A3 Workshop on Soft Matter 2017

Date: 18-20 Jan 2017

Venue: TOKYO ELECTRON House of Creativity, Tohoku University, Sendai

Organizer:

Masao Doi (Beihang University), Yasumasa Nishiura(Tohoku University), Jinhae Park (Chungnam National University), Yana Di (Chinese Academy of Sciences), Xianmin Xu (Chinese Academy of Sciences), Natsuhiko Yoshinaga (Tohoku University, AIST),

Program

18 Jan.

11:45 – 13:15 Lunch at Hagi restaurant

13:25

"Opening"

Session: liquid crystal

13:30 - 14:30 Jun-ichi Fukuda (AIST)

Exotic structures of a chiral liquid crystal and their optical properties

(Coffee Break)

14:45 - 15:45 Jinhae Park (Chungnam National University, Korea)
Mathematical Theories related to Liquid Crystals

(Coffee Break)

16:00 – 17:00 Round Table Discussion (session organiser: Jinhae Park)

19 Jan.

Session: wetting and interfacial dynamics

9:30 – 10:30 Ko Okumura (Ochanomizu University)
Simple models and scaling arguments for understanding miscellaneous problems in soft matter physics

(Coffee Break)

10:45 – 11:45 Xianmin Xu (CAS)
Analysis and computation for wetting problems on rough surface

11:45 – 13:15 Lunch at Hagi restaurant

13:15 – 14:15 Yana Di (CAS)
Numerical simulation of Vlasov equation using moment expansion method

(Coffee Break)

14:30 – 15:30 Karel Svadlenka (Kyoto University)
Numerical approximation of multiphase interface evolution

(Coffee Break)

15:30 – 16:30 Round Table Discussion (session organiser: Masao Doi)

18:30 - Banquet
Tenryukakau
http://www.tenryukaku.com/con_08.html

20 Jan.

Session: nonequilibrium collective phenomena

9:30 – 10:30 Ryohei Seto (OIST)
Shear thickening and extension thickening of dense suspensions

(Coffee Break)

10:45 – 11:45 Kuniyasu Saito (AIMR Tohoku University)
A microscopic theory for discontinuous shear thickening of frictional granular particles

11:45 - 13:15 Lunch at Hagi restaurant

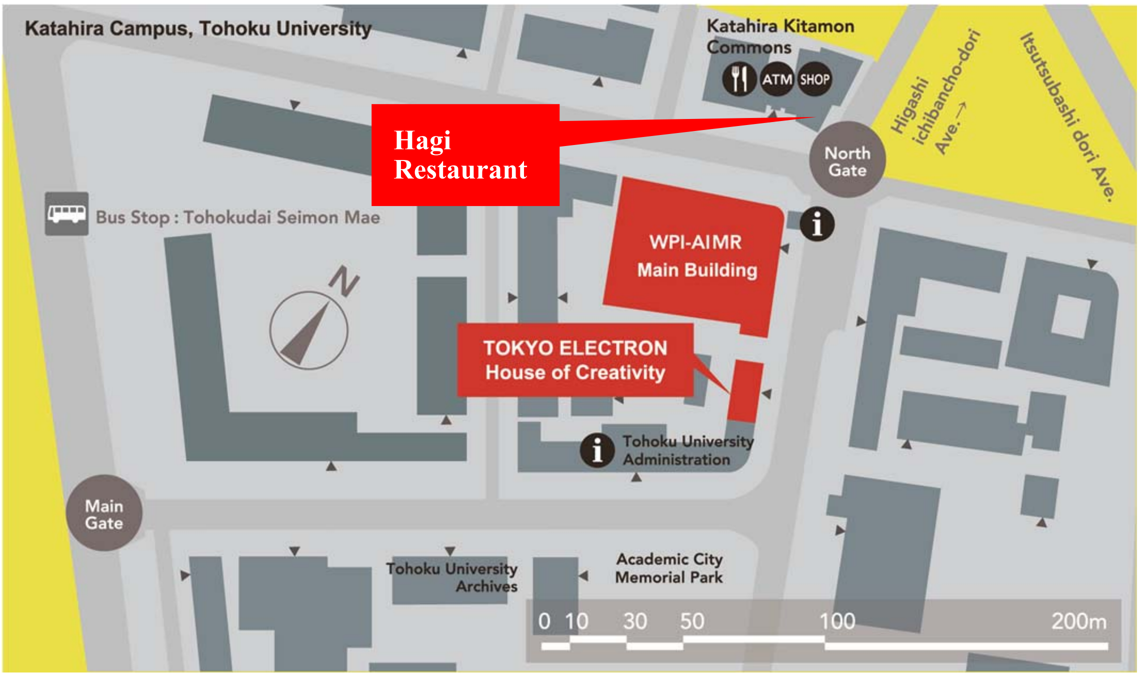
13:15 - 14:15 Natsuhiko Yoshinaga (AIMR Tohoku University, MathAM-OIL AIST)
The Hydrodynamics and Collective Behaviours of Self-Propelled Active Systems

(Coffee Break)

14:30 – 15:30 Round Table Discussion (session organiser: Natsuhiko Yoshinaga)

Access

Detailed information is available in:
http://www.tfc.tohoku.ac.jp/about_us/contact_and_access.html



Abstract

Exotic structures of a chiral liquid crystal and their optical properties

Jun-ichi Fukuda (AIST)

Chiral liquid crystals exhibit various exotic ordered structures because the lack of inversion symmetry allows the local orientational order to twist spontaneously. In this talk, I will present my recent studies focusing on exotic ordered structures of a chiral liquid crystal frustrated by spatial confinement, and also their optical properties.

Mathematical Theories related to Liquid Crystals

Jinhae Park (Chungnam National University, Korea)

In this talk, I plan to give a brief introduction to mathematical theory of liquid crystals. We then discuss mathematical questions related to liquid crystals including interface problems and singularities which observed very often in the literature. At the end of the talk, we also talk about some interesting open questions which is of great interest.

Simple models and scaling arguments for understanding miscellaneous problems in soft matter physics

Ko Okumura (Ochanomizu University)

Simple models that captures the physical essence are useful in understanding complex phenomena. Arguments at the level of scaling laws are also powerful for the same purpose. Recently, we have studied some different topics in soft matter physics by using simple models and scaling arguments. In this talk, we overview such our recent activities on mechanical properties of biological materials, capillary phenomena, and granular dynamics. We then focus on specific topics, which may include Kirigami, crack propagation, thin film dissipation, and meandering instability.

Analysis and computation for wetting problems on rough surface

Xianmin Xu(CAS)

Abstract: Wetting on rough surface is common in nature and industry applications. Mathematically, it is a free interface problem proposed in a complicated domain with rough boundary. In this talk, we will introduce our recent analysis and computations for this problem. We derive a homogenized equation to describe the macroscopic contact angle on rough surface. The equation describes the local minimizers in the system and thus can be used to describe the contact angle hysteresis phenomena. Then we introduce a volume preserving threshold dynamics method for this problem. The method is simple, stable and very efficient. In each iteration, only one or two convolution operations for functions defined in a regular domain are needed, that can be easily done by fast algorithms.

Numerical simulation of Vlasov equation using moment expansion method

Yana Di

Chinese Academy of Sciences

A globally hyperbolic moment closer of the Vlasov-Maxwell equations has been derived. The resulting moment equations are computed with fraction step method for time discretization and finite volume discretization for spatial space respectively. The numerical method has been demonstrated accurate and efficient for the simulations of plasma echo and Landau damping.

Numerical approximation of multiphase interface evolution

Karel Svadlenka

Kyoto University, Graduate School of Science

The problem of calculating the motion of three interfaces meeting at a junction will be considered. First, a numerical method for the precise calculation of such a junction moving under the steepest descent of surface energy will be presented, where one allows for arbitrary surface tensions of

each interface. Then the problem of energy preserving motion of the same junction based on force balance will be mentioned. If time is left, I will share some ideas and open problems on possible directions of applying these results to fluid flow problems.

Shear thickening and extension thickening of dense suspensions

Ryohei Seto, Giulio Giusteri, Antonio Martiniello, Eliot Fried
Okinawa Institute of Science and Technology

Suspensions, namely mixtures of solid particles and a viscous liquid, are a type of complex fluid which is seen everywhere. They exhibit non-Newtonian behaviors; their viscosities depend on shear rates and their normal stress differences are finite. Especially, dense suspensions exhibit discontinuous or strong shear thickening. Shear rheometers are common devices to examine such non-Newtonian behavior. The measured viscosity and normal stress differences can be used to predict other viscometric flows. However, they are not enough to predict non-viscometric flows of non-Newtonian fluids. Since the flow-induced microstructure of suspensions actually depends on imposed flow types, the rheology is flow-dependent as well. If the main goal of rheological characterization is the prediction of general flows for arbitrary boundary conditions, we also need to know flow properties under non-viscometric flows. As a starting point, we compare the thickening phenomena of dense suspensions under simple shear and extensional flows by using particle simulations.

A microscopic theory for discontinuous shear thickening of frictional granular particles

Kuniyasu Saito (AIMR Tohoku University)

Granular materials are ubiquitous in nature and the understanding of their flow properties is crucial to industry and science. Different from usual fluids, the constituents of granular materials are macroscale discrete particles such that thermal fluctuations are negligibly small for their individual motions and inelastic interactions between them cause the dissipation of kinetic energy. As a result, the rheology of granular materials strongly depends not only on the shear rate applied to the system, but also on the volume or area fraction of the constituent particles. For example, if the fraction is sufficiently small, granular materials behave like gases, where Bagnold's scaling of shear stress predicted by kinetic theory well describes the flow behavior. On the other hand, if the fraction exceeds a critical value, i.e. the so-called jamming point, kinetic theory breaks down as we observe a finite yield stress in a quasi-static limit of shear deformations, where the shear stress becomes almost rate-independent (the "critical state" in the literature on soil mechanics). In such jammed states of granular materials, force-chain networks are fully developed in the system such that the contact contribution to the stress governs the mechanical responses, where many constitutive models have been proposed (e.g. the so-called mu-I rheology, the non-local model for slow flows, the order-parameter descriptions of phase-coexistent flows, etc.). However, the microscopic insight into dense granular flows is not fully understood and the physics of granular materials completely lack the connection between the microscale mechanics and the macroscale flow behavior of jammed states. In addition, it is recently found that frictional forces between the particles in contacts drastically change the dense granular rheology, where the shear stress jumps from Bagnold's scaling to the rate-independent jammed states and the system exhibits the strong history dependence, i.e. the discontinuous shear thickening (DST). So far, none of theoretical models have succeeded in predicting the DST of frictional granular materials.

In this study, we propose a microscopic theory for the DST of frictional granular materials, where the Liouville theory of frictionless granular particles (K. Suzuki and H. Hayakawa, Phys. Rev. Lett. 115 (2015) 098001) is extended to dense flows of frictional granular particles. Employing the Sllod equation of motions and adopting a frictional contact model with the Coulomb friction, we generalize the Liouville operator to the case of frictional grains. We explain the microscopic origin of the DST and predict the hysteresis-loop of the flow curve of frictional granular materials.

The Hydrodynamics and Collective Behaviours of Self-Propelled Active Systems

Natsuhiko Yoshinaga (AIMR Tohoku University, MathAM-OIL AIST)

Spontaneous motion has attracted lots of attention in the last decades in fluid dynamics for its potential application to biological problems such as cell motility. Recently, several model experiments showing spontaneous motion driven by chemical reactions have been proposed and revealed the underlying mechanism of the motion. Accordingly, several simple theoretical models have been extensively studied such as active Brownian particles, squirmers, self-thermophoretic swimmers and so on. We theoretically derive a set of nonlinear equations showing a transition between stationary and motile states driven away from an equilibrium state due to chemical reactions. A particular focus is on how hydrodynamic flow destabilizes an isotropic distribution of a concentration field. It is of interest that due to self-propulsive motion and flow around the droplet, a spherical shape becomes unstable and it elongates perpendicular to the direction of motion. This implies that the self-propulsion driven by chemical reaction is characterized as a pusher in terms of a flow field.

Even for the simpler models of self-propelled particles and drops, our understandings of their interactions are still primitive. In particular, it is of interest how hydrodynamic interactions and the interaction mediated by a concentration field give rise to collective behaviours such as motility-induced phase separation, global polar state, and clustering. I shall argue these issues based on our recent results of theoretical calculations.