Third China-Japan-Korea Joint Probability Workshop

8–9 May 2025

Research Institute for Mathematical Sciences, Kyoto University

8 May 2025

09:10-10:10: Ryoki FUKUSHIMA (University of Tsukuba)
Leading term of maximal edge traversal time in first passage percolation with Weibull distribution

10:30-11:15: Zhenyao SUN (Beijing Institute of Technology)
On the subcritical self-catalytic branching Brownian motions

11:25-12:10: Daehan PARK (Kangwon National University)
A probabilistic approach to time-fractional evolution equations with anisotropic diffusion

13:40-14:40: Jian DING (Peking University)
Critical level-set for the metric graph Gaussian free field

15:00-15:45: Izumi OKADA (University of Tokyo)
On the moderate deviations of the capacity of the random walk

15:55-16:45: ***Contributed talks***

Patrick VAN MEURS (Kanazawa University)
Weak solutions of a singular SDE for signed Coulomb charges in $\mathbb{R}^2$

Taegyun KIM (KAIST)
New universality class for mixed p spin spherical model

Gefei CAI (Peking University)
Touching probability of the planar Brownian loop

Runsheng LIU (Peking University)
Analyticity of 3D Brownian intersection exponents

16:55-17:45: ***Contributed talks***

Ryoichiro NODA (Kyoto University)
Collision measures of independent stochastic processes

Yifan GAO (City University of Hong Kong)
Uniqueness of generalized conformal restriction measures and Malliavin-Kontsevich-Suhov measures for $c \in (0, 1]$

Ryoji TAKANO (Osaka University)
A semigroup approach to the reconstruction theorem and its applications

Takumu OOI (Tokyo University of Science)
Homeomorphism of the Revuz correspondence for finite energy integrals

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Constructive quantum field theory and stochastic quantization

https://www.kurims.kyoto-u.ac.jp/∼croydon/CJK3.html

Abstracts

8 May 2025

09:10-10:10: Ryoki FUKUSHIMA (University of Tsukuba)

Leading term of maximal edge traversal time in first passage percolation with Weibull distribution

In this talk, I will discuss the asymptotic behavior of the maximal edge traversal time in first passage percolation. More precisely, consider the random graph obtained by assigning independent and Weibull distributed positive weights ("traversal time") to the edges of the integer lattice. We are concerned with the shortest path connecting the origin to a remote point. The main result gives sharp asymptotics of the maximal edge traversal time along the shortest path. Based on a joint work with Shuta Nakajima (Meiji University).

10:30-11:15: Zhenyao SUN (Beijing Institute of Technology)

On the subcritical self-catalytic branching Brownian motions

The self-catalytic branching Brownian motions (SBBM) are extensions of the classical one-dimensional branching Brownian motions by incorporating pairwise branchings catalyzed by the intersection local times of the particle pairs. These processes naturally arise as the moment duals of certain reaction-diffusion equations perturbed by multiplicative space-time white noise. For the subcritical case of the catalytic branching mechanism, we construct the SBBM allowing an infinite number of initial particles. Additionally, we establish the coming down from infinity (CDI) property for these systems and characterize their CDI rates. This is based on a joint work with Haojie Hou.

11:25-12:10: Daehan PARK (Kangwon National University)

A probabilistic approach to time-fractional evolution equations with anisotropic diffusion

In this presentation, we explore a Sobolev space theory for space-time non-local equations. For the time variable, we employ the Caputo fractional derivative as the non-local operator. For the spatial variable, we use the infinitesimal generator of a vector of independent subordinate Brownian motions. These equations arise naturally from fractional kinetics and have applications across various fields. A key component of our study is the estimation of heat kernels, which exhibit significantly different behavior compared to isotropic processes. Additionally, we introduce the definition of solutions and discuss related properties of function spaces.

13:40-14:40: Jian DING (Peking University)

Critical level-set for the metric graph Gaussian free field

In this talk, I will present some recent results on critical level-sets for metric graph Gaussian free fields on $\mathbb{Z}^d$ for $d \geq 3$. Joint work with Zhenhao Cai.

15:00-15:45: Izumi OKADA (University of Tokyo)

On the moderate deviations of the capacity of the random walk

In this talk, we will explore two distinct properties of the capacity of the random walk. In dimension 3, we will show Strassen's LIL and a phase transition under L^2 constraints. In dimension 4, we will demonstrate a link with the best constant of Gagliardo-Nirenberg inequality. This is joint work with Arka Adhikari (University of Maryland).

15:55-16:45: *Contributed talks*

Patrick VAN MEURS (Kanazawa University)

Weak solutions of a singular SDE for signed Coulomb charges in $\mathbb{R}^2$

The SDE system describes electrically charged particles moving in 2 dimensions, based on a 'velocity = force + noise' motion law. In this setting, the scattering of the Brownian motion is of similar strength as the electrostatic attraction force between particles of opposite charge. As a result, we will see *different* behavior of the particle system if we change the strength of the noise. I will present what we did and did not discover about the particle system. Our proofs use the theory on singular SDEs developed in the paper by Fournier and Jourdain from 2017. This is joint work with Mark Peletier and Thomas Slangen. Preprint: arXiv:2410.15855.

Taegyun KIM (KAIST)

New universality class for mixed p spin spherical model: free energy, overlap structure, non-ultrametricity for heavy tail or diluted case

In this presentation, we generalize the discussion of spin glass theory to heavy tail interaction for mixed p spin spherical model. We present how ultrametricity, RSB structure and free energy fluctuation changes if we change the Gaussian interaction to heavy tail interaction in mixed p spin spherical model.

Gefei CAI (Peking University)

Touching probability of the planar Brownian loop

Consider a planar Brownian loop ℓ such that its filling contains the origin. For such a loop ℓ, let η^{out} be its outer boundary, and define its inner boundary η^{in} to be the boundary of the connected component of $\mathbb{C} \setminus \ell$ containing the origin. In this work, we show that the probability of the touching event $\{\eta^{out} \cap \eta^{in} \neq \emptyset\}$ is exactly equal to $\frac{5\sqrt{3}}{9\pi}$. We also compute the touching probability for the outer and inner boundaries of a Brownian loop soup cluster, as an exact function of its intensity $c \in (0, 1]$. Our proof strategy is based on the interplay among Brownian motion, Schramm-Loewner evolution(SLE), Liouville quantum gravity(LQG), and Liouville conformal field theory(LCFT). This is a joint work with Jiaqi Liu(UPenn), Wei Qian(CityUHK), Xin Sun(PKU) and Baojun Wu(PKU).

Runsheng LIU (Peking University)

Analyticity of 3D Brownian intersection exponents

In this talk, we will focus on the analyticity of 3D Brownian intersection exponents. We will talk about a special type of boundary Harnack principle (BHP), which shows that a domain in $\mathbb{R}^3$ with the trace of a 3D Brownian motion removed almost surely satisfies BHP. This will imply a conditional version of separation lemma, and finally lead to the proof of analyticity. This talk is based on a joint work with Yifan Gao (CityU HK), Xinyi Li, Yifan Li and Xiangyi Liu (PKU).

16:55-17:45: *Contributed talks*

Ryoichiro NODA (Kyoto University)

Collision measures of independent stochastic processes

We introduce the notion of *collision measures*, which capture positions and times of collisions between stochastic processes, and study their convergence in conjunction with the convergence of the underlying processes.

Given two independent stochastic processes X and Y defined on a common space S, and a measure μ on S, the collision measure Π associated with μ is formally defined as a random measure on $S \times \mathbb{R}_{\geq 0}$ by

$$\Pi(dx\, dt) = \delta_{(x,x)}(X_t, Y_t)\, \mu(dx)\, dt.$$

Here, $\delta_{(x,x)}$ denotes the Dirac delta function at (x, x), and μ plays a role in determining the contribution of the collision at point x, referred to as the *weighting measure*.

Nguyen (2023) constructed Π rigorously in the case where X and Y are one-dimensional Brownian motions and μ is the Lebesgue measure, using discrete approximations. In contrast, we construct Π for a broader class of stochastic processes without resorting to discrete approximations, by utilizing the theory of positive continuous additive functionals (PCAFs).

Furthermore, within the framework of resistance metric spaces – which includes low-dimensional fractals such as the Sierpiński gasket and critical random graphs such as critical Galton–Watson trees – we prove the convergence of the corresponding collision measures under the assumptions that the processes and their heat kernels converge, and that the heat kernels near time 0 and the weighting measures satisfy certain boundedness conditions.

Yifan GAO (City University of Hong Kong)

Uniqueness of generalized conformal restriction measures and Malliavin-Kontsevich-Suhov measures for $c \in (0, 1]$

In this talk, we present a unified approach to establish the uniqueness of generalized conformal restriction measures with central charge $c \in (0, 1]$ in both chordal, radial, and loop cases (also known as the Malliavin-Kontsevich-Suhov measures), by relating these measures to the loop soups. Based on a joint work with Gefei Cai (PKU).

Ryoji TAKANO (Osaka University)

A semigroup approach to the reconstruction theorem and its applications

In our recent research, we extended a semigroup approach used in Otto & Weber (2019) and Hoshino (2023) to provide an alternative proof of the reconstruction theorem for singular modelled distributions. As an application, we constructed a local-in-time solution to the two-dimensional parabolic Anderson model with a non-translation-invariant differential operator. In this talk, I will introduce the reconstruction theorem and highlight the differences between our approach and previous works. This talk is based on joint work with Masato Hoshino (Institute of Science Tokyo).

Takumu OOI (Tokyo University of Science)

Homeomorphism of the Revuz correspondence for finite energy integrals

We show that the Revuz correspondence from the set of all smooth measures of finite energy integrals to the set of positive continuous additive functionals, is a homeomorphism under the topology induced by the Dirichlet form and $L^2(\mathbb{P}_{m+\kappa})$-norm with the local uniform topology, respectively, where m is the underlying measure and κ is the killing measure of a Dirichlet form.

9 May 2025

09:10-10:10: Kyeongsik NAM (KAIST)

Critical last passage percolation

Last passage percolation (LPP) is a model of a random metric space where the main observable is a directed path evolving in a random environment. When the environment has light tails, the fluctuations of LPP are predicted to be explained by the Kardar-Parisi-Zhang (KPZ) universality theory. However, the KPZ theory is not expected to apply for many natural environments, particularly "critical" ones exhibiting a hierarchical structure. In this talk, I will talk about such LPP with an inverse quadratic tail decay distribution which is conjectured to be the critical point for the validity of the KPZ scaling relation. As a byproduct, I will mention the resolution of a long-standing question of Martin concerning necessary and sufficient conditions for the linear growth of the LPP energy.

10:30-11:15: Sungsoo BYUN (Seoul National University)

Large deviation probabilities in last passage percolation

In this talk, I will discuss large deviation probabilities for the last passage time in geometric last passage percolation. Building on Johansson's seminal work, which established the leading-order term in this expansion, we use the Deift–Zhou steepest descent method to explicitly derive three additional terms, up to and including the constant term. I will also explore the duality between this result and the free energy expansion of two-dimensional Coulomb gases, as well as its connection to large gap probabilities in Hermitian random matrix theory. This talk is based on joint work with Christophe Charlier, Philippe Moreillon, and Nick Simm.

11:25-12:10: Ryuya NAMBA (Kyoto Sangyo University)

Fractional binomial distributions induced from the generalized binomial theorem and their applications

We introduce a new fractional analogue of the binomial distribution on the basis of the generalized binomial theorem obtained by Hara and Hino (2010). We discuss several properties of the fractional binomial distribution including the law of large numbers, the central limit theorem and the law of small numbers, the last of which leads to a fractional analogue of the Poisson distribution. As an application of the fractional binomial distribution, a fractional analogue of the Bernstein operator is also introduced. We show that the fractional Bernstein operator uniformly approximates every continuous function on the unit interval. Some limit theorems for its iterates are established as well. This talk is based on a joint work with Masanori Hino (Kyoto University).

13:30-14:15: Wei LIU (Jiangsu Normal University)

Regularization by nonlinear noise

This talk focuses on the global existence, uniqueness and the Feller property for a class of stochastic partial differential equations with suitable nonlinear noise, while the corresponding deterministic equations may only have local solutions. In particular, we discover a new phenomenon that for a potentially explosive deterministic system, an appropriate intervention of nonlinear noise can not only prevent blow-up but also lead to the finite time extinction of the associated stochastic system. Our main results have various applications, including not only all locally monotone stochastic equations in the variational framework, but also several new models such as stochastic 3D Navier-Stokes equations, stochastic p-Laplace equations with heat sources, stochastic quasi-geostrophic equations and stochastic surface growth models.

14:25-15:00: *Contributed talks*

Huijie QIAO (Southeast University)

Large deviations for generalized backward stochastic differential equations

This study focuses on generalized backward stochastic differential equations, which are coupled with a family of reflecting diffusion processes. Firstly, we establish the large deviation principle for forward stochastic differential equations with reflecting boundaries under weak monotonicity conditions. Subsequently, by utilizing the obtained result and applying the contraction principle, we prove the large deviation principle for the generalized backward stochastic differential equations. Additionally, as a supplementary outcome, we derive a limiting result concerning second order parabolic partial differential equations with nonlinear Neumann boundary conditions.

Seungjoon OH (Seoul National University)

Spectral moments of non-Hermitian complex and quaternionic random matrices

Unlike the case of Hermitian random matrices where all eigenvalues are real, eigenvalues of non-Hermitian random matrices lie on the complex plane. In this talk, I will discuss the mixed moments of the eigenvalue density of a certain class of non-Hermitian random matrices. This includes the classical ensembles; the elliptic Ginibre ensemble, the non-Hermitian Wishart ensemble, and the planar Gegenbauer ensemble. We obtain the explicit formula and the large N-limit of the spectral moments, where N is the dimension of the matrix. The techniques involved are the linearization coefficients of the orthogonal/skew-orthogonal polynomials, and the Christoffel-Darboux type formula. This talk is based on joint work with Gernot Akemann and Sung-Soo Byun.

Yong-Woo LEE (Seoul National University)

Sharp tail estimates for the number of real eigenvalues in the elliptic Ginibre ensemble

The elliptic Ginibre orthogonal ensemble (eGinOE) is a one-parameter generalization of the GinOE that interpolates between the GinOE and the Gaussian orthogonal ensemble by adjusting asymmetricity. A notable feature of the eGinOE is that its spectrum can contain real eigenvalues with non-trivial probabilities. In this talk, we focus on the number of real eigenvalues in the spectrum of the eGinOE. In particular, we derive sharp asymptotics for the probability that the spectrum contains exceptionally many real eigenvalues. This is joint work with Gernot Akemann and Sung-Soo Byun.

15:10-16:10: Seiichiro KUSUOKA (Kyoto University)

Constructive quantum field theory and stochastic quantization

Recently the singular SPDE method is applied to the constructive quantum field theory (CQFT), and CQFT again became a hot topic after many years from the previous boom. In this talk, I explain the background of CQFT and the recent progress as applications of singular SPDEs.