Active Matter: Interfaces and Boundaries

Tutorial Program

April 22-23, 2024

Beijing China

Active Matter: Interfaces and Boundaries

April 22-23, 2024 Beijing CSRC

Organizers

Hugues Chaté, Beijing Computational Science Research Center & CEA Saclay

Jure Dobnikar, IOP/CAS

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Useful Information

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

1. Tutorial Date: April 22-23, 2024

2. Onsite Registration

✧ Time: 13:30-16:30 (April 21, Sunday), 08:00-08:30 (April 22, Monday)

✧ 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)

✧ Note: No lunch and dinner will be offered on April 21, 2024.

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:**

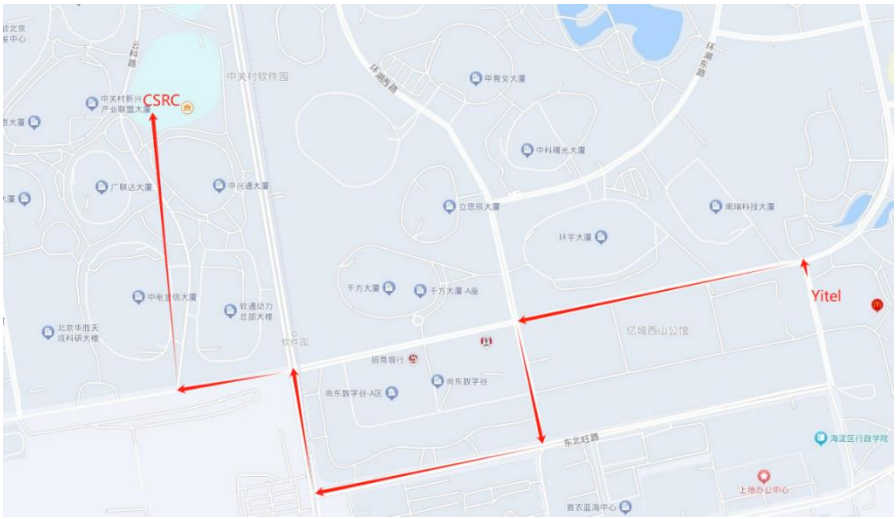
(1) Take Subway Line 13 to "**SHANG DI Station(上地站)**", take Exit A to catch Bus #909 to "**Software Park West Stop(软件园西区站)**". Cross the road, enter the park, then take the first road to the right and proceed in the north direction, CSRC will be to your right in 400 meters.

(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

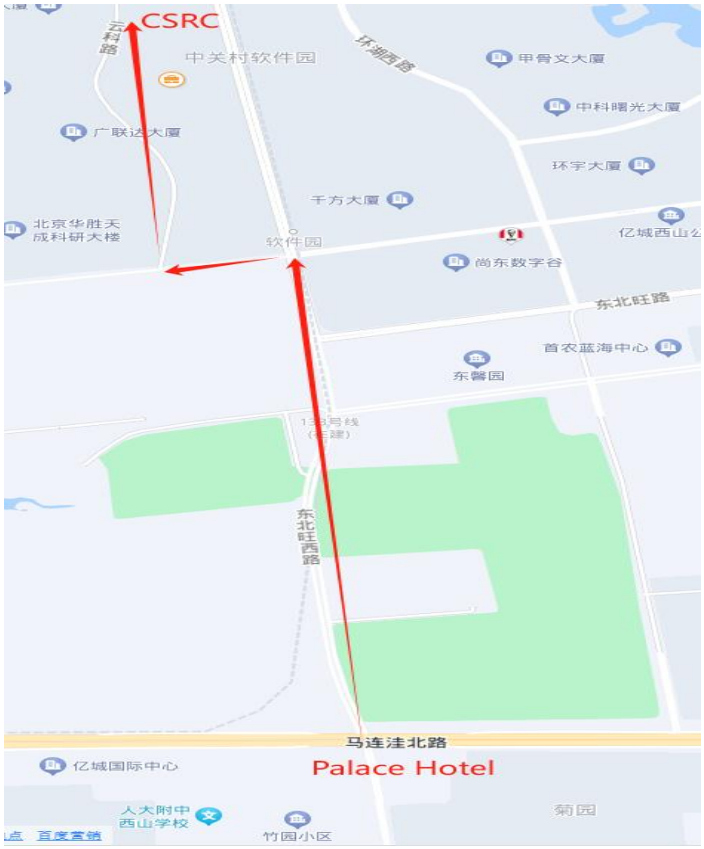
✧ **Yitel (和颐酒店) :**

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)



✧ **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)



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Tutorial Schedule

April 22, 2024 (Monday)

Registration	**April 21 13:30-16:30** **April 22 08:00-08:30**
08:30-08:40	**Welcome**
08:40-10:10	Alexandre Solon (*Sorbonne Université*) & Julien Tailleur (*MIT*) **Self-organization in active matter: From motility-induced phase separation to collective motion –Part I**
10:10-10:30	Coffee Break
10:30-12:00	Alexandre Solon (*Sorbonne Université*) & Julien Tailleur (*MIT*) **Self-organization in active matter: From motility-induced phase separation to collective motion –Part II**
12:00-13:00	Lunch (*CSRC Canteen, B1 Floor*)
13:00-14:00	Coffee & Discussions
14:00-16:00	Hepeng Zhang (*Shanghai Jiao Tong University*) **How things move: from Brownian colloids to swarming robots**
16:00-17:00	Tea & Discussions
17:00	Dinner (*CSRC Canteen, B1 Floor*)

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April 23, 2024 (Tuesday)

08:30-10:00	Ignacio Pagonabarraga (*University of Barcelona*) & Mingcheng Yang (*Institute of Physics, Chinese Academy of Sciences*) **The multiple faces of hydrodynamics in active matter-Part I**
10:00-10:30	Coffee Break
10:30-12:00	Ignacio Pagonabarraga (*University of Barcelona*) & Mingcheng Yang(*Institute of Physics, Chinese Academy of Sciences*) **The multiple faces of hydrodynamics in active matter-Part II**
12:00-13:00	Lunch (*CSRC Canteen, B1 Floor*)
13:00-14:00	Coffee & Discussions
14:00-15:30	Anton Souslov (*University of Cambridge*) **Odd viscosity and odd elasticity in chiral active matter**
15:30-16:00	Tea & Discussions
16:00-17:30	Silke Henkes (*Leiden University*) **Building microscopic models of cells sheets**
17:30	Dinner (*CSRC Canteen, B1 Floor*)

Building microscopic models of cells sheets

Silke Henkes

Lorentz Institute for Theoretical Physics, Leiden University, The Netherlands

Epithelial tissues are one of the engines of development in multicellular organism, like during the gastrulation process where the embryo turns inside out. This feat is performed by the active stresses generated by the cytoskeleton, and cells coordinate their collective mechanics over large spatial distances.

The goal of soft active matter physics is to help unearth the general mechanism of activity and mechanics contributing to these processes. This takes the form of microscopic models, composed of either particles or as a vertex model, where activity is added as either a force crawling or as active stresses along cell junctions.

I will give an overview of these models, starting with the simplest paradigmatic one, active Brownian particles (ABPs), where cell crawling is added as uncoordinated active driving. This model is simple to simulate, and I will include a numerical demonstration. Vertex models represent the cell sheet as a polygonal tiling with a cell-level potential, and the self-propelled Voronoi combines this with ABP style driving. Both models include a solid phase separated by a rigidity transition from a liquid phase which develops biologically realistic spatiotemporal correlations.

I will conclude with a sketch on more advanced vertex models which include activity along the junctions, which is more appropriate for morphogenesis.

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The multiple faces of hydrodynamics in active matter

Ignacio Pagonabarraga & Mingcheng Yang

University of Barcelona & Institute of Physics, Chinese Academy of Sciences

In these lectures we will review the role that hydrodynamics plays in the behavior of active systems in the microscale. We will analyze its relevance in the mechanisms that allow microorganisms to propel and will also discuss its impact in the collective behavior of active suspensions. We will also address the interplay between hydrodynamics and the variety of mechanisms that control the motion of active colloids and micromotors. We will discuss both the theoretical and computational approaches to handle hydrodynamics in these systems.

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Self-organization in active matter: From motility-induced phase separation to collective motion

Alexandre Solon & Julien Tailleur

Sorbonne Université, Paris, France, & MIT, Cambridge, US

We will review two prominent phase transitions in active matter: The motility-induced phase separation, which arises when interactions make active particle slow down at high densities, and the transition to collective motion, which happens when aligning interactions between particles overcome the noise acting on the particle orientations. In both cases, we will show that a rich spatial organization emerges from the microscopic interactions and we will detail how to bridge the gap between microscopic models and the field theories used to account for these transitions.

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Odd viscosity and odd elasticity in chiral active matter

Anton Souslov

DAMTP, University of Cambridge, UK

I will focus on the continuum descriptions of active matter with broken chiral symmetry. Active matter refers to any material in which the constituent particles move themselves by consuming ambient energy. These materials range from biological tissues to artificial systems designed to exhibit exotic mechanical properties. The breaking of chiral symmetry in active matter, for example due to rotating components or robotic interactions, leads to new stresses and dynamics not possible in equilibria. I will discuss the consequences for the continuum mechanics of active materials, focusing on so-called odd viscosity and odd elasticity. Odd viscosity enters the description of fluids composed of self-spinning components and conserves the fluid energy density. By contrast, odd elasticity can inject energy into an active solid. Finally, I will discuss recent experimental observations and current theoretical research, including non-reciprocal interactions, pattern formation, and the role of topology.

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How things move: from Brownian colloids to swarming robots

Hepeng Zhang

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

Across various length and time scales, thermal and active motion are ubiquitous phenomena. In this tutorial, we focus on the mechanical and statistical aspects of key experimental systems, such as Brownian colloids, swimming microorganisms, and swarming robots. By examining these systems, we gain insights into fundamental principles of statistical mechanics, biological locomotion, and collective behavior, with implications spanning from materials science to robotics.