocities and directions of motion. Combined with flow field measurement, chemical reaction kinetics measurement, and the quantum chemical calculation, changes in solute-surface interactions due to the changes of the SiO_2 inert face property are the main cause of this complexity. These changes lead to a gradual transformation from a synergistic effect dominated by O_2 concentration gradient and H_2O_2 concentration gradient to a competitive effect dominated by H_2O_2 concentration gradient. These findings promote a comprehensive understanding of the driving mechanism of chemically driven colloidal motors and advance their future application and development.

Self-introduction

Prof. Qiang He is currently a professor at the Harbin Institute of Technology and a PI at the Wenzhou Institute, University of Chinese Academy of Sciences. His interests are focused on the supramolecular assembly and self-propelled mechanism of colloidal motors, and medical swimming nanorobots. He has published more than 180 peer-reviewed papers and holds 18 patents. More detailed information can be seen at: http://homepage.hit.edu.cn/heqiang.

Bacterial rheotaxis in complex fluids

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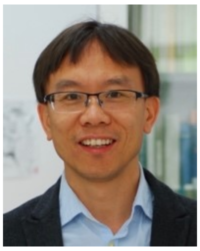
Bacterial swimming, characterized by self-propelled speed with a consistent direction, is a fascinating biological phenomenon playing a crucial role in the lives of microorganisms. Here, I will discuss how the bacteria respond to shear flow by deliberately deviating from the streamline. This response is contingent upon factors such as the chirality of bacterial flagella, shear strength, and fluidic rheology. This drift motion of bacteria has been examined both experimentally and theoretically in simple fluids. However, the orientation dynamics induced by the helical flagellum's chirality in non-Newtonian fluids —common habitats for bacteria—remains less understood. In our investigation, the flows derived from suspensions of colloids and biopolymer are imposed in order to alter the reorientation of swimming bacteria systematically. The bacterial distribution in the microfluidic channel is tuned by the shear-aligned filaments, which shows a surprising accumulation at low shear region in contrast to the typical bacterial trapping by high shear in Newtonian fluids. This unexpected behavior highlights the bacterial sorting and separation, as well as suggests the antibacterial applications in medical treatments and devices.

Self-introduction

Guangyin Jing, professor in the School of Physics of Northwest University, recently focus on the swimming and collective behavior of bacteria in the flows. Prof. Jing graduated from the Department of Physics of Sun Yat-sen University in 2002, and received Ph.D. from the School of Physics of Peking University in 2007. After that, he worked as a postdoctoral fellow in the Soft Matter Laboratory (SIMM) of ESPCI and the Fluid Mechanics Laboratory (FAST) of the University of Paris-Sud. From September 2009, he jointed School of Physics of Northwest University in Xi’an.



Hydrodynamic shape theory for active particles in fluid flow

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When observing fluid flow, our perception of its motions often relies on tracking the movements of small particles within the fluid. In this talk, we will explore the dynamics of microscopic objects, paying particular attention to those capable of self-propulsion, such as living micro-organisms. About a century ago, G. B. Jeffery derived an exact solution to the Stokes equation for a spheroidal object in a simple shear flow, unveiling a periodic path for its orientation vector, now recognized as Jeffery's orbit. By introducing the concept of hydrodynamic symmetry, based on the equation of motion, we extend Jeffery's equation to encompass general chiral axisymmetric objects. Furthermore, we will demonstrate by a classical multi-scale perturbation theory that various complex self-propelling motions can be explained by generalized asymptotic Jeffery's equation.

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Self-introduction

Dr. Kenta Ishimoto is an Associate Professor of Applied Mathematics at the Research Institute for Mathematical Sciences, Kyoto University. He received a PhD in Mathematical Science from Kyoto University in 2015, followed by research experiences at Kyoto University, University of Oxford and The University of Tokyo, before joining a faculty at Kyoto University in 2019. He is a mathematical scientist in the field of fluid dynamics and mathematical biology, working on theoretical and numerical hydrodynamics of low-Reynolds-number flow, swimming microorganisms, complex fluids, and active soft matter as well as data analysis of biological images and related mathematical modelling.

Circular motion of bacteria on complex interface

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Bacteria such as Escherichia coli perform circular motion near interfaces, which origin from free motion with force-free and torque-free conditions and the hydrodynamic interactions with the boundary. Bacteria show counterclockwise motion (view from the liquid phase) on solid-liquid interface with no slip boundary and behave clockwise motion on air-liquid interface with infinite slip length. However, on complex interface, an air layer between solid and liquid phases like super-hydrophobic surface, which surfaces dominant bacterial behavior is an interesting and unclear question. Hence, we experimentally and theoretically study the circular motion of bacteria on complex surfaces with air film of different thickness. And we found a critical length of air layer in hundred-nanometer scale, below which the effect of air phase is negligible.

Self-introduction

Prof. Yanan Liu is currently a PI at school of physics, Northwest University, Xi’an China. With an emphasis on the interaction between flexible filaments and flows, micro-swimmer in complex fluid.

Metastability of polar flocks

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Polar flocks, understood in the Vicsek/Toner-Tu sense of the collective flow of self-propelled particles aligning their velocities, remain central in active matter studies. They are a limit case of real situations: the fluid surrounding particles is ignored ("dry"), the particles are pointlike ("dilute"), so that alignment is the only interaction. Even though their relevance in the real world is limited (but not nil), they must be studied thoroughly since understanding them is crucial to approach more complicated and realistic systems.
One key property of polar flocks is that they show true long-range (polar) orientational order even in 2D. Recently, evidence started accumulating that this ordered phase is metastable. This talk will be devoted to describing these findings and discussing their implications.

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Self-introduction

Hugues Chaté is a Research Director at CEA-Saclay, France, Chair Professor at Beijing CSRC, and the Lead Editor of *Physical Review Letters.* HC's research covers a wide range of topics ranging from nonlinear dynamics to statistical physics and critical phenomena. He has played a seminal role in the development of the field of active matter. HC has written over 170 scientific papers, with about a third published in *Physical Review Letters*, which have now been cited more than 10000 times for an h-index of 60, according to Web of Science.

Extreme spontaneous deformations of active crystals

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We demonstrate that two-dimensional crystals made of active particles can experience extremely large spontaneous deformations without melting [1]. Using particles mostly interacting via pairwise repulsive forces, we show that such active crystals maintain long-range bond order and algebraically decaying positional order, but with a decay exponent whose value is not limited by the 1/3 bound given by the (equilibrium) KTHNY theory.

We rationalize our findings using linear elastic theory and show the existence of two well-defined effective temperatures quantifying respectively large-scale deformations and bond-order fluctuations. We argue that the root of these phenomena lies in the sole time-persistence of the effective noise felt by particles. They should thus be observed in many different situations, a few of which we discuss.

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Self-introduction

Xiaqing Shi is a professor at the Center for Soft Condensed Matter Physics and Interdisciplinary Research, Soochow University. He obtained his PhD in theoretical physics in 2010 from Nanjing University. He has been a visitor at CEA-Saclay, France, the Max Planck Institute for the Physics of Complex Systems in Dresden, Germany, and at the Kavli Institute for Theoretical Physics in Santa Barbara, USA. XQS's research is on soft condensed matter, with a recent emphasis on active systems such as microtubule assemblies, flocks, and bacteria colonies. His expertise ranges from large-scale numerical simulations to kinetic and hydrodynamic theories. XQS has written about 20 scientific papers, including one in Nature, 6 in PRL, 3 in PNAS, and one in Nature communications.

Mechanical and geometrical control of active vortex condensation

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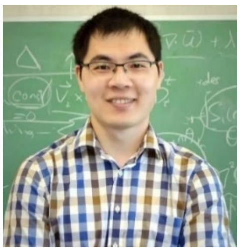
Vortex condensation is an interesting phenomenon recently found in active fluids. Upon increasing activity, the system develops global-scale vortex with long range coherent flow, instead of transitioning to active turbulence. This defies the current understanding of the dynamics of active fluids. In this talk, I will demonstrate that such active vortex condensation can be used to manufacture different types of coherent flow under appropriate mechanical or geometrical manipulations. Specifically, one is able to activate one or more vortices at arbitrary given locations or, generate parallel laminar bands that can adapt their sizes when the system size is changed. Finally, these phenomena are rationalized in a simple phenomenological model.

Self-introduction

Prof. Zhihong You is a theorist at the Department of Physics, Xiamen University. He received his doctorate in physics from Leiden University in 2019. After that, he worked at the Univeristy of California Santa Barbara for three years as a postdoc scholar, under the supervision of Prof. M. Cristina Marchetti. He is mainly interested in the theoretical aspects of active, soft&bio matter. His works involve bacterial colonies, active liquid crystals, active interfaces, and nonreciprocal (i.e. violating Newton's 3rd law) systems etc. More detailed information can be seen at the group website: yousoftmatter.org.



Motion coupled with a shape in a particle and a droplet driven by surface tension gradient

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When a particle or droplet including surface-active chemical compound such as camphor and alcohol is floated on the water surface, surface-active molecules are released from it to the water surface. Then, a concentration field of the chemical is generated, which induces the surface tension gradient and drives the particle or droplet. If we consider a circular particle or droplet, the concentration field should be isotropic with respect to the center position, and the motion of the particle or droplet is realized through the spontaneous symmetry breaking. In such cases, the particle or droplet moves at a constant velocity in a certain direction determined by the perturbations. If the particle or droplet has a shape other than a cricle, the direction of motion should relate to the shape. We investigated the cases for an elliptic particle [1], a triangular particle [2], and a deformable droplet [3]. We also investigated the case with a greatly-deformed droplet. In the presentation, we will discuss the relationship between the motion and shape in these cases.

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Self-introduction

Prof. Hiroyuki Kitahata got his PhD in 2006 from Kyoto University, Kyoto, Japan. He was an assistant professor (2004–2008) at Department of Physics, Kyoto University. In 2008, he moved to Department of Physics, Chiba University. He was working as a lecturer (2008–2010) and an associate professor (2011–2020), and is now working as a professor (2020–) at Department of Physics, Chiba University. He is one of head editors of the Journal of the Physical Society of Japan. He has been working on nonlinear physics, especially on active matter and spatiotemporal self-organization. More detailed information can be seen at: http://nonlinear.s.chiba-u.jp/~kitahata/top_e.html.

Active Matter c2c

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