## Poster Presenters (in alphabetical order)

**Hidemasa Bessho** (Nagoya University)

Title: Non-linear viscoelasticity near jamming transition density

Abstract: We numerically study the rheology of a frictionless jammed particle system. When the system is under a time-dependent strain, the system is known to exhibit rich viscoelastic and nonlinear behaviors. If the amplitude of the oscillatory strain is very small, the shear modulus shows critical and algebraic frequency dependence. On the other hand, if the oscillation frequency is very small but the strain amplitude is finite, the stress shows nonlinear and algebraic strain dependence, which is called Softening. The natural question is the case both the frequency and strain amplitude are finite and sit in the critical regime. Our study aims to perform numerical simulations for various frequencies and strains, and identify a unified scaling function of the shear modulus. Our preliminary results suggest a nontrivial nonlinear-viscoelastic rheology at the jamming criticality distinct from the yielding.

**Angelo Giorgio Cavaliere** (Osaka University)

Title: Statistical inference of an assembly of vectors with a large number of components through their p-body products

Abstract: We study a new class of exactly solvable Bayesian inference problems that we name High rank tensor decomposition (HRTD) [1], which is an inverse problem of a constraint satisfaction problem recently introduced in [2]. In HRTD, noisy observations are made starting from the p-body products of a large number of vectors with a large number of components, from which one is asked to recover the original vectors assignment. The p-body products are defined on tree-like networks that are dense but not globally coupled. In this ``intermediately dense'' regime, the free-energy functional can be computed using the replica method and the performance of Bayesian inference is theoretically characterized. We also develop standard message-passing algorithms that are then used to solve the inference problem on real instances and for various settings.

Our theoretical results for infinite-size systems are found in general to give good expectation values for the inference errors on finite-size systems.

[1] A. Cavaliere, R. Nagasawa, S. Yokoi, T. Obuchi and H. Yoshino. in preparation

[2] H. Yoshino, SciPost Phys. 4, 40 (2018).

**Yuki Rea Hamano** (Osaka University)

Title: Spatial evolution of RSB in layered p-spin model

Abstract: Recently it was shown that multilayer Perceptrons exhibit a unique glass phenomenology: spatially heterogeneous replica symmetry breaking (RSB) [1]. In this talk we first show that a similar heterogeneous RSB pattern can be found in a generalized model of spin glasses (p-spin models with p=4) arranged on a layered geometry with frozen boundaries. Next we present results of Monte Carlo simulations of the same model (p=4) aimed to examine the theoretical result.

[1] H. Yoshino, SciPost Phys. Core 2, 005 (2020).

**Daisuke Ishima** (Kyoto University)

Title: Eigenvalue analysis of amorphous solids consisting of frictional grains under ahermal quasistatic shear

Abstract: We perform eigenvalue analysis of two-dimensional amorphous solids comprising frictional grains under athermal quasistatic shear. The eigenvalue analysis of amorphous solids with friction is performed for two cases; (i) The contact force between grains expressed as the Hertzian force under a linear response regime and (ii) the contact force between grains owing to a linear spring, which is equivalent to a harmonic potential under finite shear strain.

**Koji Iwase** (Nagoya Institute of Technology)

Title: Karman vortex around the obstacle with active Brownian particles

Abstract: The flow around an obstacle has been investigated much in fluid dynamics, where the vortex and turbulence instability is caused by increasing the control parameter, i.e., the Reynold number . The so-called Karman vortex is one of the familiar phenomena in our daily life, which was well investigated to clarify the mechanism by the numerical

methods, not only macroscopic fluid dynamics (DNS) but microscopic molecular dynamics simulation . In this study, we focus on the Karman vortex with the active fluid composed of the active Brownian particles instead of the repulsive particle (WCA or LJ) and explore the change of macroscopic flows and substantial shifts of a critical point of bifurcation. We observe the flow stream's phase instability driven by motility-induced phase separation (MIPS). We will report its microscopic origins (diffusional characteristics and hexatic orientational order) in the workshop.

**Hiroki Moriya** (Titech)

Title: Macroscopic approach for the large deviation of the symmetric simple exclusion process

Abstract: We study the current fluctuation of the symmetric simple exclusion process (SEP). To calculate its large deviation, we use the macroscopic fluctuation theory (MFT) that provides the path integral formulation for the diffusive model. The saddle point equation can be mapped into the classically integrable PDEs through a generalization of the canonical Cole-Hopf transformation. The inverse scattering method (ISM) enables us to analyze the solutions of this PDEs and we derive the large deviation function of the current starting from the step initial condition. It coincides with the formula obtained previously by microscopic calculations. This provides the first analytic confirmation of the validity of the MFT for an interacting model in the time dependent regime.

This presentation is based on a joint work with Kirone Mallick and Tomohiro Sasamoto.

**Daigo Mugita** (Nagoya Institute of Technology)

Title: Local structure analysis on pressure and inherent structure using the free volume estimator (NELF-A) in dense poly-disperse hard disk systems

Abstract: In many-particle systems, the free volume of a tagged particle constructed from excluded volume by surrounding particles made a crucial contribution to describing the macroscopic properties in the history of liquid state theory. Several numerical algorithms

for calculating the free volume of a tagged particle have been invented, such as Monte Carlo (MC) sampling using a random number and Voronoi tessellation. However, MC is an approximate calculation using random numbers and the computational cost of the Voronoi tessellation is relatively high. Especially in the poly-disperse system, the algorithm for constructing the Voronoi polyhedron becomes complex. As an alternative algorithm, we proposed the simple, efficient, and precise method of categorizing Neighbors for Enclosing Local Free Area (called NELF-A), which is easily applied to dense polydisperse hard disk systems often used in glassy model systems. As an application of NELF-A, we obtained pressure and inherent structure by calculating free volume, and investigated the difference in calculation efficiency and accuracy between NELF-A and conventional methods, which will be reported in the workshop.

**Taisei Nakamura** (Nagoya Institute of Technology)
Title: In this study, we investigate the phase behavior of the self-propelled hard disk systems with the Vicsek-type interaction via event-driven molecular dynamics simulation systematically. In addition to the ordinal order-disorder transition of the collective velocity field known in the original point particle of the Vicsek model, we observed the novel competition driven by the global positional order (so-called Alder transition) due to the exclusive effect of hard disk, which causes anomalous fluctuations around phase transition and transition shifts.

**Hiroyoshi Nakano** (The University of Tokyo)
Title: Molecular dynamics study of nonequilibrium long-range spatial correlations in simple fluids
Abstract: Nonequilibrium systems exhibit a variety of cooperative phenomena that are absent in equilibrium systems. One of the well-studied and widely-known examples is the occurrence of long-range spatial correlations. Extensive theoretical studies since the 1980s have shown that the occurrence of long-range spatial correlations is a ubiquitous feature of anisotropic nonequilibrium systems with the conservation law. However, the numerical verification of these theoretical results remains limited, particularly, in the context of nonequilibrium fluid systems subjected to shear flow and temperature gradient.

Recently, we performed large-scale molecular dynamics simulations in nonequilibrium fluid systems and unambiguously observed the nonequilibrium spatial long-range correlations using systems consisting of over ten million particles. In this presentation, we review these results.

**Yoshihiko Nishikawa** (Tohoku University)

Title: Heterogeneous equilibrium dynamics of a three-dimensional lattice glass model

Abstract: The drastic slowing down of the dynamics upon approaching the glass transition has been a subject of debate over decades. There are several theories that can describe the observed dynamical features of glasses but are based on completely different physical pictures. Here, we study the equilibrium dynamics of a recently proposed lattice glass model in three dimensions deep inside the glassy temperature regime. At very low temperature, we find a highly heterogeneous dynamics, even stronger than off-lattice particle models, with a very small fraction of particles traveling large distances. Those particles facilitate other particles' mobility at the early stage of relaxation, and eventually trigger collective motions of particles. Its dynamic length scale grows with decreasing temperature. Interestingly, some static length scales grow as fast as the dynamic length scale, suggesting the dynamic slowing down is caused by the growing thermodynamic length scale.

**Samuel Poincloux** (The University of Tokyo)

Title: Flow and deformation of a sponge-like granular media

Abstract: We experimentally explore the mechanical response of an assembly of ring-shaped grains. The rings can rearrange like grains in sand, but also sustain massive elastic compression, like a typical sponge. This model hybrid material, at the border between porous and granular media, may help understand the interplay between compressibility and catastrophic flow occurring in landslide or snow avalanche. We investigate this interplay by quantifying and comparing irreversible displacement with ring and structural deformations.

**Daisuke S. Shimamoto** (The University of Tokyo)

Title: Dynamics of polydisperse particles with power size distribution

Abstract: As a model of jammed systems consisting of extremely polydisperse particles, we consider a system whose size follows a power distribution. Its structure and response to shear deformation will be discussed.

**Yutaka Sumino** (Department of Applied Physics)

Title: Collective behavior of binary sized colloids induced by electro hydrodynamic effect

Abstract: Electro hydrodynamics (EHD) flow is a flow induced by an electric field around an electrode. Particles dispersed in an aqueous phase sit close to an electrode surface creates incoming flow even under AC electric fields induced by the coupling of screening cloud with distorted electric field due to particles. This EHD flow depends on the size of particles. This fact can create non-reciprocal interaction between particles: effective force produced by EHD flow can be unbalanced when the particle size are different.

In this study, we created a system with binary sized colloid particle dispersed in an aqueous phase under AC electric fields. Here, we found that the collection of particles created non-settling active dynamics. With simplified model of particles, we show that this collective behavior is due to unbalanced effective force due to EHD flow, and asymmetric size of excluded volume.

**Yuki Takaha** (The University of Tokyo)

Title: Relaxation and crystallization dynamics of a monodisperse soft-sphere glass

Abstract: The conventional crystallization theory based on classical nucleation theory provides a qualitatively good agreement for crystallization near the freezing point. However, crystallization qualitatively different from the theory has been observed in colloidal systems in a very deeply supercooled glassy state. Thus, its crystallization time will be expected to be peculiar, but it has not been quantitatively confirmed. We evaluated the relaxation and crystallization time of a soft-sphere particle system by numerical experiments. The conventional crystallization theory predicts that the temperature dependence of the two timescales coincides at low temperatures, but our results show that the temperature dependence of crystallization is Arrhenius-like while the relaxation

time exhibits a super-Arrhenius dependence. Furthermore, we found that crystallization occurring in glass was described by the hopping between the inherent structures of the particle configurations. Our study suggests that crystallization specific to glasses, which has been observed in colloidal systems, may occur in a greater variety of particle systems, and leads to a better understanding of glass formation in simple molecules.

**Yukihiro Tomita** (Osaka University)

Title: Analysis of point-to-set lengths by 1+d dim replicated liquid theory in large-d limit

Abstract: We have developed an inhomogeneous replicated liquid theory which can describe glasses with spatial variations [1]. It becomes exact in 1+d dimensions in large-d limit. As a first application of it, we study the point-to-set (PS) lengths [2] of hard-spheres enclosed in a cavity of length L. We found that PS lengths diverge at the dynamical and static glass transition densities by power laws. The exponents agree with those obtained in previous studies via inhomogeneous MCT [3], p-spin spinglass model with Kac interaction [4] and hard-spheres in an one-dimensional chain of cells [5]. Moreover it predicts a spatial evolution of the glass order parameter, i. e. the mean-squared displacements within the cavity.

[1] Y. Tomita and H. Yoshino, in preparation.

[2] Biroli G., Bouchaud J.-P., Cavagna A. Grigera T. S., and Verrocchio P., Nat. Phys., 4. 771 (2008).

[3] Biroli G., Bouchaud J.-P., Miyazaki K. and Reichman D. R., Phys. Rev. Lett., 97 (2006) 195701.

[4] Franz S. and Montanari A., J. Phys. A: Math. Theor., 40 (2007) F251.

[5] H. Ikeda and A. Ikeda, Europhys. Lett., 111, 40007(2015)

**Masato Usui** (Tokyo Institute of Technology)

Title: Exact results for a stochastic one-dimensional two-species particle system

Abstract: Recently, nonlinear fluctuating hydrodynamics (NLFHD) was proposed as a phenomenological method to analyze physical quantities of one-dimensional non-equilibrium systems.

NLFHD predicts the superdiffusive behaviors of two-point correlation functions of conserved quantities corresponding to anomalous heat transport.
There are some physical assumptions in the derivation of governing equations of NLFHD and this implies that NLFHD does not have a foundation based on microscopic dynamics.
We accomplished the first theoretical confirmation of the NLFHD taking advantage of the exact solution for the Arndt-Heinzel-Rittenberg (AHR) model [1,2].
The AHR model is a stochastic one-dimensional particle system with two kinds of particles moving in opposite directions.
It has been proved that the AHR model is integrable, i.e., the eigenequation for the Markov matrix can be solved by the algebraic Bethe ansatz [3].
However, it was known how the wave functions, which are the components of the eigenvector, are concretely represented as the functions of positions of particles only when the transition rates are restricted by a certain constraint.
We suggested a way to represent the wave functions as the functions of positions of particles if the constraint is violated.
In this poster session, we will show the confirmation of NLFHD for the AHR model, and give the way to construct the wave functions of the AHR model with general transition rates.

[1]. L. Cantini, J. Phys. A: Math. Theor. 41 (2008) 095001
[2]. Z. Chen, J. de Gier, I. Hiki, and T. Sasamoto, Phys. Rev. Lett. 120 (2018) 240601
[3]. Z. Chen, J. de Gier, I. Hiki, T. Sasamoto, and M. Usui, Commun. Math. Phys. 395 (2021) 59-142

**Manami Yamagishi** (the University of Tokyo)
Title: Dynamics of a quantum active particle based on non-Hermitian quantum walks
Abstract: We present a model of a quantum active particle using non-Hermitian quantum walks in one and two dimensions and analyze its dynamics. Although there are a number of works on active matter, most of them are conducted in classical systems. Adachi et al. [1] used a non-Hermitian quantum spin system to simulate a “stoquastic” active matter. In contrast to their work with many-body systems, we start with simpler, one-particle

systems to allow systems real-time evolution in a fully quantum range. In particular, we utilize a model of quantum walks [2] proposed by Yamagishi et al. to model dynamics of quantum active matter in two dimensions. We observed activeness and quantumness at the same time.

[1] K. Adachi et al., Phys. Rev. Research 4, 013194 (2022).
[2] M. Yamagishi et al., arXiv:2212.13044 (2022).

**Kento Yasuda** (Kyoto University)

Title: Most probable path of an active Brownian particle

Abstract: In this study, we investigate the transition path of a free active Brownian particle (ABP) on a two-dimensional plane between two given states. The extremum conditions for the most probable path connecting the two states are derived using the Onsager–Machlup integral and its variational principle. We provide explicit solutions to these extremum conditions and demonstrate their nonuniqueness through an analogy with the pendulum equation indicating possible multiple paths. The pendulum analogy is also employed to characterize the shape of the globally most probable path obtained by explicitly calculating the path probability for multiple solutions. We comprehensively examine a translation process of an ABP to the front as a prototypical example.
Interestingly, the numerical and theoretical analyses reveal that the shape of the most probable path changes from an I to a U shape and to the $\ell$ shape with an increase in the transition process time. The Langevin simulation also confirms this shape transition. We also discuss further method applications for evaluating a transition path
in rare events in active matter.