Workshop

Junior Female Researchers in Probability 2024

Berlin, July 3–5, 2024

Contents

Introduction

It is our great pleasure to welcome you to the workshop **Junior female researchers in probability**. We hope you enjoy illustrative talks and an interactive and inspiring exchange and networking.

Venue

The workshop will take place in presence at TU Berlin (HBS) at Hardenbergstraße 16–18, 10623 Berlin.

Presentations

The talks of the keynote and invited speakers each last one hour, and the contributed talks each last 20 minutes including questions.

Website

You can find further information on the web page of the workshop: `https://wias-berlin.de/workshops/JFRP24/`.

Organisers

Peter Bank, Laura Körber, Gemma Lucia Sedrakjan, Weile Weng (TU Berlin)
Marta Dai Pra, Dörte Kreher, Janine Steck, Maite Wilke Berenguer (HU Berlin)
Ana Djurdjevac (FU Berlin)
César Zarco-Romero, Alexander Zass (WIAS Berlin)

Timetable

Registration Wednesday 8:30–8:50

Welcome Wednesday 8:50–9:00

	WEDNESDAY 3	THURSDAY 4	FRIDAY 5	
9:00–10:00	Véber	Winter	9:00–10:00	Langer
10:00–10:40	coffee break		10:00–10:40	coffee break
10:40–11:00	Mellis	Kerriou	10:40–11:00	Bősze
11:00–11:20	Dopmeyer	Korfhage	11:00–11:20	Hucker
11:20–11:40	André	Kubatovics	11:20–11:40	Lukashevych
11:40–12:00	Salvador	Gros	11:40–12:00	Zhu
12:00–13:30	lunch break		12:00–13:30	lunch break
13:30–13:50	Wang	Koutsimpela	13:30–13:50	Weinberger
13:50–14:10	Nansubuga	Mitchell	13:50–14:50	Carpentier
14:10–14:30	Vardanyan	Kotelnikova	14:50–15:00	closing remarks
14:30–14:50	Aydogan	Pistolato		
14:50–15:30	coffee break			
15:30–15:50	Dragazi	Mokanu		
15:50–16:50	Eisenberg	Sasada		
17:00–18:30	Q&A session			
19:00		conference dinner		

Keynote speakers

A spatial measure-valued model for chemical reaction networks in heterogeneous systems

Amandine Véber
University Paris-Cité

In this talk, we shall introduce a measure-valued Markov process modelling a finite system of biochemical reactions taking place in a continuous, compact, space. In its general form, molecules need to be close to each other to react; some reactions or chemical species may be localised in space; some species are abundant (with a number $O(N)$ of molecules) while others may be rare (with $O(1)$ molecules). We shall first show that, as we let N tend to infinity, a suitable normalisation of the counting measure describing the state of the system converges to a measure-valued piecewise deterministic Markov process. In a second part, we shall describe a Central Limit Theorem associated to this convergence.

This is joint work with Lea Popovic (Concordia University).

Convergence of the Aldous-Broder chain on the high dimensional torus

Anita Winter
University of Duisburg-Essen

The CRT is the scaling limit of the UST on the complete graph. The Aldous Broder chain on a connected regular graph $G = (V, E)$ is a MC with values in the space of rooted trees with vertices in V that has the UST on G as its invariant distribution. In Evans, Pitman and Winter (2006) the so-called root growth with regrafting process (RGRG) was constructed. It was further shown that the suitable rescaled Aldous Broder chain on the complete graph converges to the RGRG weakly with respect to the GH-topology. It was shown in Peres and Revelle (2005) that (up to a dimension depending constant factor) the CRT is also the Gromov-weak scaling limit of the UST on the d-dimensional torus, d 5. This result was recently strengthens in Archer, Nachmias and Shalev (2024) to convergence with respect to the GH-weak topology, and therefore also with respect to the GH-topology. In this talk we show that the suitable rescaled Aldous Broder chain on the high-dimensional torus also converges to the RGRG weakly with respect to the GH-topology when initially started in the trivial rooted tree.

Joint work with Osvaldo Angtuncio Hernandez and Gabriel Berzunza Ojeda.

Invited talks

On optimal ranking in crowd-sourcing problems in several scenarios

Alexandra Carpentier

University of Potsdam

Consider a crowd sourcing problem where we have n experts and d tasks. The average ability of each expert for each task is stored in an unknown matrix M, from which we have incomplete and noise observations. We make no (semi) parametric assumptions, but assume that the experts can be perfectly ordered: so that if an expert A is better than an expert B, the ability of A is higher than that of B for all tasks. We either assume the same for the task, or not, depending on the scenario. This implies that if the matrix M, up to permutations of its rows and columns, is either isotonic, or bi-isotonic. We focus on the problem of recovering the optimal ranking of the experts and/or of the tasks, in l2 norm. We will consider this problem with some side-information - i.e. when the ordering of the tasks (if it exists) is known to the statistician - or not. In other words, we aim at estimating the suitable permutation of the rows of M. We provide a minimax-optimal and computationally feasible method for this problem in three scenarios of increasing difficulty: known order of the task, unknown order of the tasks, no order of the tasks. The algorithms we provide are based on hierarchical clustering, PCA, change-point detection, and exchange of informations among the clusters.

This talk is based on a joint ongoing work with Emmanuel Pilliat, Maximilian Graf and Nicolas Verzelen.

Insurance - A Wide Field to Apply Probability

Julia Eisenberg

TU Vienna

When considering a life or a non-life insurance portfolio, it is a natural wish to reduce the risk or to maximise the profit. However, the perception of risk depends on the risk measure chosen. The spectrum of possible risk measures is wide and includes, for instance, ruin probability, expected discounted cash flow, expected utility of terminal wealth and many more.

In this talk, we consider life and non-life insurance frameworks where the company's surplus is modelled by a stochastic process. The set of admissible controls is designed in line with the long-term aims of the insurer. These strategies along with the overall target of the insurer are formulated in terms of a stochastic control problem. We discuss possibilities to find the optimal strategy and the value function solving the respective control problems.

Is Statistical Theory Essential for Understanding Deep Learning?

Sophie Langer

University of Twente

The remarkable practical success of deep learning has revealed some major surprises from a theoretical perspective. Despite the non-convex loss landscape of neural networks, gradient methods consistently find near-optimal solutions and overparameterized networksthose with significantly more parameters than the sample sizeexhibit great generalization results. These observations cannot be fully explained by existing statistical theory: According to the bias-variance trade-off, overparameterized networks should perform worse, and statistical studies typically focus on an empirical risk minimizer, excluding the training process, such as gradient descent, from their analysis.

Given these discrepancies, a natural question arises: Is statistical theory even necessary to understand deep learning? In this talk, we will explore the role of statistical theory in understanding deep learning, as well as its limitations and the necessity to connect with other research areas.

Probabilistic aspects of the box-ball system

Makiko Sasada

University of Tokyo

The box-ball system (BBS), introduced by Takahashi and Satsuma in 1990, is a cellular automaton that exhibits solitonic behaviour. The BBS has been studied from various viewpoints such as tropical geometry, combinatorics, and discrete integrable systems (cf.[6]). As a new perspective, research on probabilistic approaches to this system has been rapidly expanding in recent years, including the application of the Pitman transform, analysis of invariant measures and scaling limits ([1, 2, 4, 5]). At the same time, in the field of mathematical physics, the macroscopic behavior of integrable systems has been found to have universality that differs from chaotic systems ([3]). The BBS is one of the few models that is mathematically tractable to verify such universality. In this talk, I will introduce these new research topics that have been spreading over the past several years from the basics.

References

[1] D. A. Croydon, T. Kato, M. Sasada, and S. Tsujimoto, *Dynamics of the box-ball system with random initial conditions via Pitmans transformation*, Mem. Amer. Math. Soc, 283, 1398 (2023).

[2] D. A. Croydon and M. Sasada, *Invariant measures for the box-ball system based on stationary Markov chains and periodic Gibbs measures*, J. Math. Phys. **60** (2019), 083301.

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Contributed talks

Genealogies in multitype frequency-dependent branching processes

Mathilde André

Collège de France - University of Vienna

Our work delves into the universality class of a very celebrated entity in population genetics: Kingman's coalescent. Introduced in [Kin82], it serves as baseline models for panmictic, neutral populations. More generally, Λ-coalescents catalog the genealogies of constant-sized exchangeable populations models known as Cannings models. We establish a broad class of regulated multitype individual-based models extending beyond exchangeable and fix-sized populations, yet for which the scaling limit of the genealogies sampled at a given time is still Kingman's coalescent. Thus, our result strides towards refining the intuition that neutral, Cannings-like genealogies can arise from complex interactions.

We prove convergence in distribution of the genealogies for the Gromov-Weak topology, using a change of measure and building on the multiple spine decomposition formalism developed by [FRS23]. The underlying purpose is to formulate a versatile methodology to derive scaling limits of genealogies within structured populations subject to type-frequency interactions. This method streamlines computations on forest-valued processes to a fine-grained analysis of the simpler stochastic process driving the type frequencies in the population. Kingman's coalescence rates are recovered from the contribution of the spinal immigration to this frequency process.

This is joint work with Félix Foutel-Rodier (University of Oxford) and Emmanuel Schertzer (University of Vienna).

References

[FRS23] Félix Foutel-Rodier and Emmanuel Schertzer. Convergence of genealogies through spinal decomposition with an application to population genetics. *Probability Theory and Related Fields*, 187(3):697–751, 2023.

[Kin82] John F. C. Kingman. The coalescent. *Stochastic Processes and their Applications*, 13(3):235–248., 1982.

Optimal portfolio strategies in jump-diffusion markets with relative performance concerns

Burcu Aydogan
RWTH Aachen University

We work on a portfolio management problem for one agent and a large group of agents under relative performance concerns in jump-diffusion markets with the CRRA utility function. We have stochastic optimal control problems for both the representative agent and the group to determine what the group does and the agent's optimal proportion in the portfolio relative to the group's performance. Our framework assumes that the agent's performance does not affect the group, while the group affects the agent's utility. Moreover, we investigate special cases where all agents in the market are homogeneous in their risk aversion and relative performances. We explore the qualitative behavior of the agent and show some numerical results depending on her relative performance consideration and risk tolerance degree. Further, we compare the optimal strategies with small and market benchmark portfolios under under jump-diffusion markets assumption.

This is a joint work with Mogens Steffensen from University of Copenhagen.

References

[BM24] B. Aydogan and M. Steffensen. Optimal investment strategies under the relative performance in jump-diffusion markets. *Decisions in Economics and Finance*, Under Review, 2024.

[LZ19] D. Lacker and T. Zariphopoulou. Mean-field and n-agent games for optimal investment under relative performance criteria. *Mathematical Finance*, Under Review, 29:1003–1038, 2019.

Estimating the rate of horizontal gene transfer in a host-parasite model

Zsuzsanna Bősze
Georg August University Göttingen, Institute for Mathematical Stochastics

Horizontal gene transfer (HGT) is the movement of genetic material between organisms other than by the transmission from parent to its offspring. The presence of HGT during the evolution of symbiotic systems (hosts and parasites) can lead to significant incongruences between the phylogenetic trees of the hosts and the parasites separately. Here we introduce a theoretical model for the evolution of a host-parasite system with HGTs as well as an estimator for the rate of HGTs using only the information coming from the separate phylogenetic trees. We present some of its mathematical properties regarding existence, consistency and asymptotic normality. Moreover, using this estimator, we introduce a new stochastic algorithm that takes the two separate phylogenetic trees as an input and returns a possible joint evolutionary scenario of the two levels. This is joint work with Anja Sturm.

The two-size Wright–Fisher model: an analysis via (uniform) renewal theory

Hannah Dopmeyer
Bielefeld University

Consider a population with two types of (one-dimensional) individuals, where type is interpreted as size (length): large individuals are of size 1 and small individuals are of size ϑ, $\vartheta \in (0,1)$. Each generation has an available space of length G. To form a new generation, individuals from the current generation are sampled one by one, and if there is at least some available space, they reproduce and their offspring are added to the new generation. The probability of sampling an individual whose offspring is small is given by $\mu^G(x)$, where x is the proportion of small individuals in the current generation. We call this stochastic model in discrete time the *two-size Wright–Fisher model*. The function μ^G can be used to model mutation and/or various forms of frequency-dependent selection. Denoting by $(X_t)_{t\geq 0}$ the frequency process of small individuals, we show convergence on the evolutionary time scale Gt to the solution of the SDE

$$\mathrm{d}X_t = \big(-\kappa X_t(1-X_t) + \mu(X_t)\big)\mathrm{d}t + \sqrt{X_t(1-X_t)(1-\kappa X_t)}\,\mathrm{d}B_t,$$

where $\kappa = 1-\vartheta$, $\mu(x) = \lim_{a\to\infty} G(\mu^G(x) - x)$, and B is a standard Brownian motion.

To prove this statement, the dynamics inside one generation of the model are seen as a renewal process, with the population size as the first-passage time $\tau(G)$ above level G. Methods from (uniform) renewal theory are applied and in particular a uniform version of Blackwell's renewal theorem (for binary, non-arithmetic random variables) is established.

This project is joint work with Gerold Alsmeyer (University of Münster) and Fernando Cordero (Bielefeld University, BOKU University).

Improved model-free bounds for multi-asset options using option-implied information and deep learning

Evangelia Dragazi
National Technical University of Athens

We consider the computation of model-free bounds for multi-asset options in a setting that combines dependence uncertainty with additional information on the dependence structure. More specifically, we consider the setting where the marginal distributions are known and partial information, in the form of known prices for multi-asset options, is also available in the market. We provide a fundamental theorem of asset pricing in this setting, as well as a superhedging duality that allows to transform the maximization problem over probability measures in a more tractable minimization problem over trading strategies. The latter is solved using a penalization approach combined with a deep learning approximation using artificial neural networks. The numerical method is fast and the computational time scales linearly with respect to the number of traded assets. We finally examine the significance of various pieces of additional information. Empirical evidence suggests that "relevant" information, *i.e.* prices of derivatives with the same payoff structure as the target payoff, are more useful that other information, and should be prioritized in view of the trade-off between accuracy and computational efficiency.

References

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[2] Lux Thibaut and Papapantoleon Antonis. *Improved Fréchet−Hoeffding bounds on d-copulas and applications in model-free finance*. arXiv.1602.08894, 2016.

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From 3 to infinity: a microscopic analysis of variable-speed branching Brownian motion

Annabel Gros

University of Bonn

The extremes of variable speed branching Brownian motion (BBM) exhibit a phase transition when the "speed function", which describes the time-inhomogeneous variance, is the identity function. In this talk we study this transition more closely by choosing piecewise linear, concave speed functions converging to the identity function from above. We show that the logarithmic correction of the order of the maximum interpolates smoothly between the correction of standard BBM, $\frac{3}{2\sqrt{2}}\log(t)$, and the correction for BBM with piecewise linear speed functions. A key part of the proof is the precise control of the path of an extremal particle.

Based on joint work with Alexander Alban (U Mainz), Anton Bovier (U Bonn) and Lisa Hartung (U Mainz).

Early stopping for conjugate gradients in statistical inverse problems

Laura Hucker

Humboldt-Universität zu Berlin

We consider estimators obtained by applying the conjugate gradient algorithm to the normal equation of a prototypical statistical inverse problem. For such iterative procedures, it is necessary to choose a suitable iteration index to avoid under- and overfitting. Unfortunately, classical model selection criteria can be prohibitively expensive in high dimensions. In contrast, it has been shown for several methods that sequential early stopping can achieve statistical and computational efficiency by halting at a fully data-driven index depending on previous iterates only. Residual-based stopping rules, similar to the discrepancy principle for deterministic problems, are well understood for linear regularisation methods. However, in the case of conjugate gradients, the estimator depends nonlinearly on the observations, allowing for greater flexibility. This significantly

complicates the error analysis. We establish adaptation results for both the prediction and the reconstruction error in this setting.

This is joint work with Markus Reiß.

Random Friend Trees

Céline Kerriou
University of Cologne

We study a random recursive tree model featuring complete redirection called the random friend tree and introduced by Saramäki and Kaski. Vertices are attached in a sequential manner one by one by selecting an existing target vertex and connecting to one of its neighbours (or friends), chosen uniformly at random. This model has interesting emergent properties, such as a highly skewed degree sequence. In contrast to the preferential attachment model, these emergent phenomena stem from a local rather than a global attachment mechanism. The structure of the resulting tree is also strikingly different from both the preferential attachment tree and the uniform random recursive tree: every edge is incident to a macro-hub of asymptotically linear degree, and with high probability all but at most $n^{9/10}$ vertices in a tree of size n are leaves. We prove various results on the neighbourhood of fixed vertices and edges, and we study macroscopic properties such as the diameter and the degree distribution, providing insights into the overall structure of the tree. We also present a number of open questions on this model and related models.

Existence of a robust phase in the Poisson Boolean model with convex grains

Marilyn Korfhage
University of Cologne

Consider a homogenous Poisson Point Process on $\mathbb{R}^d$, equipped with convex grains, i.e. i.i.d. copies of a random convex body that is rotationally-invariant in distribution. We define for such a convex body a non-increasing sequence of diameters. The first diameter is the classical diameter of the convex body. The i-th diameter is then defined as the diameter of the orthogonal projection of the body from the previous step along the $(i-1)$-st diameter onto the $(d-i+1)$-dimensional hyperplane. This projected body is then projected further when determining the next diameter. We state several criteria on the diameter distribution and moment conditions for the volume of the convex body that result in either a dense process, i.e. the whole space is covered by the grains, or robustness, i.e. the union of the grains has an unbounded connected component for any intensity of the underlying Poisson process. Importantly, we do not impose any conditions on the joint distribution of the diameters. If the grains are chosen to be Euclidean balls, it is known that density and robustness are equivalent. We show in our general model that in any dimension $d \geq 2$ there exists grain distributions where robustness does not imply density.

Joint work with Peter Gracar and Peter Mörters.

A law of the iterated logarithm for iterated random walks, with application to random recursive trees

Valeriya Kotelnikova

Taras Shevchenko National University of Kyiv

Consider a general branching process (a.k.a Crump-Mode-Jagers process) generated by an increasing random walk whose increments have finite second moment. Let $Y_k(t)$ be the number of individuals in generation $k \in \mathbb{N}$ born in the time interval $[0, t]$. I shall discuss a law of the iterated logarithm for $Y_k(t)$ with fixed k, as $t \to +\infty$. As a corollary, I shall also present a law of the iterated logarithm for the number of vertices at a fixed level k in a random recursive tree, as the number of vertices goes to ∞.

The talk is based on the joint article [IKK22+] with Olexander Iksanov (Kyiv) and Zakhar Kabluchko (Münster).

References

[IKK22+] O. Iksanov, Z. Kabluchko and V. Kotelnikova, *A law of the iterated logarithm for iterated random walks, with application to random recursive trees*. Preprint (2022) available at `https://arxiv.org/abs/2212.13441`

Tagged particles and size-biased dynamics in mean-field interacting particle systems

Angeliki Koutsimpela

University of Augsburg

We establish a connection between tagged particles and size-biased empirical processes in interacting particle systems, in analogy to classical results on the propagation of chaos. In a mean-field scaling limit, the evolution of the occupation number on the tagged particle site converges to a time-inhomogeneous Markov process with non-linear master equation given by the law of large numbers of size-biased empirical measures.

Joint work with S. Grosskinsky.

Branching processes in nearly degenerate varying environment

Kata Kubatovics

University of Szeged

We investigate branching processes in varying environment, for which $\overline{f}_n \to 1$ and $\sum_{n=1}^{\infty}(1-\overline{f}_n)_+ = \infty$, $\sum_{n=1}^{\infty}(\overline{f}_n - 1)_+ < \infty$, where $\overline{f}_n$ stands for the offspring mean in generation n. Since subcritical regimes dominate, such processes die out almost surely, therefore to obtain a nontrivial limit we consider two scenarios: conditioning on non-extinction, and adding immigration. In both cases we show that the process converges in distribution without normalization to a nondegenerate compound-Poisson limit law. We also prove functional limit theorems in the above cases. In the conditional setup, the limiting process is a simple birth and death process conditioned on non-extinction at time 1, while the process with immigration tends to a continuous time branching process with immigration with a simple birth and death branching counterpart. The proofs rely on the shape function technique, worked out by Kersting [K20].

This is a joint work with Péter Kevei.

References

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Likelihood function derivatives for a linear mixed model

Sofiia Lukashevych

Taras Shevchenko National University of Kyiv

Restricted Maximum Likelihood (REML) estimation is a statistical method used to estimate parameters in a mixed-effects model, especially in the range of linear mixed models. It serves as an extension of the maximum likelihood estimation method, which aims to provide unbiased and efficient parameter estimates, especially in scenarios involving correlated data. In the REML approach, the likelihood function is adjusted to remove confounding parameters associated with fixed effects. This modification improves the efficiency of parameter estimation, especially in situations where the emphasis is on the estimation of variance components or when fixed and random effects are considered in the model.

My research explores the properties of linear mixed models with simple random effects of the form:

$$\begin{aligned} &y_i = X_i\beta + Z_i\gamma_i + \epsilon_i, \quad i = 1, \ldots, M \\ &\gamma_i \sim N(0, \psi), \quad \epsilon_i \sim N(0, \sigma^2 I), \end{aligned} \tag{0.0.1}$$

where M is the number of distinct groups, each consisting of n_i observations. Random effects γ_i and within-group errors ϵ_i are independent across different groups and within the same group. β

is a p-dimensional vector of fixed effects, γ_i is a q-dimensional vector of random effects, and X_i and Z_i are known design matrices of dimensions $n_i \times p$ and $n_i \times q$, of fixed and random effects respectively. Vectors ϵ_i represent within-group errors with a spherically Gaussian distribution.

Assuming a compound symmetry, autoregressive[1], Toeplitz and variance components in the correlation structure of the matrix ψ governing the dependence among within-group errors, analytical formulas for the first derivative and the second partial derivative of the restricted maximum likelihood function with respect to the correlation parameters of the model are derived.

My research findings of analytical representation of derivatives facilitates the effective utilization of numerical algorithms like Newton-Raphson or Levenberg-Marquardt.

References

[1] Lukashevych, S., Yamnenko, R. *Likelihood function derivatives for a linear mixed model with compound symmetry assumption.* **M**ohyla Mathematical Journal, 2024, pp.24–27.

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Coalescents with migration in the moderate regime

Sophia-Marie Mellis

Bielefeld University

Multi-type models have recently experienced renewed interest in the stochastic modeling of evolution. This is partially due to their mathematical analysis often being more challenging than their single-type counterparts; an example of this is the site-frequency spectrum of a colony-based population with moderate migration.

In this talk, we model the genealogy of such a population via a multi-type coalescent starting with $N(K)$ colored singletons with $d \geq 2$ possible colors (colonies). The process is described by a continuous-time Markov chain with values on the colored partitions of the colored integers in $\{1, \dots, N(K)\}$; blocks of the same color coalesce at rate 1, while they are also allowed to change color at a rate proportional to K (migration).

Given this setting, we study the asymptotic behavior, as $K \to \infty$ at small times, of the vector of empirical measures, whose i-th component keeps track of the blocks of color i at time t and of the initial coloring of the integers composing each of these blocks. We show that, in the proper time-space scaling, it converges to a multi-type branching process (case $N(K) \sim K$) or a multi-type Feller diffusion (case $N(K) \gg K$). Using this result, we derive an applicable representation of the site-frequency spectrum.

This is joint work with Fernando Cordero and Emmanuel Schertzer.

Globally centered discrete snakes

Rivka Mitchell

University of Oxford

We prove that under a global finite variance and a tail behaviour assumption on the displacements, any globally centered discrete snake on a Bienaymé tree whose offspring distribution is critical and admits a finite third moment has the Brownian snake driven by a normalised Brownian excursion as its scaling limit. Our proof relies on two perspectives of Bienaymé trees. To prove convergence of finite dimensional distributions we rely on a line-breaking construction from a recent paper of Addario-Berry, Blanc-Renaudie, Donderwinkel, Maazoun and Martin. To prove tightness, we adapt a method used by Haas and Miermont with regard to Markov branching trees.

This is based on joint work in progress with Louigi Addario-Berry, Serte Donderwinkel, and Christina Goldschmidt.

On ergodicity of Lévy-type processes in $\mathbb{R}^d$

Yana Mokanu

Department of Mathematical Analysis and Probability Theory, National Technical University of Ukraine, Kyiv, Ukraine

In this talk we derive sufficient conditions for the ergodicity of the specific class of Lévy-type processes. It is assumed that on test functions the generator of the respective semigroup admits the representation

$$Lf(x) = l(x)\nabla f(x) + \int_{\mathbb{R}^d\setminus\{0\}} \big(f(x+u) - f(x) - \nabla f(x)u\mathbb{1}_{|u|\leq 1}\big)\,\nu(x,du),$$

where $\nu(x,du)$ is a Lévy-type measure and $l\colon \mathbb{R}^d \to \mathbb{R}^d$. The conditions are given in terms of the Lévy-type measure $\nu(x,\cdot)$ and applicable to the case, when the drift term is absent. The Foster-Lyapunov criterion is used to prove the results.

References

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On stochastic differential equations with jumps of Marcus-type

Martha Nansubuga

HU Berlin

We study existence and uniqueness of stochastic differential equations (SDEs) driven by semimartingales with jumps, where the jumps of the solution are obtained as small relaxation time limits of fast curvilinear motions along the solution of a non-linear ordinary differential equation, and between the jumps, the solution to the SDE moves along the (coefficient) vector field in the sense of Marcus [1]. For stochastic integrals driven by a continuous process, stochastic integrals in the Marcus sense coincide with stochastic integrals in the Stratonovich sense and satisfy a chain rule for drivers with jumps. We study SDEs with time-dependent coefficients, which are compared and checked in [2]. I will give an outlook on my ongoing research where such stochastic differential equations are to be applied.

References

[1] Steven I. Marcus. Modeling and approximation of stochastic differential equations driven by semimartingales. *Stochastics: An International Journal of Probability and Stochastic Processes* 4, no.3 (1981): 223–245 Submitted. arXiv:2402.16701.

[2] Thomas G. Kurtz, Étienne Pardoux, Philip Protter. Stratonovich stochastic differential equations driven by general semimartingales. *Annales de lIHP Probabilités et statistiques* vol. 31, no. 2, pp. 351-377, 1995.

Limit theorems for p-domain functionals of stationary Gaussian random fields

Francesca Pistolato

University of Luxembourg

The topic of the talk are the *p-domain functionals* of stationary Gaussian random fields. More precisely, given a Gaussian random field $B = (B_x)_{x\in\mathbb{R}^d}$, $d \geq 2$, we study the asymptotic behaviour of

$$\int_{t_1 D_1 \times \cdots \times t_p D_p} \phi(B_x)\, dx, \qquad \text{as } t_i \to \infty,\ \forall i = 1, \ldots, p,$$

where $D_i \subset \mathbb{R}^{d_i}$ is bounded for any $i = 1, \ldots, p$, and $d_1 + \ldots + d_p = d$.

An important result to understand the behavior of such functionals is Breuer-Major theorem, that links the *short-range dependence* of the field, that is the integrability of (a power of) the covariance function of B, together with the rescaled functional satisfying a Central Limit Theorem (CLT).

In this talk, under further assumptions on the covariance function, we will show how the asymptotic behaviour of p-domain functionals can be simply obtained from that of 1-domain functionals, explaining in a new light and in a more systematic way some results from the recent literature. For instance, the result provides a new proof of the convergence of the qth variation of the fractional Wiener sheet to a Gaussian distribution, proved in [2], and improves their estimate on the rate of convergence. Moreover, it allows us to produce new examples of long-range dependent fields satisfying CLTs. The talk is based on [1].

References

[1] N. Leonenko, L. Maini, I. Nourdin and F. Pistolato. Limit theorems for p-domain functionals of stationary Gaussian fields. Submitted. arXiv:2402.16701.

[2] A. Réveillac, M. Stauch and C. Tudor. Hermite variations of the fractional Brownian sheet. *Stoch. Dyn.* 12(2012), no.3, 1150021, 21 pp.

From duality to correlations

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In this talk, we introduce the concept of Stochastic Duality. From it, we will see an approach, based on duality, on how to bound the k-points centered correlation functions of a given interacting particle system (IPS) when it has the duality property and also a specific type of duality function. The problem of finding such bounds is an essential tool to derive the non-equilibrium fluctuations of a boundary-driven IPS. We will see an application of those results for the symmetric simple partial exclusion process, SEP(α), the symmetric simple inclusion process, SIP(α), and independent particles, IRW, all considered with open boundary. The case $k = 2$ for SEP(α) is joint work with Chiara Franceschini, Patrícia Gonçalves and Milton Jara [1] and the general case is a work in progress with Patrícia Gonçalves.

References

[1] C. Franceschini, P. Gonçalves, M. Jara, B. Salvador (2023): Non-equilibrium fluctuations for SEP(α) with open boundary, submitted and online at `https://arxiv.org/abs/2308.09144`.

Mean Field Games with Terminal State Constraints

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We study a mean field game (MFG) with state dynamics described by stochastic differential equations affected by both idiosyncratic and common noise, and subject to the constraint that the terminal state variable belongs to a nonempty convex closed set. Moreover, the mean field interaction enters through both state and control in the dynamics and the costs. Inspired by the work of Ji and Zhou [JZ], we establish an auxiliary MFG problem and derive the stochastic maximum principle (SMP) for an auxiliary optimization problem under fixed flows. By introducing a suitable forward-backward stochastic differential equation (FBSDE) of conditional McKean-Vlasov type, we prove the existence of its solution and verify that it constitutes a MFG equilibrium. Additionally, we apply our findings to MFGs of optimal liquidation and of optimal investment with a quadratic relative performance criterion.

This is based on a joint work with Luciano Campi (University of Milan) and Luca Di Persio (University of Verona).

References

[JZ] S. Ji and X.Y. Zhou. A maximum principle for stochastic optimal control with terminal state constraints, and its applications. *Communications in Information and Systems* , 6(4):321–338, 2006.

Optimal tournament design in continuous time

Yuqiong Wang
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We consider the problem of finding the optimal scheme for a knock-out tournament with $2n$ players, aiming at determining the top player. In each game in the tournament, one observes a Brownian motion with drift where the drift is a Bernoulli random variable whose value reflects the players' abilities. However, these observations come at a cost: a fixed penalty $c > 0$ per unit time of observation. We formulate and solve an optimal control problem to minimise the probability of making a mistake while keeping the cost of observation low. Additionally, we discuss a few variants of the problem and some possible generalisations. This is joint work with Erik Ekström.

Stochastic Differential Equations Involving the Local Time of the Unknown Process Driven by Stable Processes

Johanna Weinberger
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Stochastic differential equations involving the local time of the unknown process with Brownian forcing were thoroughly discussed by Jean-François Le Gall in his seminal paper [LG84] from 1984. A special case of these equations are of the form

$$X_t = x_0 + \int_{\mathbb{R}} \ell_t^x \mu(dx) + B_t, \quad t \geq 0,$$

where B is a standard Brownian motion, $x_0 \in \mathbb{R}$, μ is a Radon measure and ℓ is the local time of X given by the Tanaka's formula. In this talk, we formulate an analogous equation in dimension $d = 1$, where B is replaced by an α-stable process L with $\alpha \in (1, 2)$ and discuss weak and strong existence and uniqueness of solutions, as well as the equivalence to singular SDEs with drift μ. To this end, we define a local time ℓ by deriving a Tanaka-type formula for semimartingales whose martingale part is an α-stable process with $\alpha \in (1, 2)$. We show that ℓ coincides with the occupation density of X for solutions to singular SDEs under mild assumptions on the drift μ. The talk is based on joint work with Leonid Mytnik.

References

[LG84] J. F. Le Gall. One-dimensional stochastic differential equations involving the local times of the unknown process. *Stochastic analysis and applications, Proc. int. Conf., Swansea 1983, Lect. Notes Math.* 1095, 51-82 (1984).

On the pitchfork bifurcation for the Φ_2^4 equation

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In this talk, we present a bifurcation analysis for the Φ_2^4 equation

$$\partial_t \varphi = \Delta \varphi + \alpha \varphi - \varphi^3 + 3\varphi \cdot \infty + \xi,$$

where $\varphi : \mathbb{R}_+ \times \mathbb{T}^2 \to \mathbb{R}$, ξ is space-time white noise on $\mathbb{R}_+ \times \mathbb{T}^2$, and $\alpha \in \mathbb{R}$. While the noise-free system exhibits a pitchfork bifurcation, the introduction of noise disrupts the bifurcation, leading to a phenomenon known as "synchronisation by noise". However, with finite-time Lyapunov exponents, we can still detect the underlying pitchfork bifurcation. Specifically, a change in the sign of the finite-time Lyapunov exponents implies a shift in local stability on a finite time scale, offering a new perspective on the dynamics of the Φ_2^4 equation.

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