A3 Project International Workshop on Soft matter（2018）

Conference Program

Date: Nov. 8th –Nov. 10th, 2018

Venue: Meeting Room N219, the South Building of AMSS
The Academy of Mathematics and Systems Science, CAS
Addr: No.55, ZhongGuanCun DongLu, Haidian District, Beijing
会议地点：中国科学院数学与系统科学院南楼 N219 会议室
地址：北京市海淀区中关村东路 55 号

Accommodation: Liaoning International Hotel
会议住宿酒店：辽宁大厦
Addr: No.2A North 4th Ring West Road, Haidian District, Beijing
地址：北京市海淀区北四环西路 2A

08th Nov. 2018, Meeting Room N219, the South Building of AMSS		
14:00-15:00	**Registration**	
15:00-15:20	**Photos time**	
First session **Chair: Prof. Masao Doi**		
Time	**Speaker**	**Title**
15:30-16:30	**Xue-Feng Yuan** Advanced Institute of Engineering Science for Intelligent Manufacturing, Guangzhou University	Modelling Complex Fluids in Highly Nonlinear Flow Regime
16:30-17:00	**Karel Svadlenka** Kyoto University	Numerical simulation of sensory tissue formation
17:00-17:30	**Narina Jung** Ulsan National Institute of Science and Technology(UNIST)	Lattice gas model for the evaporation-induced self-alignment of nanorods
18:00 Reception Dinner at Liaoning International Hotel		

09th Nov. 2018, Meeting Room N219, the South Building of AMSS		
First session **Chair: Prof. Xue-Feng Yuan**		
Time	**Speaker**	**Title**
09:00-10:00	**Ramin Golestanian** Max Planck Institute for Dynamics and Self-Organization	Collective Chemotaxis in Active Matter
10:00-10:30	**Natsuhiko Yoshinaga** WPI-AIMR, Tohoku University	Geometric control of wave instability in Min protein oscillations
10:30-11:000 Coffee break		
11:00-11:30	**Xinpeng Xu** Guangdong Technion-Israel Institute	Dynamic modeling of several soft matter solutions: from thin films of polymer solutions to droplets of active colloidal solutions
11:30-12:00	**Fanlong Meng** Max Planck Institute for Dynamics and Self-Organization	Magnetic swimmers in a microfluidic channel
12:00 lunch at Wuke restaurant		
Second session **Chair: Prof. Ramin Golestanian**		
14:00-15:00	**An-Chang Shi** McMaster University	Spherical Packing Phases of Block Copolymers
15:00-15:30	**John Molina** Kyoto University	Modeling the Mechanosensitivity of Crawling Cells
15:30-16:00 Coffee break		
16:00-16:30	**Jinhae Park** Chungnam National University	Defects in Smectic Liquid Crystals
16:30-17:00	**Jaeseung Lee** Seoul National University	On the second order Kuramoto model and its hydrodynamic limit
17:00-17:30	**Yinglong Zhang** Seoul National University	Synchronization dynamics for Kuramoto oscillators
18:00 Banquet at Liaoning International Hotel		

10th Nov. 2018, Meeting Room N219, the South Building of AMSS		
First session **Chair: Prof. An-Chang Shi**		
Time	**Speaker**	**Title**
09:00-09:30	**Wei Wang** Zhejiang University	Sharp interface limit for the nematic-isotropic two phases flow confirmation of the sharp interface limit
09:30-10:00	**Zhen Zhang** Southern University of Science and Technology	Modeling and simulation of moving contact lines in complex fluids
10:00-10:30	**Yueyuan Gao** MathAM-OIL, AIST c/o AIMR, Tohoku University	Finite volume methods for a first order conservation law involving a Q-Brownian motion
10:30-11:000 Coffee break		
11:00-11:30	**Yana Di** The Academy of Mathematics and Systems Science, CAS	Dynamic simulations of Q-tensor model of nematic liquid crystal flows
11:30-12:00	**Xianmin Xu** The Academy of Mathematics and Systems Science, CAS	Sharp-interface limit of a phase-field model for two-phase flow with moving contact lines
12:00 lunch at Wuke restaurant		

Xue-Feng Yuan

Director, Institute for Systems Rheology (ISR)
Professor/Dean, Advanced Institute of Engineering Science for Intelligent Manufacturing, Guangzhou University
Email: xuefeng.yuan@gzhu.edu.cn

Modelling Complex Fluids in Highly Nonlinear Flow Regime

Abstract:

Comprehensive experimental data spanning from molecular and rheometric characterisation to full flow characterisation in benchmark flow problems for poly(ethylene oxide) (PEO) and polyacrylamide (PAAm) solution are obtained. It covers a range of flow regimes in term of De number, Re number and Elastic (El=De/Re) number. In this talk, I shall review experimental data, present an integrated simulation platform and simulation results of polymer solutions in a wide range of Wi-Re number regime, and then discuss challenges in modelling elastic turbulence and turbulence drag reduction.

Karel Svadlenka

Associate professor
Graduate School of Science, Department of Mathematics,
Kyoto University
Email: karel@math.kyoto-u.ac.jp

Numerical simulation of sensory tissue formation

Abstract:

Sensory tissues are composed of several types of cells which typically form specific patterns. However, the process of pattern formation is still not well understood. We propose a time-dependent model of interfacial network based on tension and adhesion at cell boundaries, which is very simple but whose numerical implementation is complicated when addressed in the straightforward manner. Subsequently, ideas to design a simple numerical scheme, several issues related to its implementation, and results of simulations will be presented.

Narina Jung

Postdoctoral Researcher
School of Mechanical and Nuclear Engineering
Ulsan National Institute of Science and Technology (UNIST)
Email: narinajung@gmail.com

Lattice gas model for the evaporation-induced self-alignment of nanorods

Abstract:

For a system consisting of anisotropic nanoparticles, control of the orientational order is of central importance in applications to micro- and nano-scale devices and sensors. A coarse-grained lattice gas model is developed to study the dynamics of self-alignment of nanorods in a drying film and to predict the orientational configuration after deposited on a substrate. We assume that, during relaxation of nanorods, spatial diffusion rates depend on rod orientations and particles interact through the excluded volume. The effects of concentration and aspect ratio of nanorods, and evaporation rates on the kinetics of self-alignment are investigated.

Ramin Golestanian

Scientific member / Director
Max Planck Institute for Dynamics and Self-Organization
Email: Ramin.Golestanian@ds.mpg.de
Links: www.ds.mpg.de/lmp/en

Collective Chemotaxis in Active Matter

Abstract:

In my talk, I will discuss the non-equilibrium dynamics of particles, which have two types of activity: (1) chemical activity in the form of releasing or consuming chemicals, and(2) motility that is affected or caused by the chemical activity. These activities will mediate long-range interactions and lead to non-equilibrium fluxes, which join together to lead to interesting collective effects. I examine theoretically the consequences of this interaction, using several examples from synthetic and living systems, including: collective chemotaxis in a solution of catalytically active colloids that could lead to cluster formation, aster condensation, and spontaneous oscillations [1], swarming - in the form of a comet - of light-induced thermally active colloids with negative Soret coefficient due to a shadowing interaction [2], spontaneous formation of small static [3] and dynamic [4] clusters or “molecules” that can exhibit functionality that depends on geometry, and collective behavior of a colony of cells that divide and interact

chemotactically [5]. Finally, I will discuss the limit of slowly diffusing chemicals in the context of trail-following bacteria and how the interaction with the trail leads to complex dynamical behaviour at the single bacterium level [6] and provides a route to bacterial self-organization into micro-colonies [7].

[1] S. Saha, R. Golestanian and S. Ramaswamy, Phys. Rev. E **89**, 062316 (2014)
[2] J.A. Cohen and R. Golestanian, Phys. Rev. Lett. **112**, 068302 (2014)
[3] R. Soto and R. Golestanian, Phys. Rev. Lett. **112**, 068301 (2014)
[4] R. Soto and R. Golestanian Phys. Rev. E **91**, 052304 (2015)
[5] A. Gelimson and R. Golestanian, Phys. Rev. Lett. **114**, 028101 (2015)
[6] W.T. Kranz, A. Gelimson, K. Zhao, G.C.L. Wong and R. Golestanian, Phys. Rev. Lett. **117**, 038101 (2016)
[7] A. Gelimson, K. Zhao, C.K. Lee, W.T. Kranz, G.C.L. Wong and R. Golestanian, Phys. Rev. Lett. **117**, 178102 (2016)

Natsuhiko Yoshinaga

Associate professor
WPI Advanced Institute for Materials Research (WPI-AIMR),
Tohoku University
E-mail: yoshinaga@tohoku.ac.jp

Geometric control of wave instability in Min protein oscillations

Abstract:

Emergence of patterns in biological systems has attracted much attention among broad areas in science to understand the generic mechanism of biological functions associated with these patterns. The Min systems have been studied intensively due to their robust realization both in vivo and vitro systems. Stimulated by these experiments, theoretical models using nonlinear reaction-diffusion equations have been proposed.

Nevertheless, the theoretical understanding of Min pattern is still incomplete. In particular, a generic view of geometric effects on the pattern is required to answer whether travelling or standing (pole-to-pole) wave is chosen. Here, we consider waves on curved surface and show pole-to-pole oscillation is stabilized for an elongated shape.

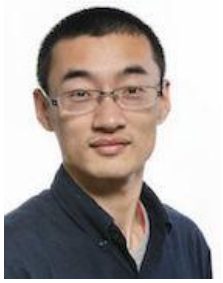
Xinpeng Xu

Assistant Professor，
School of Physics
Guangdong Technion-Israel Institute
Email: xu.xinpeng@gtiit.edu.cn

Dynamic modeling of several soft matter solutions: from thin films of polymer solutions to droplets of active colloidal solutions

Abstract:

Binary or ternary fluid solutions are typical examples of soft matter whose microstructure and hydrodynamics are strongly coupled. My group is interested in the coupling between phase dynamics and two-phase hydrodynamics in soft matter solutions, e.g., polymer solutions and colloidal suspensions. In this talk, I will show our modeling efforts from simple binary solutions, to polymer solutions, to diblock copolymer solutions, and to active colloids suspending in solutions. Focus will be placed on evaporating thin films of diblock copolymer solutions. The idea of two-fluid model formulated by Onsager's variational principle will be the key to the modeling of these various soft matter solutions. Some simulations results will also be shown during the talk.



Fanlong Meng

Post-Doctor Fellowship
Max Planck Institute for Dynamics and Self-Organization
Email: fanlong.meng@ds.mpg.de

Magnetic swimmers in a microfluidic channel

Abstract:

Magnetotactic bacteria can be focused to the radial centre of the channel when swimming in a microfluidic channel under a magnetic field, and found to form clusters if the external magnetic field is strong or the flow speed is large [1]. However, the underlying mechanism was missing. We showed in our recent work [2] that the magnetic microswimmers (not only for magnetotactic bacteria, but also applicable synthetic magnetic microswimmers) can form interesting large-scale clusters when the magnetic attractive interaction dominates thermal fluctuations. By applying analytic techniques and conducting Brownian dynamics simulation, we provide the critical condition for clustering of magnetic microswimmers, which matches well with the experiment. Hydrodynamic interactions between the microswimmers are also incorporated as a generalisation. Understanding the physics of magnetic active matter will help advance the cause of studying matter out of equilibrium, and provides

new insight for technological applications of synthetic magnetic microrobots (for drug delivery, solution stirring, etc.) with desired collective properties.

References:

N. Waisbord, C. T. Lefèvre, L. Bocquet, C. Ybert, and C. Cottin-Bizonne, Phys. Rev. Fluids, 1, 053203 (2016)

F. Meng, D. Matsunaga, and R. Golestanian, Phys. Rev. Lett. 120, 188101 (2018)

An-Chang Shi

Professor
Department of Physics and Astronomy
McMaster University
E-mail: shi@mcmaster.ca

Spherical Packing Phases of Block Copolymers

Abstract:

Spherical packing is an interesting problem in mathematics and physics with a long history dated back to the work of Kepler and Lord Kelvin. In recent years, intricate periodic and aperiodic spherical packing phases have emerged in a host of soft matter systems including supramolecular assemblies, surfactants and block copolymers, underscoring the universality of emergent order in condensed matter. In particular, the rich phase behavior of block copolymers provides an ideal model system to study the origin and stability of order phases in soft matter. Our recent study of block copolymer systems using the self-consistent field theory reveals that one key mechanism of forming complex spherical phases is the conformational asymmetry of the blocks. Furthermore, we have predicted that the segregation of different polymeric species in block copolymer blends provides another mechanism to stabilize spherical packing phases with very different sized-spherical domains. I will summarize recent progresses on this fascinating topic and discuss possible future research directions.

John Molina

Assistant Professor
Department of Chemical Engineering
Kyoto University
Email: john@cheme.kyoto-u.ac.jp

Modeling the Mechanosensitivity of Crawling Cells

Abstract:

The ability of cells to actively respond to signals received from their environment is crucial for all biological systems and holds great promise for future applications in medicine and tissue engineering. For example, there is currently great interest in designing bio-materials that can control the proliferation and differentiation of stem cells.

In this work, we focus on the mechanosensitive response of crawling cells, i.e., how they sense and respond to mechanical forces. Experimentally, this can be studied by placing the cells on cyclically stretched substrates, whereby they are observed to reorient in a cell-specific manner. While much is known about slow-crawling cells (with stress fibers), our understanding of how fast-crawling cells (without stress fibers) move is still limited. They are observed to reorient perpendicular to the direction of stretching[1], but the precise mechanism responsible for this is not completely understood.

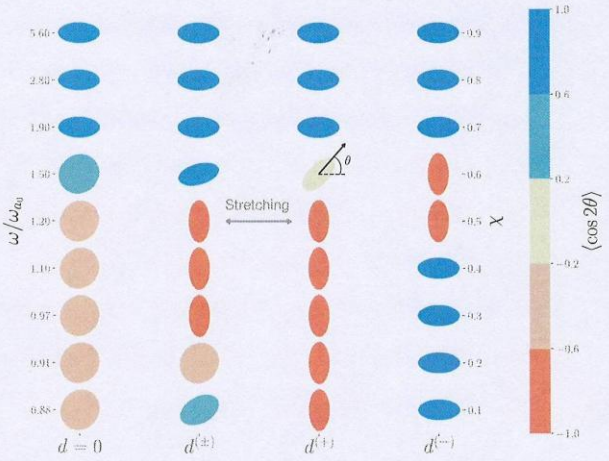


Fig. 1 Phase diagram showing the final orientation of the cells as a function of frequency ω and adhesion response function d. Red (blue) ellipses correspond to complete perpendicular (parallel) alignment.

To address this issue, we have developed a computational model capable of relating the mechanosensitive response of fast-crawling cells on cyclically stretched substrates to their sub-cellular dynamics[2]. This includes the dynamics of the cell membrane, the actin-cytoskeleton, and the focal adhesion sites. Depending on which process is probed by the stretching, and the type of coupling to the substrate, we observe significantly different realignment dynamics. In particular, we show that an asymmetry in the stability of adhesions during extension/compression can be exploited to align the cells at specific orientations (Fig. 1), and can account for the realignment observed experimentally. Our results and proposed simulation method can be used to design novel cell-sorting assays and help to interpret current and future experiments.

References

[1] C. Okimura, K. Ueda, Y. Sakumura, Y. Iwadate, *Cell. Adhes. Migr.* **10**, 331 (2016); C. Okimura and Y. Iwadate, *Cell. Adhes. Migr.* **10**, 406 (2016)

[2] J. J. Molina and R. Yamamoto, *arXiv*:1807.02295

Jinhae Park

Professor
School of Mathematics,
Chungnam National University
Email: jhpark2003@cnu.ac.kr

Defects in Smectic Liquid Crystals

Abstract:

We consider a system of smectic liquid crystals. In smectic liquid crystals, there is additional oreder parameter which describes layer structures. Due to interaction bewteen direction field and smectic layers, it is often observed that periodic patterns of defects appear in the system. In this talk, we investigate a simple smectic energy to prove existence such defects.

Jaeseung Lee

Postdoctoral Researcher
Department of Mathematical Sciences
Seoul National University
Email: jaeseunglee@snu.ac.kr

Emergent dynamics of Lohe-type particle swarming model on the unit sphere and its stability/instability properties.

Abstract:

Collective coherent motions are ubiquitous in classical and quantum many-body systems. We study the particle swarming model on the unit sphere which can be derived from the Lohe matrix model.

In this model, the particles are governed by the first order ODE and their Euclidean norm is preserved. We give a rigorous derivation of PDE and study the stability/instability properties of the model.

Dr. Yinglong Zhang

Postdoctoral Researcher
Department of Mathematical Sciences,
Seoul National University
E-mail: yinglongzhang@amss.ac.cn

Synchronization dynamics for Kuramoto oscillators

Abstract:

The synchronization of coupled oscillators was first reported by Huygens in the middle of the 17th century via the two pendulum clocks hanging over the common bar. Since then, it has been noticed and reported in sciatic literature from time to time until Winfree and Kuramoto took systematic studies based on time continuous dynamical systems. In the last forty years, the Kuramoto model served as a prototype model for phase synchronization and it has been extensively studied by mathematicians, physicists and engineers. In 1986, H. Sakaguchi and Y. Kuramoto pointed out that frustration was needed if the oscillators coupled strongly enough.

Thus, in this talk, I will introduce the Kuramoto model with frustration and talk about its synchronization dynamics.

Wei Wang

Professor

School of Mathematical Sciences

Zhejiang University

Email: wangw07@zju.edu.cn

Sharp interface limit for the nematic-isotropic two phases flow

Abstract:

I will talk about the nematic-isotropic two phase flow under the Landau-de Gennes' Q-tensor framework. When the elastic constants tend to zero, the system will converge to a sharp interface model. We will discuss the derivation of the boundary conditions and the rigorous.

Zhen Zhang

Associate Professor
Department of Mathematics,
South University of Science and Technology of China
Email: zhangz@sustc.edu.cn

Modeling and simulation of moving contact lines in complex fluids

Abstract:

We introduce a sharp interface models for moving contact lines with surfactant. A continuous model with the boundary conditions is derived for the dynamics of two immiscible fluids with moving contact lines based on thermodynamic principles. FEM-based numerical method is developed to solve the resulting free boundary problem. We also discuss related models on elastic materials such as membrane.

Dr. Yueyuan Gao

Postdoctoral Researcher
MathAM-OIL, AIST c/o AIMR,
Tohoku University
Email: yueyuan.gao@aist.go.jp

Finite volume methods for a first order conservation law involving a Q-Brownian motion

Abstract :

In this talk, we consider a first order stochastic conservation law involving a Q-Brownian motion.

After presenting the research idea of studying stochastic conservation laws and some numerical simulations of stochastic Burgers equation by finite volume method and Monte-Carlo method, we prove the well-posedness of the measure-valued entropy solution to the stochastic conservation laws involving a Q-Brownian motion. The existence of the measure-valued entropy solution is proved by showing that the discrete solution obtained by a finite volume method converges along a subsequence in the sense of Young measures as the volume size and time-step size tend to zero. The uniqueness is proved as a corollary of the Kato inequality. We use doubling variables techniques to prove the Kato inequality, and to that purpose, we also study the well-posedness of the associated stochastic parabolic problem.

This is joint work with Tadahisa Funaki and Danielle Hilhorst.

References

[1] C. Bauzet, J. Charrier and T. Gallouët, Convergence of flux-splitting finite volume schemes for hyperbolic scalar conservation laws with a multiplicative stochastic perturbation, *Mathematics of Computation*, **85**, 2016, 2777–2813.

[2] C. Bauzet, G. Vallet and P. Wittbold, The Cauchy problem for a conservation law with a multiplicative stochastic perturbation, *Journal of Hyperbolic Differential Equations*, 9(**4**), 2012, 661–709.

[3] R. Eymard, T. Gallouët, R. Herbin. *Finite volume methods.* Handbook of numerical analysis. Vol. VII, Norht-Holland, Amsterdam, 2000.

[4] T.Funaki, Y. Gao and D. Hilhorst. Convergence of a finite volume scheme for a stochastic conservation law involving a Q-Brownian motion. *DCDS-B*, AIMS, 23(**4**), 2018, 1461–1504.

Yana Di

Associate Professor
The Academy of Mathematics and Systems Science,
CAS
Email: yndi@lsec.cc.ac.cn

Dynamic simulations of Q-tensor model of nematic liquid crystal flows

Abstract:

We present a linear energy-stabled numerical scheme for the hydrodynamic Beris-Edwards model. Several numerical examples are shown to demonstrate the effectiveness of the model and the numerical scheme in simulating the dynamics of defects in flows of nematic liquid crystals.

Xianmin Xu

Associate Professor
The Academy of Mathematics and Systems Science,
CAS
Email: xmxu@lsec.cc.ac.cn

Sharp-interface limit of a phase-field model for two-phase flow with moving contact lines

Abstract:

Moving contact line is a classical problem that falls beyond the framework of conventional hydrodynamics. Standard no-slip boundary condition leads to infinite energy dissipation. To overcome the difficulties, many models are proposed. One of them is proposed by T. Qian, X.-P. Wang & S. Sheng, which is a phase-field model that can describe slipping of the contact line on solid boundary due to uncompensated Young stress and is consistent the molecular dynamics simulations. In this talk, we will show some recent study on the sharp-interface limit of the model. By asymptotic analysis, we show that the model will converge to different sharp-interface limits under different choices for the mobility parameter and a relaxation parameter in the boundary condition. Numerical results are consistent with the analysis results and also illustrate the different convergence rates of the sharp-interface limits for different scalings of the two parameters.

This is a joint work with Yana Di and Haijun Yu.