Stochastic Processes and Complex Systems

25–29 August 2025

TOKYO ELECTRON House of Creativity,
Katahira Campus, Tohoku University

Monday 25th August	Tuesday 26th August	Wednesday 27th August	Thursday 28th August	Friday 29th August
09:15–10:00 Li	09:15–10:00 Maas	09:15–10:00 Nourdin	09:15–10:00 Zhang	09:15–10:00 Nakajima
Coffee break	*Coffee break*	*Coffee break*	*Coffee break*	*Coffee break*
10:30–11:15 Shiozawa	10:30–11:15 Hartung	10:30–11:15 Hino	10:30–11:15 Sasada	10:30–11:15 Junk
11:30–12:15 Z.-Q. Chen	11:30–12:15 Nakashima	11:30–12:15 Hanson	11:30–12:15 Hoshino	11:30–12:15 Nakano
13:45–14:30 Uemura	13:45–14:30 Costantini		13:45–14:30 Hairer	13:45–14:30 Miermont
14:45–15:30 Archer	14:45–15:30 Kawabi		14:45–15:30 Hernández-Torres	
Coffee break	*Short break*		*Coffee break*	
16:00–16:25 Noda	15:45–16:15 Poster talks		16:00–16:45 Shiraishi	Public Lecture 16:30–17:45 Hairer
16:30–16:55 Ebina	16:15–17:45 Poster session	*Conference dinner** (18:00–20:00)	17:00-17:25 Watanabe	
17:00–17:25 Takano				

*The conference dinner will take place at Sakura Hall; for those who have registered to attend, please refer to the back cover.

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Webpages

https://sites.google.com/view/workshop-spcs

https://www.tfc.tohoku.ac.jp/event/4308.html

Abstracts

August 25

Xue-Mei Li (EPFL and Imperial College London)

The cubic stochastic nonlinear wave equation with rougher-than-white noise

We investigate the cubic stochastic nonlinear wave equation (SNLW) on the two-dimensional torus, driven by spatial noise rougher than white noise. The problem is how rough can we take the noise for there is a well-posed solution theory. The solution would be of the form of the sum of a rough term, obtained by solving a linear stochastic equation, and a smooth part. We report the progress so far. This is joint work with Xianfeng Ren.

Yuichi Shiozawa* **(Doshisha University)**

Volume growth, big jump, and essential spectrum for regular Dirichlet forms†

Let (E, d) be a locally compact separable metric space, and let m be a positive Radon measure on E with full support. Let $(\mathcal{E}, \mathcal{F})$ be a regular Dirichlet form on $L^2(E; m)$ with an associated generator $(L, \mathcal{D}(L))$. Let $\sigma_{\mathrm{ess}}(-L)$ denote the essential spectrum of $(L, \mathcal{D}(L))$ and $\lambda_e = \inf \sigma_{\mathrm{ess}}(-L)$. For a strongly continuous Markov semigroup $\{T_t\}_{t>0}$ on $L^2(E; m)$ generated by L, it is known that T_t is compact for each $t > 0$ if and only if $\sigma_{\mathrm{ess}}(-L) = \emptyset$, that is, $\lambda_e = \infty$. We can thus regard λ_e as an intensity of the noncompactness of T_t.

Brooks (1981/1984) established an upper bound of λ_e for the Laplace-Beltrami operator on a complete and noncompact Riemannian manifold in terms of the volume growth/decay rate. Notarantonio (1998) extended the result of Brooks to a strongly local regular Dirichlet form by using the volume growth rate with respect to the intrinsic metric. Folz (2014) also extended the result of Brooks to a regular Dirichlet form on a weighted graph by using the volume growth rate with respect to the adapted metric. Haeseler-Keller-Wojciechowski (2013) further extended the result of Brooks to a regular Dirichlet form with no killing inside by using the intrinsic metric in the sense of Frank-Lenz-Wingert (2014), and applied their result to operators on weighted graphs. However, since this intrinsic metric needs to control big jumps, the associated volume growth rate could be so large that we may not get an upper bound of λ_e.

In this talk, we establish an upper bound of λ_e by following the previous works as mentioned above and S. (2015/2016). Namely, we introduce a function defining the size of jump heights, and control small jumps only by the associated length function. We then apply this bound to regular Dirichlet forms of pure jump type with no graph structure.

We here focus on regular Dirichlet forms of pure jump type. Let $C_0(E)$ be the totality of continuous functions on E with compact support, and let $\mathcal{F}_{\mathrm{loc}}$ be a localized space of $\mathcal{F}$.

Assumption 1. (i) For any $u \in \mathcal{F} \cap C_0(E)$,

$$\mathcal{E}(u, u) = \iint_{E \times E \setminus \mathrm{diag}} (u(x) - u(y))^2 \, J(x, \mathrm{d}y) m(\mathrm{d}x).$$

Here diag $= \{(x, x) : x \in E\}$, and $J(x, \mathrm{d}y)$ is a measurable kernel on the Borel measurable space $(E, \mathcal{B}(E))$ such that the measure $J(\mathrm{d}x, \mathrm{d}y) = J(x, \mathrm{d}y)m(\mathrm{d}x)$ is symmetric.

(ii) There exist families of functions $\{\rho_r\}_{r>0} \subset \mathcal{F}_{\mathrm{loc}} \cap C(E)$ and $\{F_r\}_{r>0} \subset C(E \times E)$ such that the following hold:

- For each $x, y \in E$, $F_r(x, y) = F_r(y, x) > 0$ $(r > 0)$, and $F_r(x, y)$ is increasing in $r > 0$.
- For any $r > 0$,

$$(M_1(r) :=) \operatorname*{ess\,sup}_{x \in E} \int_{d(x,y) < F_r(x,y)} (\rho_r(x) - \rho_r(y))^2 \, J(x, \mathrm{d}y) < \infty,$$

$$(M_2(r) :=) \operatorname*{ess\,sup}_{x \in E} \int_{d(x,y) \geq F_r(x,y)} J(x, \mathrm{d}y) < \infty.$$

*This work was supported by JSPS KAKENHI Grant Number 22K18675, 23K25773.

†This talk is based on the preprint with the same title (arXiv:2503.22899)

(iii) For each fixed $r>0$, $K_{\rho_r}(R)=\{x\in E : \rho_r(x)\le R\}$ is compact for any $R>0$, and there exists $R_0>0$ for any compact set $K\subset E$ such that $K\subset K_{\rho_r}(R_0)$.

Theorem 2. Under Assumption 1, the next assertions hold.

(1) If $m(E)=\infty$, then

$$\lambda_e \le \inf_{r>0}\left(\frac{\mu_r^2}{4}M_1(r)+2M_2(r)\right) \qquad \left(\mu_r := \liminf_{R\to\infty}\frac{1}{R}\log m(K_{\rho_r}(R))\right).$$

(2) If $m(E)<\infty$ and $(\mathcal{E},\mathcal{F})$ is recurrent, then

$$\lambda_e \le \inf_{r>0}\left(\frac{\nu_r^2}{4}M_1(r)+2M_2(r)\right) \qquad \left(\nu_r := \liminf_{R\to\infty}\frac{-1}{R}\log m(E\setminus K_{\rho_r}(R))\right).$$

Let us explain how to prove Theorem 2. As in the previous works, we appeal to Persson's formula: if a sequence $\{f_n\}\subset\mathcal{F}$ is weakly convergent to 0 in $L^2(E;m)$, then $\lambda_e\le\liminf_{n\to\infty}\mathcal{E}(f_n,f_n)$ holds (see, e.g., Keller-Lenz-Wojciechowski (2021)). Our point in the proof is to decompose the quadratic form $\mathcal{E}(f_n,f_n)$ as

$$\begin{aligned}\mathcal{E}(f_n,f_n) &= \int_{d(x,y)<F_r(x,y)}(f_n(x)-f_n(y))^2\,J(x,\mathrm{d}y)m(\mathrm{d}x)\\ &\quad+\int_{d(x,y)\ge F_r(x,y)}(f_n(x)-f_n(y))^2\,J(x,\mathrm{d}y)m(\mathrm{d}x).\end{aligned}$$

We can then estimate the first term of the right hand side above by $M_1(r)$ and volume growth/decay rate, and the second one by $M_2(r)$ and $\|f_n\|_{L^2(E;m)}$. Note that if $m(E)<\infty$ and $(\mathcal{E},\mathcal{F})$ is recurrent, then any constant function belongs to $\mathcal{F}$. We use this property to construct a suitable sequence $\{f_n\}\subset\mathcal{F}$ in the proof of Theorem 2 (2).

Example 3. Suppose that any closed ball in E is compact and $d_0(x)=d(o,x)\in\mathcal{F}_{\mathrm{loc}}$ for some $o\in E$. Suppose also that there exists a nonnegative Borel measurable function $J(x,y)$ on $E\times E$ such that $J(x,\mathrm{d}y)=J(x,y)\,m(\mathrm{d}y)$, and that the following (i) and (ii) hold.

(i) $m(E)=\infty$ holds, and for some positive constants c_1, c_2, η and κ,

$$m(B_0(R))\le\begin{cases}c_1r^\eta & (0<r<1),\\ c_2e^{\kappa r} & (r\ge 1).\end{cases}$$

(ii) Let η and κ be the same constants as in (i). Then for some positive constants c_3, c_4 and $\alpha\in(0,2)$,

$$J(x,y)\le\begin{cases}\dfrac{c_3}{d(x,y)^{\eta+\alpha}} & (d(x,y)<1),\\ \dfrac{c_4e^{-\kappa d(x,y)}}{d(x,y)^{1+\alpha/2}} & (d(x,y)\ge 1).\end{cases}$$

Letting $\rho_r(x)=d_0(x)$ and $F_r(x,y)=r$, we get the estimates of $M_1(r)$ and $M_2(r)$. Then by Theorem 2 (1), there exists $c_*>0$ such that $\lambda_e\le c_*\kappa^\alpha$.

When the generator is the fractional Laplace operator on the hyperbolic space, an associated regular Dirichlet form fulfills the conditions (i) and (ii) (see, e.g., Grigor'yan-Huang-Masamune (2012) and Ryznar-Żak (2016)), and the volume growth rate appears in the bottom of the essential spectrum. Our upper bound λ_e has a similar expression as above.

Zhen-Qing Chen (University of Washington)

Quantitative homogenization for time-dependent random conductance models with stable-like jumps

In this talk, I will present quantitative homogenization results for stable-like long range random walks in time-dependent random conductance models, where the conductances are bounded but can be degenerate. Based on joint work with X. Chen, T. Kumagai and J. Wang.

Toshihiro Uemura (Kansai University)

*Convergence of smooth measures and PCAFs**

In this talk, we are concerned with the intricate yet precisely established relationship between positive continuous additive functionals (PCAFs) and smooth measures, which is explicitly given by the Revuz correspondence for a regular Dirichlet form.

We begin by defining smooth measures of finite energy integral ($\mathcal{S}_0$), describing their crucial characterization through the existence of unique α-potentials. A significant part of our work details the properties of measures in $\mathcal{S}_0$, including the establishment of $(\mathcal{S}_0, \rho)$ as a Polish space (where ρ is a metric based on 1-potentials). We also demonstrate that ρ-convergence implies vague convergence, and conversely, ρ-bounded vague convergence implies weak convergence in $\mathcal{S}_0$. Furthermore, $\mathcal{S}_0$ exhibits favorable algebraic properties, such as monotonicity, forming a convex cone, and acting as an ideal.

We then extend to the convergence of PCAFs and smooth measures in $\mathcal{S}$. While $\mathcal{S}$ is a vast class, posing challenges for standard convergence notions, we introduce a strategy leveraging **nests** (increasing sequences of compact sets). By restricting measures to these nests, they fall into the analytically well-behaved $\mathcal{S}_0$ class. This framework enables us to establish a convergence of PCAFs via the measures in $\mathcal{S}$ using the ρ-convergence of their restrictions to common nests.

Next we examine the extent to which $\mathcal{S}$ covers absolutely continuous measures. For this, we introduce integrability in the broad sense ($\dot{L}^1_{\mathsf{loc}}(E;m)$), a function class broader than classical $L^1_{\mathsf{loc}}(E;m)$, showing that $fm \in \mathcal{S}$ for $f \in \dot{L}^1_{\mathsf{loc}}(E;m) \cap \mathcal{B}_+(E)$. This analysis concludes by establishing a convergence of PCAFs for absolutely continuous measures under specific L^p-convergence of the densities.

Finally, we address the *convergence of smooth measures attached to a (compact) nest via* PCAF*s*. Given that smooth measures are not necessarily Radon, standard weak or vague convergence is insufficient. We introduce the novel concept of *weak convergence on a nest*, alongside *vague convergence on the nest in the resolvent sense*. Furthermore, under certain L^1_{loc}-convergence and uniform boundedness conditions on the expected values of restricted PCAFs, we prove that the associated smooth measures converge vaguely on the nest in the resolvent sense. If an additional boundedness condition on 1-potentials holds, this further implies weak convergence of their 1-potentials and weak convergence of measures on the nest. This rigorous framework offers new tools for analyzing singular measures within the context of Dirichlet forms.

*joint work with Yasuhito Nishimori, Matsuyo Tomisaki and Kaneharu Tsuchida, partly also with Takumu Ooi

Eleanor Archer (Université Paris-Dauphine)

Scaling limit of the steady state cluster

The steady state cluster was introduced by Edward Crane in 2018 as the conjectured local limit of the Ráth-Tóth forest fire model and can be defined as the random finite rooted tree $\mathcal{C}$ satisfying the following: $\mathcal{C}$ is a singleton with probability $1/2$ and otherwise is obtained by joining by an edge the roots of two independent trees $\mathcal{C}'$ and $\mathcal{C}''$, each having the law of $\mathcal{C}$, and then re-rooting the resulting tree at a uniform random vertex.

In this talk we will discuss a joint work in progress with Edward Crane in which we show that its Gromov-Hausdorff-Prokhorov scaling limit is the Aldous' Brownian CRT.

Ryoichiro Noda* **(Kyoto University)**

Convergence of collision measures

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

Let $X = (X_t)_{t \geq 0}$ be a stochastic process on a space S, and let $Y = (Y_t)_{t \geq 0}$ be an independent copy of X. Given a measure μ on S, the *collision measure* Π associated with μ is formally defined as a random measure on $S \times [0, \infty)$ 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 determines the contribution of the collision at each point x, serving as a *weighting measure*.

Nguyen [1] rigorously constructed Π in the setting where X is the one-dimensional Brownian motion and μ is the Lebesgue measure, using discrete approximations. In contrast, we construct Π for a broader class of stochastic processes without relying on discrete approximations, by utilizing the theory of positive continuous additive functionals (PCAFs). This is motivated by the observation that a collision between X and Y corresponds to a hitting of the diagonal set $\{(x, x) \mid x \in S\}$ by their product process $Z = (X, Y)$. This perspective allows the collision measure to be regarded as an occupation measure of Z on the diagonal, making it accessible via the theory of PCAFs.

Our main result establishes that if spaces S_n, stochastic processes X_n on S_n, their heat kernels p_n, and weighting measures μ_n converge in a suitable Gromov–Hausdorff-type topology, then the corresponding collision measures also converge, provided the following assumption holds:

$$\limsup_{\delta \to 0} \sup_{x,y \in S_n} \int_0^\delta \int_{S_n} p_n(t, x, z)\, p_n(t, y, z)\, \mu_n(dz)\, dt = 0.$$

(NB: In the case where S_n is noncompact, the above condition is required to hold with S_n replaced by closed balls of all radii.) This condition is natural for ensuring the convergence of collisions, as it implies that the expected total number of collisions in the time interval $[0, \delta]$ vanishes as $\delta \to 0$ uniformly in the starting points and in n.

Collision is characteristic of low-dimensional behavior, and our result applies to a broad class of low-dimensional (fractal) spaces, including the Sierpiński gasket and critical random graphs, such as critical Galton–Watson trees.

References

[1] D.-T. Nguyen, *Scaling limit of the collision measures of multiple random walks*, ALEA Lat. Am. J. Probab. Math. Stat. **20** (2023), no. 2, 1385–1410. MR 4683379

*Research Institute for Mathematical Sciences, Kyoto University, Kyoto, 606-8502, JAPAN. E-mail:sgrndr@kurims.kyoto-u.ac.jp

Masahisa Ebina (Kyushu University)

Local central limit theorems for Wiener chaos

Malliavin-Stein's method is a fruitful combination of Malliavin calculus and Stein's method, and it provides a powerful probabilistic technique for establishing quantitative central limit theorems, particularly for functionals of Gaussian processes. In this talk, we will discuss how the theory of generalized functionals in Malliavin calculus can be combined with Malliavin-Stein's method to derive local central limit theorems for Wiener chaos. This is based on ongoing joint work with Ivan Nourdin and Giovanni Peccati.

Ryoji Takano* (The University of Osaka)

Transportation cost inequalities for BPHZ models

We study transportation cost inequalities (TCIs) for BPHZ models, with an eye toward applications to singular stochastic partial differential equations (SPDEs). The proof builds on an extension of a convergence result for BPHZ models, discussed in the seminal work of Bailleul & Hoshino (2023), by incorporating more general regularity-integrability structures. As a result, our approach may allow the treatment of TCIs for a broader class of singular SPDEs. This is joint work with Ismaël Bailleul (Univ. Brest) and Masato Hoshino (Institute of Science Tokyo).

*rtakano@sigmath.es.osaka-u.ac.jp

August 26

Jan Maas (Institute of Science and Technology Austria)

Kinetic optimal transport

We discuss kinetic versions of the optimal transport problem for probability measures on phase space. These problems arise from a large deviation principle and they are based on the minimisation of the squared acceleration. We argue that a natural geometry on probability measures is obtained by an additional minimisation over the time-horizon. While the resulting object is not a metric, it defines a geometry in which absolutely continuous curves of measures can be characterised as reparametrised solutions to the Vlasov continuity equation. This is based on joint work with Giovanni Brigati (ISTA) and Filippo Quattrocchi (ISTA).

Lisa Hartung (Johannes Gutenberg Universität Mainz)

The mean field stubborn voter model

In this talk, we look at a variant of the voter model in which some voters keep their opinions for a long time, and we are interested in how this affects the consensus time. This is modeled through iid fat-tailed waiting times in the voter model on the complete graph. Our main result is the existence of a limiting infinite voter model on the slowest updating sites. We further derive explicitly the consensus probabilities in the limit model. To prove this, we study properties of the coalescing system of random walks that forms the dual of the limit voter model and proof, among others, coming down from infinity. The talk is based on joint work with C. Mönch (Mainz) and F. Völlering (Leipzig).

Makoto Nakashima (Nagoya University)

Martingale measure associated with the critical 2d stochastic heat flow

In this talk, we will focus on the stochastic heat equation:

$$\partial_t u_t = \frac{1}{2}\Delta u_t + \lambda u \dot{W}$$

where $\dot{W}$ is the space-time white noise on $[0,\infty) \times \mathbb{R}^d$. It is known that it is ill-posed for $d \geq 2$, and the spatial dimension $d = 2$ is referred to critical for stochastic heat equation in the literature of singular SPDE. Recently, Caravenna, Sun, and Zygouras obtained the nontrivial limit of the approximated stochastic heat equation with suitable renormalization, which is called the critical $2d$ stochastic heat flow (Critical $2d$ SHF).

Regarding critical $2d$ SHF as a measure-valued process, we find the associated martingale measure in the sense of Walsh.

We will also talk about the regularity and positivity of the critical $2d$ SHF.

Cristina Costantini (University of Chieti-Pescara)

Obliquely reflecting diffusions in curved, nonsmooth domains

The talk is based on joint works with T.G. Kurtz.

Reflecting diffusions arise in many applications: from stochastic networks, to singular stochastic control, to models for the motion of physical particles, etc.. In many examples the domain in which the reflecting diffusion is to be confined is nonsmooth or the vector field of directions of reflection varies nonsmoothly: in these cases it is not obvious that a reflecting diffusion with the prescribed directions of reflection exists and is uniquely characterized.

After reviewing the literature, I will show how our recent reverse ergodic theorem for inhomogeneous killed Markov chains allows to deal with some new classes of domains and directions of reflection.

Specifically, I will discuss two significant cases. In a piecewise $\mathcal{C}^1$ domain in dimension 2, we obtain weak existence and uniqueness in distribution of the semimartingale reflecting diffusion under conditions that allow for a wider class of directions of reflection than the well known 1993 Dupuis and Ishii paper and for cusps in the boundary. For polyhedral domains, our condition on the directions of reflection reduces to the completely-$\mathcal{S}$ condition, which is optimal. Obliquely reflecting diffusions in 2-dimensional piecewise curved $\mathcal{C}^1$ domains are of interest, for instance, in singular stochastic control.

In a piecewise $\mathcal{C}^2$ cone in arbitrary dimension, we uniquely characterize the law of the semimartingale obliquely reflecting Brownian motion, under some conditions on the cone and the vector field of directions of reflection. These processes arise, for instance, in the study of Internet congestion control. Examples where our conditions are satisfied will be given.

Hiroshi Kawabi (Keio University)

Strong uniqueness of Dirichlet operators related to stochastic quantization for the $\exp(\Phi)_2$*-model*

This talk is based on a joint work with Hirotatsu Nagoji (Kyoto University). Let $\Lambda = (\mathbb{R}/2\pi\mathbb{Z})^2$ be the two dimensional torus and $H^s(\Lambda), s \in \mathbb{R}$ denotes the L^2-Sobolev space of order s with periodic boundary condition. We put $H := L^2(\Lambda)$. Let μ_0 be the mean-zero Gaussian measure on $H^{-\beta}(\Lambda)$, $\beta > 0$ with the covariance operator $(1-\Delta)^{-1}$. We define the $\exp(\Phi)_2$-measure $\mu^{(\alpha)}$ by

$$\mu^{(\alpha)}(d\phi) = \frac{1}{Z^{(\alpha)}} \exp\Big(- \int_\Lambda [\![\exp(\alpha\phi)]\!](x)dx\Big)\mu_0(d\phi),$$

where $\alpha \in (-\sqrt{8\pi}, \sqrt{8\pi})$ is the charge constant, $Z^{(\alpha)} > 0$ is the normalizing constant and the Wick exponential is formally introduced by the expression

$$[\![\exp(\alpha\phi)]\!](x) = \exp\Big(\alpha\phi(x) - \frac{\alpha^2}{2}\mathbb{E}^{\mu_0}\big[\phi(x)^2\big]\Big)dx, \quad x \in \Lambda.$$

Note that the diverging term $\mathbb{E}^{\mu_0}\big[\phi(x)^2\big]$ plays a role of the Wick renormalization.

We now set $E := H^{-\beta}(\Lambda)$ for a suitable constant $\beta \in (0,1)$ and consider a pre-Dirichlet form $(\mathcal{E}, \mathfrak{F}C_b^\infty)$ defined by

$$\mathcal{E}(F,G) = \frac{1}{2}\int_E \big(D_H F(\phi), D_H G(\phi)\big)_H \mu^{(\alpha)}(d\phi), \quad F, G \in \mathfrak{F}C_b^\infty,$$

where $\mathfrak{F}C_b^\infty$ is the set of all smooth cylindrical functions on E and D_H denotes the H-derivative. Applying the integration by parts formula with respect to $\mu^{(\alpha)}$, we have

$$\mathcal{E}(F,G) = -\int_E \mathcal{L}F(\phi)G(\phi)\mu^{(\alpha)}(d\phi), \quad F, G \in \mathfrak{F}C_b^\infty,$$

where

$$\mathcal{L}F(\phi) = \frac{1}{2}\mathrm{Tr}\big(D_H^2 F(\phi)\big) - \frac{1}{2}\big\langle \phi, (1-\Delta)D_H F(\phi)\big\rangle - \frac{\alpha}{2}\big\langle [\![\exp(\alpha\phi)]\!], D_H F\big\rangle, \quad \phi \in E,$$

and $\mathcal{L}F \in L^p(\mu^{(\alpha)})$ for all $\alpha^2 < 8\pi$ and $p \geq 1$. This means that the pre-Dirichlet operator $(\mathcal{L}, \mathfrak{F}C_b^\infty)$ is dissipative (and hence closable) in $L^p(\mu^{(\alpha)})$.

Our main result in this talk is the following.

Theorem. *Let* $p \geq 2$ *and the charge constant* α *satisfies*

$$\alpha^2 < \frac{16\pi}{9p-6}.$$

Then the pre-Dirichlet operator $(\mathcal{L}, \mathfrak{F}C_b^\infty)$ *is* L^p*-unique, that is, there exists exactly one* C_0*-semigroup in* $L^p(\mu^{(\alpha)})$ *such that its generator extends* $(\mathcal{L}, \mathfrak{F}C_b^\infty)$*. In particular,* $(\mathcal{L}, \mathfrak{F}C_b^\infty)$ *is essentially self-adjoint in* $L^2(\mu^{(\alpha)})$ *provided that* $\alpha^2 < 4\pi/3$.

August 27

Ivan Nourdin (University of Luxembourg)

Limit theorems for additive functionals of fractional Brownian motion

In this talk, I will first review first- and second-order limit theorems (laws of large numbers and fluctuation results) for various additive functionals of fractional Brownian motion with Hurst parameter $H \in (0, 1)$. This overview will illustrate the rich diversity of possible limiting behaviors: depending on the functional form and the value of H, the fluctuations can converge to a standard Brownian motion, an Hermite process, a Brownian motion subordinated to the local time, the derivative of the local time, etc. In a second part, I will discuss the case where the Hurst parameter equals zero, based on a model introduced by Neuman and Rosenbaum in a financial context.

This presentation is based on ongoing joint work with Arturo Jaramillo (CIMAT, Guanajuato) and Giovanni Peccati (University of Luxembourg).

Masanori Hino (Kyoto University)

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

A generalized binomial theorem was established by Hara and Hino (2010) for proving the neo-classical inequality. We introduce a new fractional analogue of the binomial distribution on the basis of the generalized binomial theorem and study its properties. They include the law of large numbers, the central limit theorem, large deviation principles, 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 proposed. We discuss a few limit theorems; in particular, a generalization of the Wright–Fisher diffusion process is captured as a certain limit of the iterates. Based on joint works with Ryuya Namba (Kyoto Sangyo Univ.).

Jack Hanson (The City College of New York)

Robust construction of the incipient infinite cluster in high dimensional critical percolation

We give a new construction of the incipient infinite cluster (IIC) associated with high-dimensional percolation in a broad setting and under minimal assumptions. Our arguments differ substantially from earlier constructions of the IIC; we do not directly use the machinery of the lace expansion or similar diagrammatic expansions. We show that the IIC may be constructed by conditioning on the cluster of a vertex being infinite in the supercritical regime $p > p_c$ and then taking $p \searrow p_c$. Furthermore, at criticality, we show that the IIC may be constructed by conditioning on a connection to an arbitrary distant set V, generalizing previous constructions where one conditions on a connection to a single distant vertex or the boundary of a large box.

The input to our proof is the asymptotic for the two-point function obtained by Hara, van der Hofstad, and Slade. Our construction thus applies in all dimensions for which those asymptotics are known, rather than explicitly requiring convergence of a diagrammatic expansion. Our construction will be instrumental in upcoming work related to structural properties and scaling limits of various objects involving high-dimensional percolation clusters at and near criticality.

August 28

Xicheng Zhang (Beijing Institute of Technology)

Heat kernel estimates for nonlocal kinetic operators

We employ probabilistic techniques to derive sharp, explicit two-sided estimates for the heat kernel of the nonlocal kinetic operator

$$\Delta_v^{\alpha/2} + v \cdot \nabla_x, \quad \alpha \in (0, 2),\ (x, v) \in \mathbb{R}^d \times \mathbb{R}^d,$$

where $\Delta_v^{\alpha/2}$ represents the fractional Laplacian acting on the velocity variable v. Additionally, we establish logarithmic gradient estimates with respect to both the spatial variable x and the velocity variable v. In fact, the estimates are developed for more general non-symmetric stable-like operators, demonstrating explicit dependence on the lower and upper bounds of the kernel functions. These results, in particular, provide a solution to a fundamental problem in the study of *nonlocal* kinetic operators. (This is a joint work with Haojie Hou.)

Makiko Sasada (The University of Tokyo)

Harmonic period matrices and diffusion matrices associated to large-scale interacting systems : Towards a universal theory of the hydrodynamic limit

Hydrodynamic limit provides a rigorous mathematical method to derive macroscopic partial differential equations as a proper space-time scaling limit of microscopic large-scale interacting systems. In our previous works, we have proposed an encompassing axiomatic framework to describe a wide range of general microscopic large-scale interacting systems with a finite local state space on general crystal lattices, opening the path toward a universal proof of the hydrodynamic limit.

In this talk, assuming simply that our interaction is *exchangeable* and the associated stochastic process is reversible with respect to some homogenous product measures, we define the *inverse harmonic period matrix* derived from the geometry of the microscopic large-scale interacting system. As our main result, we prove that this inverse period matrix can be calculated via a certain variational formula, which corresponds to the *diffusion matrix* of the macroscopic partial differential equation(s) in all of the cases where the corresponding diffusive hydrodynamic limit is rigorously proved. Our result gives an interpretation of the diffusion matrix in terms of the geometry of the microscopic model. Our proof does not require taking any scaling limits, and does not require the gradient condition nor any assumptions on the spectral gap estimates. Through our theory, the essential aspects of the non-gradient methods, which are often considered difficult to understand, can be understood in a very simple way. Our theory clearly shows that non-gradient methods have a parallel structure to the invariance principle for random walks and to homogenization theory. We expect that the inverse harmonic period matrix in general determines the diffusion matrix of the hydrodynamic limit. I will give a precise conjecture for the universal hydrodynamic limit in our very general framework.

This talk is based on joint work with Kenichi Bannai.

Masato Hoshino (Institute of Science Tokyo)

Random models on regularity-integrability structures

In the study of singular SPDEs, it has been a challenging problem to obtain a simple proof of a general probabilistic convergence result (BPHZ theorem). Differently from Chandra and Hairer's Feynman diagram approach, Linares, Otto, Tempelmayr, and Tsatsoulis recently proposed an inductive proof based on the spectral gap inequality by using their multiindex language. Inspired by their approach, Hairer and Steele also obtained an inductive proof by using the regularity structure language. In this talk, we introduce an extension of the regularity structure including integrability exponents, and provide a simpler proof of BPHZ theorem.

This talk is based on a joint work with Ismael Bailleul (Université de Bretagne Occidentale).

Martin Hairer (EPFL and Imperial College London)

Spectral gap for the infinite-volume Φ^4_3 measure at high temperature

We consider the natural (Langevin) dynamic for the Φ^4_3 measure in infinite volume. It is shown that, at high enough temperature, this dynamic is exponentially ergodic and obeys a 'one force, one solution' principle. This provides a particularly strong form of uniqueness and stability for the corresponding invariant measure. Some consequences are rotation invariance and exponential decay of correlations for the Φ^4_3 measure. This is joint work with Pawel Duch, Jaeyun Yi, and Wenhao Zhao.

Saraí Hernández-Torres (Universidad Nacional Autónoma de México)

Exceptional points in the three-dimensional uniform spanning tree scaling limit

Three-dimensional models in statistical physics have long posed significant challenges. In recent years, however, there has been notable progress in understanding the three-dimensional uniform spanning tree (UST) and loop-erased random walk (LERW). While the existence of their scaling limits is now established [1, 2, 3], the limiting objects remain mysterious.

In this talk, we present ongoing work on exceptional points in the scaling limit of the UST. Specifically, we study the limiting tree $\mathcal{T}$ and its embedding ϕ into $\mathbb{R}^3$. We compute the Hausdorff dimension of points in $\mathcal{R}^3$ that have multiple preimages under ϕ, revealing a rich interplay between the intrinsic geometry of $\mathcal{T}$ and the Euclidean geometry of its embedding.

Joint work with Omer Angel (UBC), David Croydon (Kyoto University), Xinyi Li (Peking University), Xiangyi Liu (Peking University), Runsheng Liu (Peking University), and Daisuke Shiraishi (Kyoto University).

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Daisuke Shiraishi (Kyoto University)

Chemical and resistance exponents for 4D simple random walk

Consider a simple random walk $S = (S_n)_{n\geq 0}$ on $\mathbb{Z}^d$ started at the origin. Regard $S[0, n]$ as a random graph whose vertex set and edge set are given by $\{S_k \,|\, 0 \leq k \leq n\}$ and $\big\{\{S_k, S_{k+1}\} \,|\, 0 \leq k \leq n-1\big\}$.

In [1], the following three quantities are studied:

- D_n = the graph (chemical) distance between the origin and S_n on $S[0, n]$,
- R_n = the effective resistance between the origin and S_n on $S[0, n]$,
- L_n = the length (the number of steps) of the loop-erasure of $S[0, n]$.

In contrast to substantial progress in L_n not only for $d = 2$ but also for $d = 3$ ([3], [4]), much less is known about D_n and R_n for both $d = 2$ and $d = 3$.

What about the four-dimensional case? (For $d = 1$ and $d \geq 5$, the problem is much simpler.) It is shown in [2] that $\mathbb{E}(L_n)$ is asymptotic to $cn(\log n)^{-\frac{1}{3}}$. In this talk, I will show that there exist constants $c_1, c_2 > 0$ such that

$$\lim_{n\to\infty} \frac{\mathbb{E}(D_n)}{c_1 n(\log n)^{-\frac{1}{2}}} = 1 \quad \text{and} \quad \lim_{n\to\infty} \frac{\mathbb{E}(R_n)}{c_2 n(\log n)^{-\frac{1}{2}}} = 1.$$

(The exact values of c_1 and c_2 are not computed. Even $c_1 \neq c_2$ is not proven!)

After establishing a law of large numbers for D_n and R_n, I will also present some fluctuation results for $D_n - \mathbb{E}(D_n)$ and $R_n - \mathbb{E}(R_n)$. These results will be useful for research on random interlacements and random walks on $S[0, \infty)$ in four dimensions.

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Satomi Watanabe (Kyoto University)

Collisions of simple random walks on the range of a four-dimensional simple random walk

We discuss collisions of multiple independent simple random walks on a graph. Whether the number of collisions is finite or infinite serves as an indicator of the structure of the underlying graph, and its behavior on random graphs has attracted much attention in recent years. In this talk, we consider simple random walks on a random graph given by the trajectory of a four-dimensional simple random walk. We present a quantitative estimate of the number of collisions between two random walks and report on our ongoing research regarding triple collisions.

August 29

Shuta Nakajima* (Meiji University)

Moderate deviations in first-passage percolation for bounded weights

First-passage percolation (FPP) is an important model in modern probability theory that studies the growth of random interfaces in disordered environments. On the lattice $\mathbb{Z}^d$, FPP assigns independent, identically distributed non-negative weights to edges, with the passage time $T(x, y)$ between points defined as the minimum total weight along any connecting path. For large distances, scaling arguments show that $T(0, N\mathbf{u})$ grows approximately as $N\mu(\mathbf{u})$, where $\mu(\mathbf{u})$ represents a deterministic speed.

While limit shape behavior is well understood, characterizing fluctuations remains a significant challenge. FPP is conjectured to belong to the Kardar–Parisi–Zhang (KPZ) universality class, with typical fluctuations scaling as N^χ (commonly believed to be 1/3 in two dimensions). Despite substantial research, rigorous mathematical confirmation has been difficult to achieve.

This talk examines the moderate deviation regime in FPP, where passage times deviate from expected values by N^a for exponents a between χ and 1. These deviations occupy a middle ground—larger than typical fluctuations but smaller than the system size. By studying how these deviations behave at different rates, we gain insights into FPP's underlying random geometry.

I will present theorems establishing asymptotics for moderate deviation probabilities:

$$\mathbb{P}\Big(T(0, N\mathbf{u}) > N\mu(\mathbf{u}) + N^a\Big) \quad \text{and} \quad \mathbb{P}\Big(T(0, N\mathbf{u}) < N\mu(\mathbf{u}) - N^a\Big)$$

Our approach uses concentration techniques via multi-scale analysis, previously applied to related models. We quantify how local geometric constraints—particularly limit shape curvature—interact with global probabilistic fluctuations. This creates a connection between fluctuation theory and large deviations, linking sublinear fluctuations to the stretched-exponential decay rates in large-deviation regimes.

*This work is a collaboration with Wai-Kit Lam.

Stefan Junk (Gakushuin University)

Equivalence of fluctuations of discretized SHE and KPZ equations in the subcritical weak disorder regime

We study discretized versions of the stochastic heat equation (SHE) and the Kardar-Parisi-Zhang (KPZ) equation, constructed via the directed polymer model, in spatial dimension $d \geq 3$. In the weak disorder regime, both equations satisfy a law of large numbers, and their fluctuations are conjectured to converge to the Edwards-Wilkinson limit. However, existing proofs of this convergence require a sub-optimal moment condition (bounded second moment as the mollification of white noise is turned off).

We show that the fluctuations of both equations are asymptotically equivalent throughout the interior of the weak disorder phase. In particular, this implies that they must have the same scaling limit, the existence of which remains an open problem. To prove our result, we combine the main theorem from [1], which determines the first-order behavior of the SHE fluctuations in weak disorder, with the local limit theorem for the polymer model from [2], which allows us to linearize the log-partition function (after suitable averaging and centering).

Based on joint work [3] with Shuta Nakajima.

Keywords: Stochastic Heat Equation, KPZ Equation, Directed Polymers, Weak Disorder, Scaling Limit, Local Limit Theorem.
AMS MSC 2020: 82D30, 60K37, 60H15.

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Fumihiko Nakano (Tohoku University)

Statistical properties of some quantum disordered systems

Quantum disordered system is one of the most important topics in mathematical physics, and various interesting phenomena, such as Anderson localization, quantum Hall effect, topological insulator are observed. A typical characteristics is densely distributed point spectrum with exponentially localized eigenfunctions, but recently its statistical properties are drawing much attention. In this talk, we first overview the developments on the 1-dimensional decaying systems, and then discuss some of the recent topics :
(1) d-dimensional decaying systems : we have a phase transition on the spectrum, depending on the tail of the on-site distribution. Extremal value statistics can also be studied.
(2) systems with critical energies : some special systems(e.g., polymer-model, mosaic-model) have finite set of critical energies embedded in the localized regime, because of which they have non-vanishing transport. We can see a “sharp” transition for the local eigenvalue statistics : from clock to Poisson with no intermediate ones.
(3) $H_{2|2}$-model : this is a 1-dimensional random Schrödinger operator with explicit connection to a RWRE and non-linear σ-model. In this model, transition of spectral properties is linked to the recurrence-transience of RWRE, and behavior of correlation functions of the σ-model.

Grégory Miermont (ENS de Lyon)

Scaling limits of random planar maps large faces

Many ”local” models of random planar maps, obtained by gluing uniformly at random the edges of a collection of polygons with given degree, in order to obtain a topological sphere, are known to converge to the so-called Brownian sphere, a canonical model of random surface. However, it is possible to escape from the wide universality class of the Brownian sphere, either by considering models of random planar maps with long-range correlations, typically by endowing them with a statistical physics model at criticality, or by considering local models in which the variance of the face degrees distribution is infinite. In this talk, we investigate this second question by showing that random Boltzmann maps whose face degree distributions belong to a stable domain of attraction converge in the scaling limit to a random fractal object, which is called a stable carpet or a stable gasket depending on the value of the stable exponent. Indeed, a phase transition for the topology of these objects occur at the value 3/2 of the stable exponent. This completes earlier results by Le Gall-Miermont, who obtained a scaling limit result only up to extraction of subsequences. This is joint work with Nicolas Curien and Armand Riera.

Poster Abstracts

Junlong Chen (Great Bay University)

Stochastic homogenization for singular-degenerate parabolic equations

We investigate the periodic space-time homogenization of a class of singular-degenerate parabolic equations perturbed by singular noise. The model is motivated by hydrodynamic limits in statistical physics. Our contribution is twofold. First, we study the qualitative periodic homogenization of the porous medium equation and the fast diffusion equation in a bounded domain using the two-scale expansion method. Second, at the mesoscopic level, we show that the limiting equation is a nonlinear parabolic equation with deterministic homogenized coefficients, consistent with the hydrodynamic limit results in statistical physics. This is a Joint work with Jinqiao Duan(Great Bay University).

Daniel Goodair (EPFL)

A Cauchy approach to nonlinear SPDEs

Perhaps the most standard method for proving (local) well-posedness of nonlinear SPDEs is to truncate the nonlinearity by a cut-off, then argue through relative compactness of an approximate sequence of solutions. Motivated by the stochastic Navier-Stokes equations where one would rather constrain the nonlinearity through stopping times, we present an alternative approach relying on a Cauchy argument up until the hitting threshold. With this technique we establish the existence of global analytically strong solutions to 2D stochastic Navier-Stokes equations, as well as bootstrapping higher order spatial regularity in two and three dimensions on their lifetime of existence.

Chenlin Gu (Tsinghua University)

The diffusivity of supercritical Bernoulli percolation is infinitely differentiable

We prove that, the diffusivity and conductivity on $\mathbb{Z}^d$-Bernoulli percolation ($d \geq 2$) are infinitely differentiable in supercritical regime. This extends a result by Kozlov [*Uspekhi Mat. Nauk* 44 (1989), no. 2(266), pp 79–120]. The key to the proof is a uniform estimate for the finite-volume approximation of derivatives, which relies on the perturbed corrector equations in homogenization theory. The renormalization of geometry is then implemented in a sequence of scales to gain sufficient degrees of regularity. To handle the higher-order perturbation on percolation, new techniques, including *cluster-growth decomposition* and *hole separation*, are developed.

Leo Hahn (Université de Neuchâtel)

Convergence of non-reversible Markov processes via lifting and flow Poincaré inequality

We propose a general approach for quantitative convergence analysis of non-reversible Markov processes, based on the concept of second-order lifts and a variational approach to hypocoercivity. To this end, we introduce the flow Poincaré inequality, a space-time Poincaré inequality along trajectories of the semigroup, and a general divergence lemma based only on the Dirichlet form of an underlying reversible diffusion. We demonstrate the versatility of our approach by applying it to a pair of run-and-tumble particles with jamming, a model from non-equilibrium statistical mechanics, and several piecewise deterministic Markov processes used in sampling applications, in particular including general stochastic jump kernels.

Naotaka Kajino (Kyoto University)

On singularity of p-energy measures among distinct values of p for affine nested fractals

For $p \in (1, \infty)$, a *p-energy form* $(\mathcal{E}_p, \mathcal{F}_p)$, a natural L^p-analogue of the standard Dirichlet form for $p = 2$, was constructed on a class of p.-c.f. self-similar sets by Herman–Peirone–Strichartz (2004), on general p.-c.f. self-similar sets by Cao–Gu–Qiu (2022), on Sierpiński carpets by Shimizu (2024) and Murugan–Shimizu (2025+), and on a large class of infinitely ramified self-similar fractals by Kigami (2023) and Kigami–Ota (2025+). Very little, however, has been understood concerning properties of important analytic objects associated with $(\mathcal{E}_p, \mathcal{F}_p)$ such as p-harmonic functions and p-energy measures.

This poster is aimed at presenting the result of the presenter's recent joint work with Ryosuke Shimizu (Kyoto University) that, for a class of p.-c.f. self-similar sets with good geometric symmetry known as affine nested fractals, *the p-energy measure* $\mu^p_{\langle u \rangle}$ *of any* $u \in \mathcal{F}_p$ *and the q-energy measure* $\mu^q_{\langle v \rangle}$ *of any* $v \in \mathcal{F}_q$ *are mutually singular for any* $p, q \in (1, \infty)$ *with* $p \neq q$ *if and only if for some (or equivalently, any) distinct boundary points (outmost vertices)* x, y *of the fractal there exist at least two arcs in* K *from* x *to* y. Here an *arc* in K from x to y refers to a set of the form $\gamma([0, 1])$ for a continuous injection $\gamma\colon [0, 1] \to K$ with $\gamma(0) = x$ and $\gamma(1) = y$.

Ignacio Madrid (The University of Tokyo)

Long-time behaviour of a measure-valued branching process with state-dependent reinforcement

We study a stochastic multi-type population model, where the individuals can adapt their jump kernel using the empirical distribution of their past states through a reinforcement mechanism. We consider general state spaces and continuous time, under the formalism of measure-valued stochastic processes. We adapt results from the theory of measure-valued Pólya processes (MVPP) and of reinforced Galton-Watson trees. In particular, we are interested in the effect of reinforcement and selection on the long-time behaviour of the population process. We first reduce the population-level dynamics to the study of a single MVPP through a Feynman-Kac representation and show that the population-level distribution of strategies concentrates around an optimal strategy which we characterize via a variational principle. Some biological applications in models of reinforced adaption are discussed.

Qingyan Meng (Great Bay University)

Fokker-Planck equation for a stochastic heat equation with Q-Wiener noise and non-homogeneous boundary conditions

This work is devoted to the study of the Fokker-Planck equation for a stochastic heat equation with an additive Q-Wiener noise and non-homogeneous boundary conditions. Moreover, the Feynman-Kac formula is used to obtain the probabilistic representation of the solution. The analysis is further extended to cases with multiplicative noise involving nonlocal diffusion operators under homogeneous boundary conditions. Notably, the evolution of the probability density function for the stochastic heat equation depends critically on the spatial location.

Yuzaburo Nakano (Yokohama National University)

Elephant random walks with variable step length

The elephant random walk (ERW) is a discrete-time stochastic process with a long-time memory of its whole history. In the first part, we introduce a variation of the ERW whose steps are polynomially decaying. We show that it admits phase transition from divergence to convergence (localization) at a critical point, and the strong enough memory shifts the critical point for localization. In the second part, based on a joint work with Masato Takei (Yokohama National University), we study some properties of the Takagi-van der Waerden class functions, a well-known class of continuous but nowhere differentiable functions, via variations of elephant random walks remembering the recent past.

Kôhei Sasaya (The University of Tokyo)

Construction of p-energy measures associated with strongly local p-energy forms

We constructed canonical p-energy measures associated with strongly local p-energy forms without any assumptions of self-similarity, where p-energy forms are L^p-versions of Dirichlet forms. Furthermore, we proved that the measures satisfy the chain and Leibniz rules, and that such a "good" energy measures are unique. As an application, we also proved the p-energy version of Le Jan's domination principle.

Szymon Sobczak (EPFL)

Navier-Stokes with a fractional transport noise as a limit of multi-scale dynamics

This work is concerned with investigating a multi-scale model in stochastic fluid dynamics. We consider a slow/fast system of equations modelling the evolution of a fluid on a 3-dimensional torus, perturbed by a fractional Brownian noise. We take the fractional Ornstein-Uhlenbeck as a fast process, which interacts with the slow Navier-Stokes equation via advection. We show that in the limit, there is a subsequence converging to a solution of a 3-dimensional Navier-Stokes equation perturbed by a fractional Brownian transport noise. We also provide an alternative, rough path notion of solution to the limit equation.

Xiaoyu Yang (Kyushu University)

Large deviation for slow-fast rough system with level 3 geometric rough path

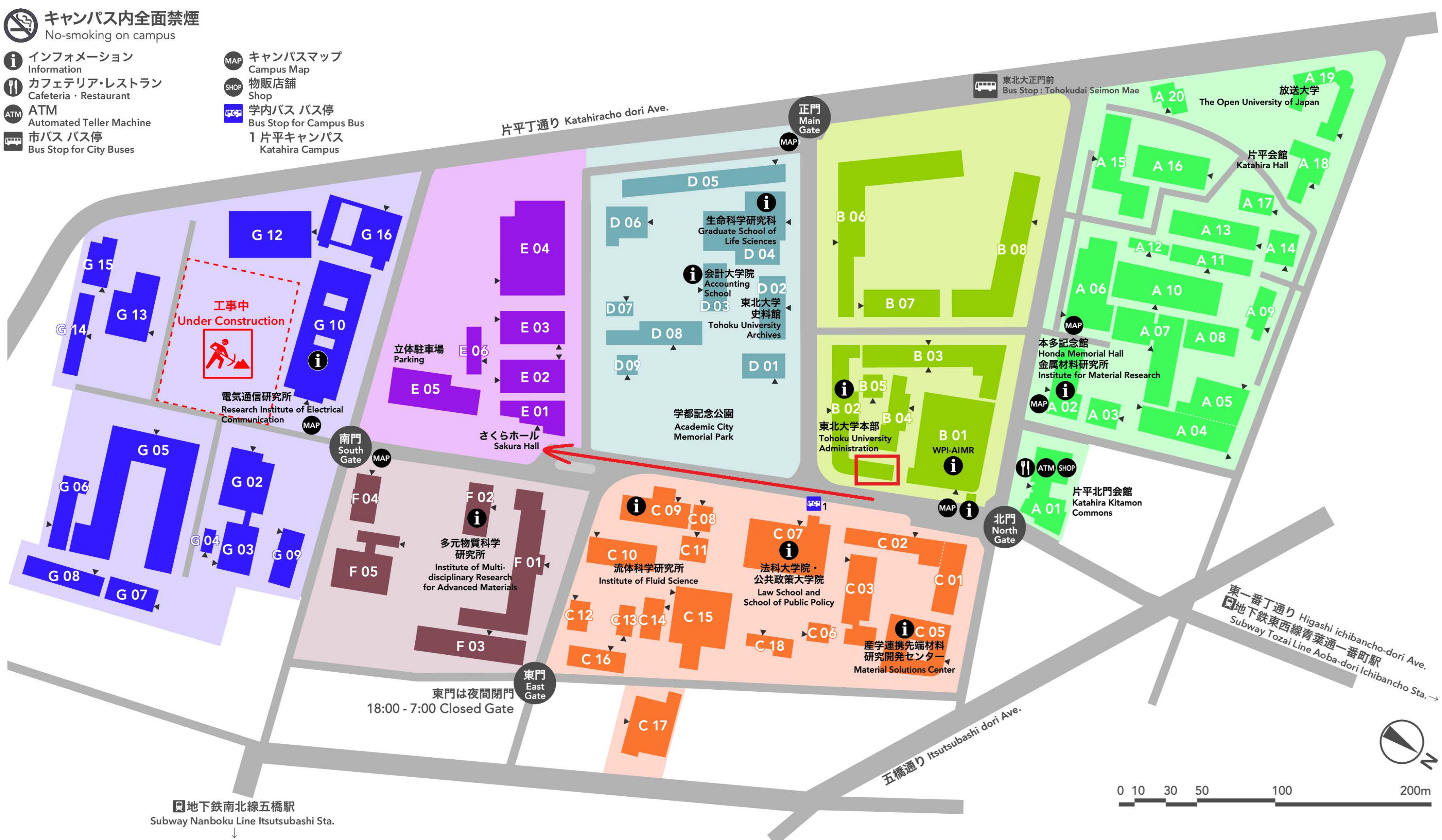
This work is to give the large deviation for a slow-fast system with level 3 random geometric rough path. Different from that driver rough path is of level 2, now the driver path comes from an anisotropic rough path that is lifted from the mixed fractional Brownian motion with Hurst parameter in $(1/4, 1/3)$. Unlike the situation of level 2, it requires showing that the translation of mixed FBM in the direction of Cameron-Martin space can still be lifted to a geometric rough path. Next, we still utilize the variational representation and weak convergence method. However, the existence of third-level rough paths still makes the weak convergence analysis more complicated, where more elaborate controlled rough path calculations are needed. Finally, we show that the controlled slow component weakly converges to the solution to the skeleton equation by averaging to the invariant measure of the fast equation and exploiting the continuity of the solution mapping. Here, the solution to the skeleton equation still could be well-defined in the Young sense within a variational setting. Besides, we also give the moderate deviation result could also be obtained with more necessary assumptions. Different from large deviation, some boundedness result of the deviation component is required.

Kexing Ying (EPFL)

Non-explosion for RDEs with coefficients having unbounded derivatives

We establish new non-explosion criteria for rough differential equations in which both the noise and drift coefficients together with their derivatives are allowed to grow at infinity. Moreover, we treat the case of additive noise separately, resulting in an improved condition for which we show is optimal by providing a counterexample.

Katahira Campus Map



Source: www.tohoku.ac.jp/en/about/map_directions.html

- The **conference venue**, the TOKYO ELECTRON House of Creativity, is indicated by ☐. The entrance is situated on the east side.
- The **conference dinner** (Wednesday, from 6pm) will be held at **Sakura Hall** (E 01 on the above map), within a 3-minute walk of the conference venue.