Monday, March 13

13:10 **Hisao Hayakawa** (Kyoto University)
Opening address

13:20 **Leticia Cugliandolo** (Sorbonne Université)
Title: "Critical behavior of surface code statistical models"
Abstract: The problem of optimal decoding of error correction can be mapped on statistical disordered spin models on the Nishimori line. I will discuss the phase diagrams, critical behaviour, and other properties of these models. This is work in collaboration with R. Agrawal, L. Ioffe, L. Faoro, and M. Picco

14:00 **Kunimasa Miyazaki** (Nagoya University)
Title: Hyperuniformity of almost ordered and disordered packing
Abstract: Jammed systems are among the earliest examples of disordered hyperuniformity; an anomalous suppression of density fluctuation on a large length scale while lacking conventional ordering. In the present work, we explore open questions on hyperuniformity near the jamming transition of two-dimensional binary soft disks. By tuning the size ratio of large and small discs from almost unity to a large but finite value, we investigate how the exponent characterizing the hyperuniformity varies depending on the degree of disorder. We find that the exponent is deceptively robust and stays constant independent of the extent of the disorder.

14:40 **Hajime Yoshino** (Osaka University)
Title: Random energy model in a pure ferromagnet
Abstract: Random energy model (REM) [1] is a caricature model which captures some essence of glass physics. It was originally derived in a spinglass model with strong quenched disorder [1]. However, it is desirable to derive REM in a microscopic disorder-free model as the quenched disorder is absent in structural

glasses [2]. In this talk, we first show that REM can be derived from a ferromagnetic Ising model with p-body interactions on the Bethe lattice with connectivity c in 'dense limit' N >> c >> 1 where N is the number of the spins [3]. Interestingly REM does not emerge in the globally coupled case c > = N. The REM found in this manner describes the glass transition in the supercooled paramagnetic phase of the ferromagnetic model. This system can be regarded as the dense limit of the same model in the sparse random networks with c=O(1) [4]. However the lattice can be completely regular [5]. We discuss some remaining interesting issues to get rid of the quenched disorder absolutely. Better understanding of this issue will help us to obtain better physical insights on the results of the replica theories which solved exactly some glass problems without quenched disorder in high dimensional limits including structural glasses [2], disorder-free spin models [3] and deep neural networks [6].

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[2] G. Parisi, P. Urbani and F. Zamponi, Theory of Simple Glasses: Exact Solutions in Infinite Dimensions, Cambridge University Press (2020).
[3] H. Yoshino, SciPost Phys. 4, 040 (2018) and in progress.
[4] S. Franz, M. Mezard2, F. Ricci-Tersenghi, M. Weigt and R. Zecchina, Europhys. Lett. 55.4, 465 (2001).
[5] H. Yoshino, T. Rizzo, A. G. Cavaliere, in progress.
[6] H. Yoshino, SciPost Phys. Core 2, 005 (2020).

15:20 Break

15:40 **Atsushi Ikeda** (The University of Tokyo)
Title: Heterogeneous jamming of binary mixture of small and large particles
Abstract: It has been well established that particulate systems show the jamming transition and critical scaling behaviors associated with it. However, our knowledge is limited to nearly monodisperse systems. Here, we conduct a thorough numerical study on this system with a special focus on the statistics of and finite-size effects

on the fraction of small particles that participate in the rigid network. We present strong evidence that two distinct jammed phases appear depending on the pressure and composition of two species. In one of two phases, only large particles are jammed, whereas both small and large particles are jammed in the other phase. These two phases are separated by the first-order phase transition line, which terminates at a critical point. We show that the jamming transition takes place highly heterogeneously at around this critical point, leading to peculiar behavior of structural, mechanical, and vibrational properties.

16:20 **Harukuni Ikeda** (Gakushuin University)

Title: Control parameter dependence of fluctuation near jamming

Abstract: Fluctuations of physical quantities play a central role in characterizing critical phenomena. However, there have been few studies on fluctuations near the jamming transition point. This presentation will show the results of our systematic numerical simulations of fluctuations near the jamming transition point. In particular, I will report that the behavior of the fluctuations changes qualitatively depending on the control parameters.

17:00 **Takeshi Kawasaki** (Nagoya University)

Title: Topological phase transitions in passive or active particles with chiral interactions

Abstract: Topological phase transitions due to chiral interactions are widely observed in condensed matter, such as chiral magnets [1], quantum Hall devices [2], spinor BEC [3] and liquid crystals [4]. In particular, there are many studies of these phase transitions in quantum systems, but much fewer in the classical. Moreover, the relationship between those in quantum and classical systems is elusive. Accordingly, we numerically study the classical molecular dynamics incorporating intermolecular chiral twisting and spheroidal steric interactions to elucidate this problem. As a result, we have shown that in several aspects (i.e., formation of helical and half-skyrmion in thermal equilibrium), the topological phase transitions in classical systems are qualitatively similar to those in quantum systems; still, their effects on the elastic field are distinct. We have also revealed that in the classical system, the competition between steric anisotropy and twisting interactions is essential to control the topological phases and resulting elastic fields [5]. In addition to the results for thermal equilibrium systems, we also present the extensions to active Brownian particles (ABP) systems, particularly characteristic motions of topological structures such as “rotating half-skyrmions”.

[1] N. Nagaosa and Y. Tokura, Nat. Nanotech. 8 899 (2013).

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[5] K. Takae and T.K., Proc. Natl. Acad. Sci. USA 119, e2118492119 (2022).

Tuesday, March 14

9:20 **Michio Otsuki** (Osaka University)

Title: An exact expression of three-body system for the nonlinear response of frictional granular materials

Abstract: We propose a simple model comprising three particles to study the nonlinear mechanical response of jammed frictional granular materials under oscillatory shear. Owing to the introduction of the simple model, we obtain an exact analytical expression of the complex shear modulus for a system including many monodispersed disks, which satisfies a scaling law in the vicinity of the jamming point. These expressions perfectly reproduce the shear modulus of the many-body system with low strain amplitudes and friction coefficients. Even for disordered many-body systems, the model reproduces results by introducing a single fitting parameter.

9:40 **Kota Mitsumoto** (The University of Tokyo)

Title: Spin-lattice glass transition without quenched disorder on pyrochlore magnet

Abstract: In the conventional view, the spin glass transitions occur due to the frustration of random interactions (quenched disorder). On the other hand, it has been known experimentally that spin glass transitions due to purely geometrical frustration without randomness may exist for the last 30 years. However, so far, there are no convincing explanations for the mechanism of this spin glass transition and the issue has remained as an important open problem.

Recently, it was experimentally suggested that lattice distortions play important roles in the spin glass transition on the prototypical geometrically frustrated spin glass Y2Mo2O7[1]. This lattice distortion is expected to be a Jahn-Teller distortion resulting from the selection of the electron orbitals[2]. Being motivated by the experiment, we introduced a model which includes not only the spin degrees of freedom but also the lattice distortions as dynamical variables. This model doesn't include any quenched disorder but both spins and lattice distortions are strongly

frustrated for geometrical reasons. We performed extensive numerical simulations for model and analyzed a mean-field theory which can be solved exactly in the infinite dimension.

In the numerical simulations[3], we found that spins and lattice distortions simultaneously freeze cooperatively at a common finite temperature. Both degrees of freedom do not exhibit any long range order below the freezing temperature. We found numerical evidences that the nonlinear dielectric susceptibility negatively diverges at the transition in addition to the negative divergence of the magnetic one. We believe this is an important suggestion for future experiments.

In the mean-field analysis using the replica method[4], we found two cases depending on the parameters such as the temperature, the ratio of energy scales associated with the spins and lattice distortions. In one case, the system exhibits the simultaneous spin and lattice glass transition. In the other case, the spin glass transition and lattice glass transitions occur separately. Very interestingly, in both cases, the RSB appears only in the phase where both spins and lattice distortions are frozen. In addition, we found that the glass susceptibilities associated with the nonlinear magnetic and dielectric susceptibilities diverge at the transition temperatures.

[1]P. M. Thygesen, et al., Phys. Rev. Lett. 118, 067201 (2017)
[2]K. Mitsumoto, C. Hotta and H. Yoshino, Phys. Rev. Research 4, 033157 (2022)
[3]K. Mitsumoto, C. Hotta and H. Yoshino, Phys. Rev. Lett. 124, 087201 (2020)
[4]K. Mitsumoto and H. Yoshino, arXiv:2301.08884

10:00 **Alberto Rosso** (LPTMS (CNRS, Univ. Paris Saclay))

Title: Exact solution for the Darcy law of yield stress fluids on the Bethe lattice

Abstract: In a series of experiments during the nineteenth century, Henry Darcy studied the flow of water in a cylinder filled with sand and established a famous empirical law: the flow of the liquid grows linearly with the pressure gradient. Today we know that Darcy's law governs the underground flow of all Newtonian fluids such as water, oil or natural gases, but its simplicity is completely broken in

presence of yield stress fluid such as cement, mud or foams. Experiments and extensive numerical simulations report a non-linear Darcy's law because the number of open channels supporting a non-vanishing flow increases with the pressure gradient. Statistical physics provides the tools to describe the complex landscape of these channels thanks to a mapping with the directed polymer with disordered bond energies. Here we consider this problem on a Cayley tree and use travelling wave equations to derive the exact pressure-dependence of the number of open channels and of the total flow. Our predictions are confirmed by extensive numerical simulations.

10:40 Break

11:00 **David Stanley Dean** (University of Bordeaux)

Title: Effusion in one dimension

Abstract: We consider the problem of how an ensemble of stochastic processes initially uniformly distributed on the negative of half the real line spreads to the positive part of the real line - notably the statistics of the number of particles on the positive real axis as a function of time. This problem for interacting and non-interacting Brownian motion has been studied in the literature using macroscopic fluctuation theory for an initial density profile with a step form. Here we study the problem for non-interacting but non-Markov Gaussian processes as well as Brownian motion. In an annealed treatment of the initial conditions, the joint probability distribution of the number of particles on the positive real axis obeys a multivariate Poisson distribution.

11:40 lunch

13:20 **Gregory Schehr** (LPTHE (Sorbonne University))

Title: First-passage properties of persistent random walks/run-and-tumble particles

Abstract: Persistent random walks, introduced in the maths literature by M. Kac, have become popular models of active matter where they are known under the name of run-and-tumble particles (RTP). In its simplest version, an RTP in dimension d, performs a ballistic motion along a certain direction, chosen uniformly at random, at a constant speed v_0 (“run”) during a certain exponential random “time of flight” ¥tau. Following this run, it “tumbles”, i.e., chooses a new direction uniformly at random and then performs a new run along this direction with speed v_0 during an exponential random time, and so on. I will present exact results for two first-passage problems related to RTPs: (i) the probability that the x-component of a single RTP in d-dimension has not changed sign up to time t and (ii) the probability that two independent RTPs on the line do not cross up to time t.

14:00 **Marco Picco** (CNRS & Sorbonne Université)

Title: Dynamics of the bidimensional Potts model in the large q limit

Abstract: I will present recent results in the study of the dynamics of the 2d Potts model in the large q limit. In particular, I will show that in this limit, dynamic scaling is universal at low temperature and I will also discuss the metastable equilibrium properties for temperatures around the phase transition.

14:40 **Amit Kumar Chatterjee** (Kyoto University)

Title: Multi species asymmetric simple exclusion process with impurity activated flips

Abstract: The asymmetric simple exclusion process (ASEP) is broadly regarded as a paradigmatic model for non-equilibrium transport processes. Motivated by a simplistic description of multi lane traffic flow, we present a multi species generalization of ASEP along with impurities. The impurities can activate flips between different species, imitating the lane change dynamics in multi lane traffic flow. The exact non-equilibrium steady state probability distribution is obtained using the technique of matrix product ansatz [1]. For special choices of the microscopic dynamics, the system exhibits (i) cluster formation as a result of counter-flow of different species and can be connected to run and tumble particles (used to model active matter) [2], (ii) negative differential mobility where current can decrease with increasing bias [1].

15:00 **Hirokazu Maruoka** (Kyoto University)

Title: Crossover of scaling law as a self-similar solution : the dynamical impact of viscoelastic board

Abstract: In the fields of soft matter, crossover of scaling law, the transition of scaling law with respect to the change of physical parameters, is frequently observed while they have failed to describe the crossover as a continuous process. In this work, I will demonstrate that the crossover of scaling law can be described by a self-similar solution which integrates different scaling laws. It was applied to a dynamical impact of viscoelastic board. The experimental data shows that the scaling law between deformation and impact-velocity varies depending on the size of sphere and impact velocity. I succeeded in describing this scale-dependences by a self-similar solution based on the viscoelastic foundation model. This work supplies the new insight to a self-similarity, critical phenomena and non-linear phenomena.

15:20 Break

15:40 **Frédéric van Wijland** (Université Paris Cité)

Title: Quantifying the performance of nonequilibrium samplers in dense systems

Abstract: We explore a class of active-like dynamical evolutions that nevertheless sample the Boltzmann distribution. We quantify their ability, or lack thereof, to accelerate dynamics with respect to reversible evolutions, especially for dense systems.

16:20 **Fernando Peruani** (CY Cergy Paris Université)

Title: On how time-independent disorder affects the motion of self-propelled particles

Abstract: Most examples of natural active matter systems, if not all, take place in heterogeneous media. Despite of this, most experimental and theoretical efforts have focused on homogeneous media and the impact of environmental heterogeneities to individual and collective properties of active systems has remained, up to recently, unexplored. Here, we will see that the physics of active systems in heterogeneous media is fundamentally different from the one in homogenous environments. For instance, in heterogeneous environments, spontaneous particle trapping of particles and sub-diffusion can occur, while long-range order of two-dimensional polar active liquids is not possible. Furthermore, in the absence of dynamic noise, it is possible to show that when the equations of motion exhibit a Hamiltonian structure, particle trapping cannot occur, while the presence of attractors in these equations indicate the asymptotic convergence of particle trajectories to bounded areas in space, i.e. traps.

References:

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R. Saavedra, F. Peruani, submitted (2023)

Wednesday, March 15

9:20 **Ryo Hanai** (Kyoto University, APCTP)

Title: Non-reciprocal frustrations: time crystalline order-by-disorder phenomenon and a spin-glass-like state

Abstract: Having conflicting goals often leads to frustrations. The conflict occurs, for example, in systems that cannot minimize simultaneously all interactions between the objects, a situation known as geometrical frustration. A typical feature of these systems is the presence of accidental ground state degeneracy that gives rise to a rich variety of unusual phenomena such as order-by-disorder phenomena and spin glasses. In this talk, I will show that a dynamical counterpart of these phenomena may arise from a fundamentally different, non-equilibrium source of conflict: non-reciprocal interactions. I show that non-reciprocal systems with anti-symmetric coupling generically generate marginal orbits that can be regarded as a dynamical counterpart of accidental degeneracy, due to the emerging Liouville-type theorem. These ``accidental degeneracy'' of orbits are shown to often get ``lifted'' by stochastic noise or weak random disorder to give rise to order-by-disorder phenomena with the peculiarity that the emerging state usually has a time crystalline order. I further report numerical evidence of a state analogous to a spin glass induced by non-reciprocal frustrations that exhibit aging and a power-law temporal relaxation associated with a short-ranged spatial correlation. This work provides an unexpected link between a seemingly unrelated field of complex magnetic materials and non-reciprocal matter.

10:00 **Etienne Fodor** (University of Luxembourg)

Title: Pulsating active matter

Abstract: Cells in tissues consume fuel to sustain periodic mechanical deformation. The combination of individual deformation and local interactions yields contraction waves, propagating throughout tissues with only negligible cell displacement. We consider a model of dense repulsive particles whose activity drives periodic change

in size of each individual. It reveals that, in dense environments, pulsation of synchronised particles is a generic route to contraction waves. The competition between repulsion and synchronisation triggers an instability which promotes a wealth of dynamical patterns, ranging from spiral waves to defect turbulence. We identify the mechanisms underlying the emergence of patterns, and characterize the corresponding transitions. We derive the hydrodynamics of our model, and propose an analogy with that of reaction-diffusion systems.

10:40 Break

11:00 **Kazumasa A. Takeuchi** (The University of Tokyo)

Title: Bacterial glass

Abstract: An interesting question in active matter physics is what states of matter may arise in active matter and how different they are from thermal systems. Bacterial populations are particularly interesting in this context, as they are known to show a plethora of collective phases, yet it remains challenging to characterize dense states of bacteria, partly because it is experimentally difficult to realize a uniform growth condition for dense populations.

Here we overcome this by a recently developed membrane-based device [1] and report the emergence of glassy states in two-dimensional suspension of Escherichia coli [2]. As the number density increases by cell growth, populations of motile bacteria transition to a glassy state, where cells are packed and unable to move. This takes place in two steps, the first one suppressing only the orientational freedom of bacteria, and the second one vitrifying the bacteria completely. We also characterize individual motion of bacteria, and find spontaneous formation of micro-domains of aligned cells. This leads to collective motion, which results in unusual behavior of characteristic quantifiers of glass. Our model experiment of dense bacteria may be relevant in broad contexts including biofilms and active rod systems in general.

This is a joint work with Hisay Lama, Masahiro J. Yamamoto, Yujiro Furuta, and Takuro Shimaya.

[1] T. Shimaya et al., Commun. Phys. 4, 238 (2021) https://doi.org/10.1038/s42005-021-00739-5
[2] H. Lama et al., arXiv:2205.10436 https://doi.org/10.48550/arXiv.2205.10436

11:40 Lunch

13:20 **Daiki Nishiguchi** (The University of Tokyo)
Title: Route from vortex order to active turbulence
Abstract: Routes to chaos and turbulence have been one of the central topics in fluid mechanics at high Reynolds numbers and statistical physics. The same question applies to the transitions between ordered states and turbulent states in low-Reynolds-number active matter systems known as active turbulence. When confined or in the presence of an array of microscopic obstacles, active turbulence in general self-organizes into ordered vortices. By combining bacterial experiments and numerical simulations on a polar active fluid model, we investigate how such emergent order gets destabilized and become turbulent. We present an unconventional route to turbulence via oscillatory states and reentrance from a chaotic state to an oscillatory state.

14:00 **Miho Yanagisawa** (The University of Tokyo)
Title: Cell-size space alterw phase transitions of dense polymer solutions
Abstract: The phase transitions of polymer solutions have been studied on both the large millimeter-scale (bulk systems) and small nanometer-scale. In the former, a mean-field picture is established, while interaction with the spatial surface dominates the overall behavior in the latter. In contrast, the phase transition at the micrometer scale, which lies between the two, remains yet to be elucidated. Furthermore, the size of this space corresponds to the size of a cell. Recent studies

on intracellular phase transitions, such as liquid-liquid phase separation, have heightened the desire to clarify the cell-size space effect on the phase transitions. In response to this, we have reported the effects of cell-size space on phase transitions of dense polymer solutions by using artificial cells. For instance, molecular diffusion, phase separation, and sol-gel transition in polymer solutions exhibit size-dependent changes within a space of less than a few 10 micrometers. Furthermore, we have recently discovered that these size-dependent changes originate from the slight polydispersity of the molecular weight (or size) of polymers, which is negligible in bulk systems. In this talk, I will introduce the cell-size confinement effects on phase transitions of dense polymers and discuss its underlying mechanics. Although our artificial cells are not active systems, they may serve as a foundation for comprehending phase transitions of dense biopolymer solutions in active and complex cells.

14:40 **Kyosuke Adachi** (RIKEN BDR)

Title: Universal properties in externally driven systems and active matter with spatial anisotropy

Abstract: Externally driven systems and active matter are prototypical nonequilibrium systems, and their collective properties have been studied in different contexts. Unique critical phenomena and generic long-range correlation have been found in externally driven systems, such as the uniformly or randomly driven lattice gas. For active matter with repulsive interactions, the critical properties of motility-induced phase separation (MIPS) have recently been investigated. Here, through simulations of particle models, we propose that a repulsive active matter with anisotropic self-propulsion shows collective behaviors akin to those of externally driven systems. We demonstrate that the long-range density correlation emerges in the active matter system in the same scenario for the case of externally driven systems. We further find that MIPS becomes anisotropic and its critical properties resemble those of the randomly driven lattice gas, which is supported by the renormalization group analysis of the coarse-grained field theory.

15:00 **Yuta Kuroda** (Nagoya University)

Title: Hyperuniformity and singular density correlation in chiral Active fluids

Abstract: Chiral active matter is a class of active matter systems where each component performs chiral motions. Most active fluids without chirality exhibit giant density fluctuations at large scales. In contrast, it is known that the density fluctuations are suppressed in chiral active fluids. This phenomenon is called hyperuniformity. The hyperuniformity has been observed numerically and experimentally in two-dimensional chiral active fluids. We developed a microscopic theory to explain the hyperuniformity in two-dimensional chiral active fluids starting from a simple particle model. We also investigated a three-dimensional case and found that this system exhibits a singular density correlation.

15:20 Poster flash talk

16:00 Poster session begins

Thursday, March 16

9:20 **Naoko Nakagawa** (Ibaraki University)

Title: Global thermodynamics for heat conduction systems

Abstract: We propose global thermodynamics which extends the thermodynamic framework to heat conduction by proposing a global temperature characterizing whole heat conduction systems. The extended variational principle leads to a nontrivial prediction such that the interface temperature in phase coexistence deviates from the equilibrium transition temperature.

10:00 **Michikazu Kobayashi** (Kochi University of Technology)

Title: Phase coexisting heat conduction in the Hamilton Potts model

Abstract: We study non-equilibrium phase coexistence in heat conduction by using the two-dimensional Hamilton Potts model. Observing that the temperature of the interface between ordered and disordered states deviates from the equilibrium transition temperature and a super-heated ordered region stably appears, we show the violation of the local equilibrium thermodynamics. The resultant temperature of the interface is quantitatively consistent with the proposal by global thermodynamics.

10:40 Break

11:00 **Hisao Hayakawa** (Kyoto University)

Title: Theory of Mpemba-like phenomena: a few example including quantum effect

Abstract: Mpemba effect (MPE) is a typical example of nonequilibrium memory effects in which liquids at high temperature can freeze faster than liquids at low temperature. Although there exists long pre-history of this effect, this effect becomes well known after the re-discovery of it by Mpemba and Osborne [1]. Despite a skeptical opinion of the validity of the Mpemba effect [2], recently the

existence of Mpemba-like anomalous thermal relaxations has been reported in various systems such as an experiment of colloid trapped in a double-well potential [3].

In this talk, I demonstrate, at least, two examples to show Mpemba-like phenomena.

I present a theoretical analysis of inertial suspensions in which the existence/non-existience of the viscous heating term in the heat equation leads to Mpmeba-like phenomena [4]. I also demonstrate quantum Mpemba-like phenomena after a quench or sudden heating-up [5]. If I will have time, I will show the theoretical analysis corresponding to Ref.[3] [6].

References:

[1] E. B. Mpemba and D. G. Osborne, Phys. Educ. 4, 172 (1969).
[2] H. C. Burridge and P. F. Linden, Sci. Rep. 6, 37665 (2016).
[3] A. Kumar and J. Bechhoefer, Nature 584, 64 (2020).
[4] S. Takada, H. Hayakawa and A. Santos, Phys. Rev. E 103, 032901 (2021) .
[5] A. K. Chatterjee and H. Hayakawa, in preparation.
[6] F. van Wijland and H. Hayakawa, in preparation.

11:40 **Leticia Cugliandolo** (Sorbonne Université)
Closing remarks

11:45 Lunch

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 ℓ 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.