# 22nd Oxford-Berlin Young Researcher's Meeting on Applied Stochastic Analysis

11 – 13 December 2025

Oxford
Mathematics

# Contents

# 1. Welcome

It is our great pleasure to welcome you to the 22nd Oxford-Berlin Young Researchers Meeting on Applied Stochastic Analysis held at Oxford. We hope you enjoy a productive meeting!

**Scientific Board**
Terry Lyons (University of Oxford)
Peter Friz (TU and WIAS Berlin)

**Conference organisers**
Mahdi Essekelli (University of Oxford)
Martin Geller (University of Oxford)
Thomas Wagenhofer (TU Berlin)
Filippo De Feo (TU Berlin)
Yuchen Su (TU Berlin)

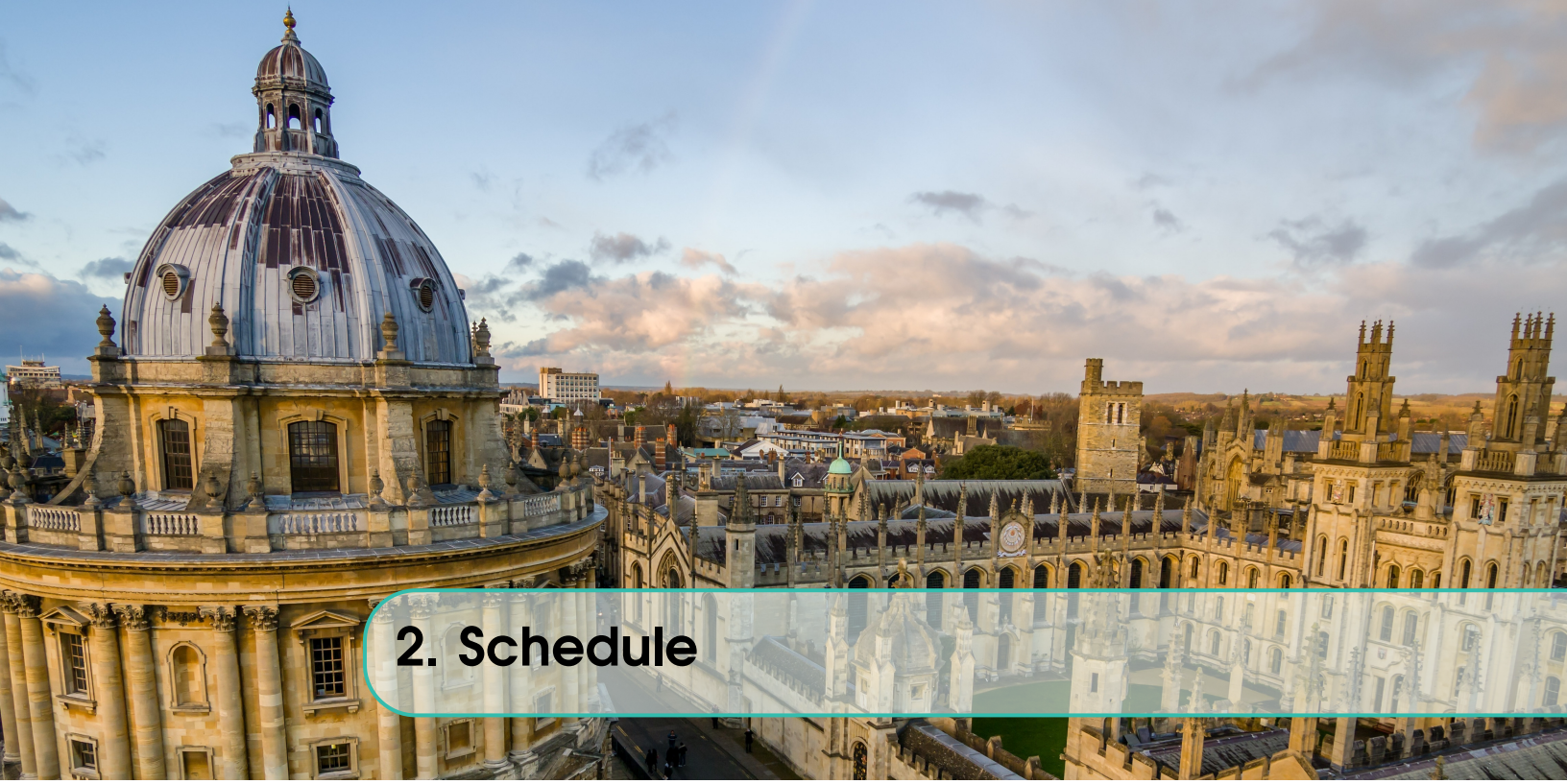
**Location**
All talks will be held in lecture theatre **L4** at the Mathematical Institute. The full address is: The Mathematical Institute, Andrew Wiles Building, Radcliffe Observatory Quarter, Woodstock Rd, Oxford OX2 6GG. It is about a 20-minute walk from Oxford train station.

**Dinner**
This will take place at St Anne's College on Thursday 11th December.

**Supporting Institutions**

DataSig

This meeting is supported by the DataSıg programme (UKRI1010).



# 2. Schedule

## Thursday, 11th December

| | | | |
|---|---|---|---|
| 10:20 AM–10:50 AM | **Welcome and Networking** | | |
| 10:50 AM–11:25 AM | Lukas Gräfner (University of Warwick) | *Construction of the 1-D Self-repelling Brownian Polymer* | 9 |
| 11:25 AM–12:00 AM | Farhad Huseynli (University of Oxford) | *Conformal Invariance of Brownian Motion and Loops on Riemann Surfaces* | 9 |
| 12:00 PM–01:30 PM | **Lunch Break** | | |
| 01:30 PM–02:05 PM | Yuchen Su (TU Berlin) | *Semilinear Rough PDEs with Discontinuous Young Driver* | 7 |
| 02:05 PM–02:40 PM | Jannis Reinhard Dause (TU Berlin) | *Moment-free Rough Stochastic Calculus and the Rough Stochastic Itô- Wentzell formula* | 8 |
| 02:40 PM–03:10 PM | **Coffee Break** | | |
| 03:10 PM–03:45 PM | Sam Morley (University of Oxford) | *Scalable Rough-path Computations with RoughPy* | 13 |
| 03:45 PM–04:20 PM | Felix Medwed (University of Potsdam) | *A Metric Group Perspective on Signatures* | 7 |
| 04:20 PM–04:55 PM | Martin Geller (University of Oxford) | *The Geometry of Rough Path Space* | 7 |
| 07:00 PM–09:00 PM | **Dinner at St. Annes College** | | |

## Friday, 12th December

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|---|---|---|---|
| 09:45 AM–10:20 AM | Felix Lotter (MPI MiS Leipzig) | *Signature Tensors of Piecewise Polynomial Paths* | 13 |
| 10:20 AM–10:55 AM | Lingyi Yang (University of Oxford) | *Distilling Score-based Diffusion Models with Signatures* | 13 |
| 10:55 AM–11:25 AM | **Coffee Break** | | |
| 11:25 AM–12:00 PM | Alif Aqsha (University of Oxford) | *Signature Scheme to Stochastic Control Problems* | 11 |
| 12:00 PM–01:30 PM | **Lunch Break** | | |
| 01:30 PM–02:05 PM | Matteo Ravot Licheri (TU Berlin) | *Connections between Cumulants and Positivity -Preserving Principles on Parabolic PDEs* | 9 |
| 02:05 PM–02:40 PM | Jethro Warnett (University of Oxford) | *The Stein-log-Sobolev Inequality and the Exponential Rate of Convergence for the SVGD Algorithm* | 10 |
| 02:40 PM–03:10 PM | **Coffee Break** | | |
| 03:10 PM–03:45 PM | Fillippo De Feo (TU Berlin) | *Stochastic Optimal Control of Interacting Particle Systems in Hilbert Spaces and Applications to Problems in Economics* | 11 |
| 03:45 PM–04:20 PM | Thomas Wagenhofer (TU Berlin) | *Microstructural Limits and Weak Error Estimates for Rough Log-Normal Volatility Models* | 11 |

## Saturday, 13th December

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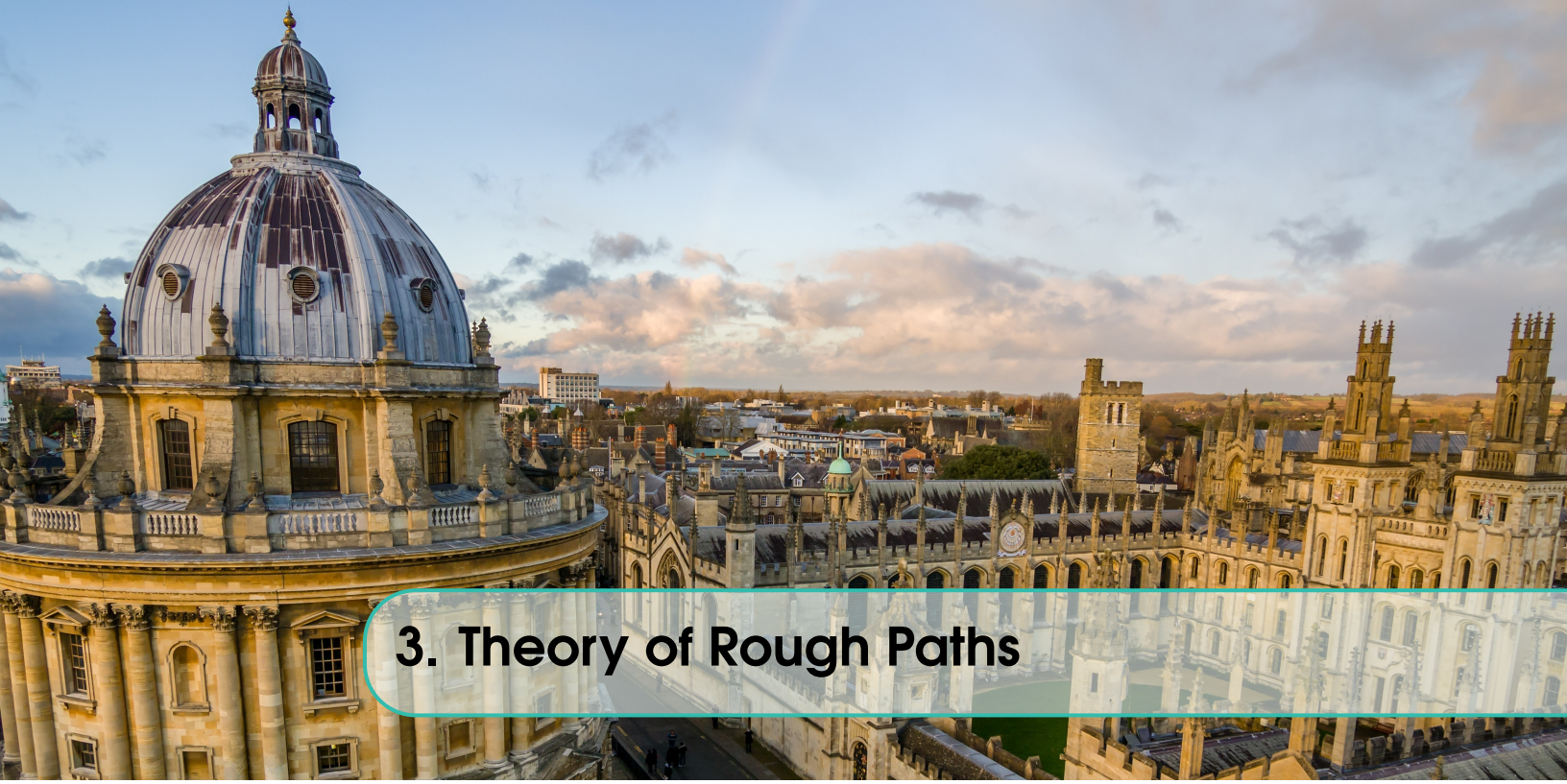
|---|---|---|---|
| 09:10 AM–09:45 AM | Jean-David Jacques (University of Potsdam) | *Geometric post-Lie Deformations and Applications to Regularity Structures* | 10 |
| 09:45 AM–10:20 AM | David McBride (University of Oxford) | *Canonical Graph Embedding Functions on Weighted Graphs* | 14 |
| 10:20 AM–10:55 AM | Zihan Guo (University of Oxford) | *Liquidity Provision and Rebate Design in Option Markets* | 12 |
| 10:55 AM–11:25 AM | **Networking and Conclusion** | | |



# 3. Theory of Rough Paths

## 3.1 The Geometry of Rough Path Space

***Martin Geller, University of Oxford***

Thursday 4:20PM–4:55PM

We describe $\mathcal{H}^p(V)$, a subset of $p$-rough path space $\Omega^p(V)$ which is a vector space under operations we call $\boxplus$ and $\odot$. We show that the domain of $\boxplus$ can be extended to $\Omega^p(V) \times \mathcal{H}^p(V)$, allowing any $p$-rough path $X$ to be additively perturbed by an $H$ in $\mathcal{H}^p(V)$. Additionally, we show that expanding the space of perturbations $\mathcal{H}^p(V)$ to include almost rough paths $\mathcal{H}^{\mathrm{am},p}(V)$ does not enlarge the space of displacements of a given $X$, i.e. $\{X \boxplus H | H \in \mathcal{H}^p(V)\} = \{X \boxplus H | H \in \mathcal{H}^{\mathrm{am},p}(V)\}$.

## 3.2 A Metric Group Perspective on Signatures

***Felix Medwed, University of Potsdam***

Thursday 3:45PM–4:20PM

The signature group, given by all terminal time points of Lyons' lifts of paths to the tensor algebra and forming a subgroup of the group-like elements, is a core object in the theory of rough paths. It was shown, first in the seminal paper by B. Hambly and T. Lyons (2010) for continuous paths of bounded variation (BV), and later generalised by H. Boedihardjo, X. Geng, T. Lyons and D. Yang (2016) to the case of weakly geometric rough paths (WGRP), that a path which gives rise to a trivial signature has to factor through a real tree. The case of BV paths was then utilised by E. Le Donne and R. Züst (2021) to investigate the metrisability of the resulting signature group and to identify it as a sequential limit of Carnot groups in the category of pointed metric groups. As a result, the signature group fails to be a topological group when equipped with the induced limiting topology. In this talk I will give a repackaged version of the results by Le Donne and Züst and show that the signature group of WGRPs also fails to be a topological group in an analogous limiting topology. I will also draw connections to existing work, in particular to Boedihardjo et al. and to the rough path topologies studied by T. Cass and W. Turner (2024). Based on discussions with P. K. Friz, S. Paycha, M. Ravot Licheri, A. Schmeding.

## 3.3 Semilinear Rough PDEs with Discontinuous Young Driver

***Yuchen Sun, TU Berlin***

Thursday 1:30PM–2:05PM

We are interested in rough PDEs of the form

$$\frac{\partial u}{\partial t} + \frac{1}{2}\mathrm{Tr}(\sigma\sigma^T \nabla_x^2 u) + b(t,x)\cdot\nabla_x u + f(t,x,u,\sigma^T\nabla_x u) + h(t,x,u)\diamond dW = 0,$$

where $W$ is a deterministic càglàd rough path of finite $q$-variation with $q \in [1,2)$ and jumps are integrated in the Marcus sense. Building on the recently developed theory of rough BSDEs with discontinuous Young drivers, we give a rigorous meaning to this equation by characterizing it as the unique limit of smooth approximations in a suitable Skorokhod topology.

## 3.4 Moment-free Rough Stochastic Calculus and the Rough Stochastic Itô-Wentzell formula

***Jannis Reinhard Dause, TU Berlin***

Thursday
2:05PM–
2:40PM

The recently developed theory of Rough Stochastic Differential Equations (RSDEs) provides a generalized framework of classical SDE Theory and Lyons' Rough Differential Equations. Its applications range from pathwise stochastic control to McKean-Vlasov SDEs with common noise and stochastic filtering. In this talk we investigate applications of Rough Stochastic Calculus (RSC). The recently introduced theory of Rough Semimartingales developed in [Friz, Zorin-Kranich, 2023] provides us with a moment-free approach to RSC using classical localisation arguments. This stands in contrast to the approach explored in most of the existing literature on RSDEs, which is based on so-called 'mixed $L^p$-spaces'. In particular this allows us to derive a (moment-free) Rough Stochastic version of the classical Itô-Wentzell-Kunita formula. Our main application for this procedure are reduced moment conditions for variation-of-constants formulas, such as the Itô-Alekseev-Gröbner formula. Based on joint work with Peter K. Friz, Arnulf Jentzen and Jian Song.

# 4. Stochastic Analysis

## 4.1 Construction of the 1-D Self-repelling Brownian Polymer

***Lukas Gräfner, University of Warwick***

Thursday
10:50AM–
11:25AM

I will present the construction of the 1-D self-repelling Brownian polymer (SRBP) which is formally the solution to an SDE with a path-dependent distributional drift: the negative gradient of its own local time. Our approach exploits the fact that the SDE is formally in one-to-one correspondence with a singular SPDE that can be solved uniquely in the sense of Energy solutions. We then give a unique dynamic characterization of the law of the SRBP and show that the process is superdiffusive and not self-avoiding. Depending on time I will comment on how this result generalizes to higher dimensions and more general self-interactions. Based on joint work with Harry Giles.

## 4.2 Conformal Invariance of Brownian Motion and Loops on Riemann Surfaces

***Farhad Huseynli, University of Oxford***

Thursday
11:25AM–
12:00PM

Conformal symmetries reveal remarkably rich structures across mathematics and physics—from complex analysis and Riemann surfaces to conformal field theory, string theory, and modern probability. This talk examines conformal maps from both complex-analytic and Riemannian perspectives, explaining why dimension two is special. We introduce Brownian motion on Riemann surfaces, establish its conformal invariance, and construct the Brownian loop measure of Lawler and Werner. We then discuss recent results of Wang and Xue (2025), who linked the Brownian loop measure to hyperbolic geometry by showing that the mass of loops in each homotopy class is determined by the geodesic length, yielding new identities between length spectra.

## 4.3 Connections between Cumulants and Positivity-Preserving Principles on Parabolic PDEs

***Matteo Ravot Licheri, TU Berlin***

Friday
1:30PM–
2:05PM

Marcinkiewicz's theorem is a classical result that provides a characterisation of (possibly degenerate) Gaussian measures: these are the only probability measures whose characteristic functions are exponentials of polynomials. A fortiori, no real-valued random variable can have as cumulant generating function a polynomial of degree $> 2$. Similarly, the fundamental solution to an evolution equation driven by a semidefinite-negative elliptic operator with constant coefficients is positive at some time $t > 0$ if and only if the degree of the elliptic is $\leq 2$ (then it is positive for all times). The goal of this talk is to show that cumulants can be viewed as differential operators and present ongoing work aiming to generalize Marcinkiewicz's theorem with a view towards rough paths.

## 4.4 Geometric post-Lie Deformations and Applications to Regularity Structures

***Jean-David Jacques, University of Potsdam***

Saturday
9:10AM–
9:45AM

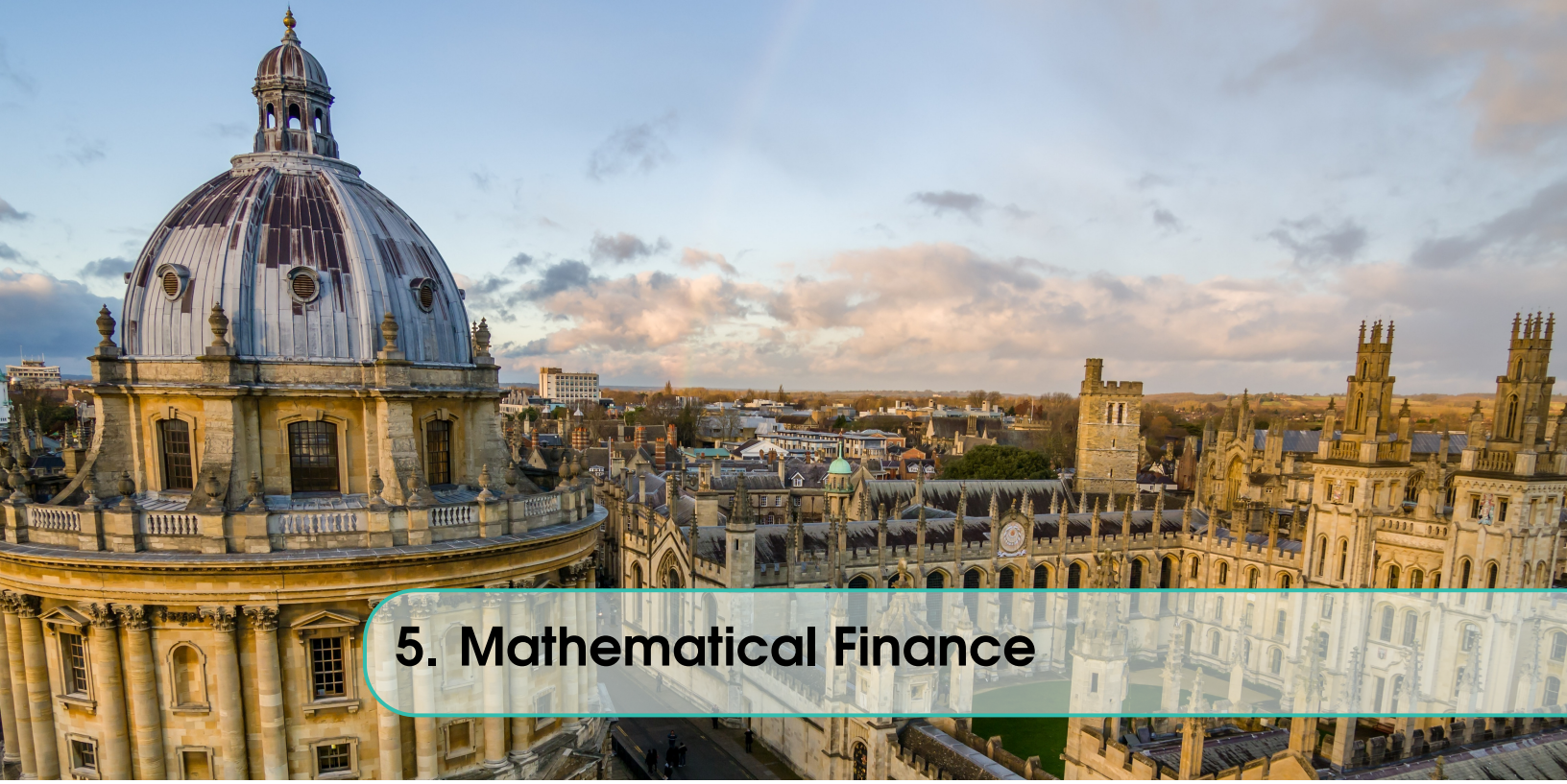
In this talk, I will first give a short introduction to post-Lie algebras and briefly explain how it is used to build the structure group for quasi-linear SPDEs in the context of regularity structures, then I will present my last results concerning geometric deformations of post-Lie algebras and possible applications to the theory of regularity structures for the renormalisation of SPDEs.

## 4.5 The Stein-log-Sobolev Inequality and the Exponential Rate of Convergence for the SVGD Algorithm

***Jethro Warnett, University of Oxford***

Friday
2:05PM–
2:40PM

The Stein Variational Gradient Descent method is a variational inference method in statistics that has recently received a lot of attention. The method provides a deterministic approximation of the target distribution, by introducing a nonlocal interaction with a kernel. Despite the significant interest, the exponential rate of convergence for the continuous method has remained an open problem, due to the difficulty of establishing the related so-called Stein-log-Sobolev inequality. Here, we prove that the inequality is satisfied for each space dimension and every kernel whose Fourier transform has a quadratic decay at infinity and is locally bounded away from zero and infinity. Moreover, we construct weak solutions to the related PDE satisfying exponential rate of decay towards the equilibrium. The main novelty in our approach is to interpret the Stein-Fisher information, also called the squared Stein discrepancy, as a duality pairing between $H^{-1}(\mathbb{R}^d)$ and $H^1(\mathbb{R}^d)$, which allows us to employ the Fourier transform. We also provide several examples of kernels for which the Stein-log-Sobolev inequality fails, partially showing the necessity of our assumptions.



# 5. Mathematical Finance

## 5.1 Stochastic Optimal Control of Interacting Particle Systems in Hilbert Spaces and Applications to Problems in Economics

***Filippo De Feo, TU Berlin***

Friday
3:10PM–
3:45PM

Optimal control of interacting particles governed by stochastic evolution equations in Hilbert spaces is an open area of research. Such systems naturally arise in formulations where each particle is modeled by stochastic partial differential equations, path-dependent stochastic differential equations (such as stochastic delay differential equations or stochastic Volterra integral equations), or partially observed stochastic systems. In this talk we present a limiting theory as the number of particles tends to infinity. We apply the developed theory to problems arising in economics where the particles are modeled by stochastic partial differential equations and stochastic delay differential equations. The talk is based on [F. de Feo, F. Gozzi, A. Święch, L. Wessels, "Stochastic Optimal Control of Interacting Particle Systems in Hilbert Spaces and Applications", *arXiv preprint arXiv:2511.21646]*

## 5.2 Signature Scheme to Stochastic Control Problems

***Alif Aqsha, University of Oxford***

Friday
11:25AM–
12:00PM

Building on the work of Kalsi, Lyons, and Perez Arribas (2020) on optimal execution with path signatures, we present a numerical scheme to solve multidimensional linear-quadratic (LQ) stochastic control problem using the expected signature path of the driving Brownian motion. We show that this approach turns the original LQ problem into a convex quadratic polynomial optimisation. We prove that the optimal value function obtained using this method converges to the true optimal value derived from the classical Hamiltonian-Jacobi-Bellman (HJB) equation. This is a joint work with Peter Bank (TU Berlin) and Leandro Sánchez-Betancourt (Oxford).

## 5.3 Microstructural Limits and Weak Error Estimates for Rough Log-Normal Volatility Models

***Thomas Wagenhofer, TU Berlin***

Friday
3:45PM–
4:20PM

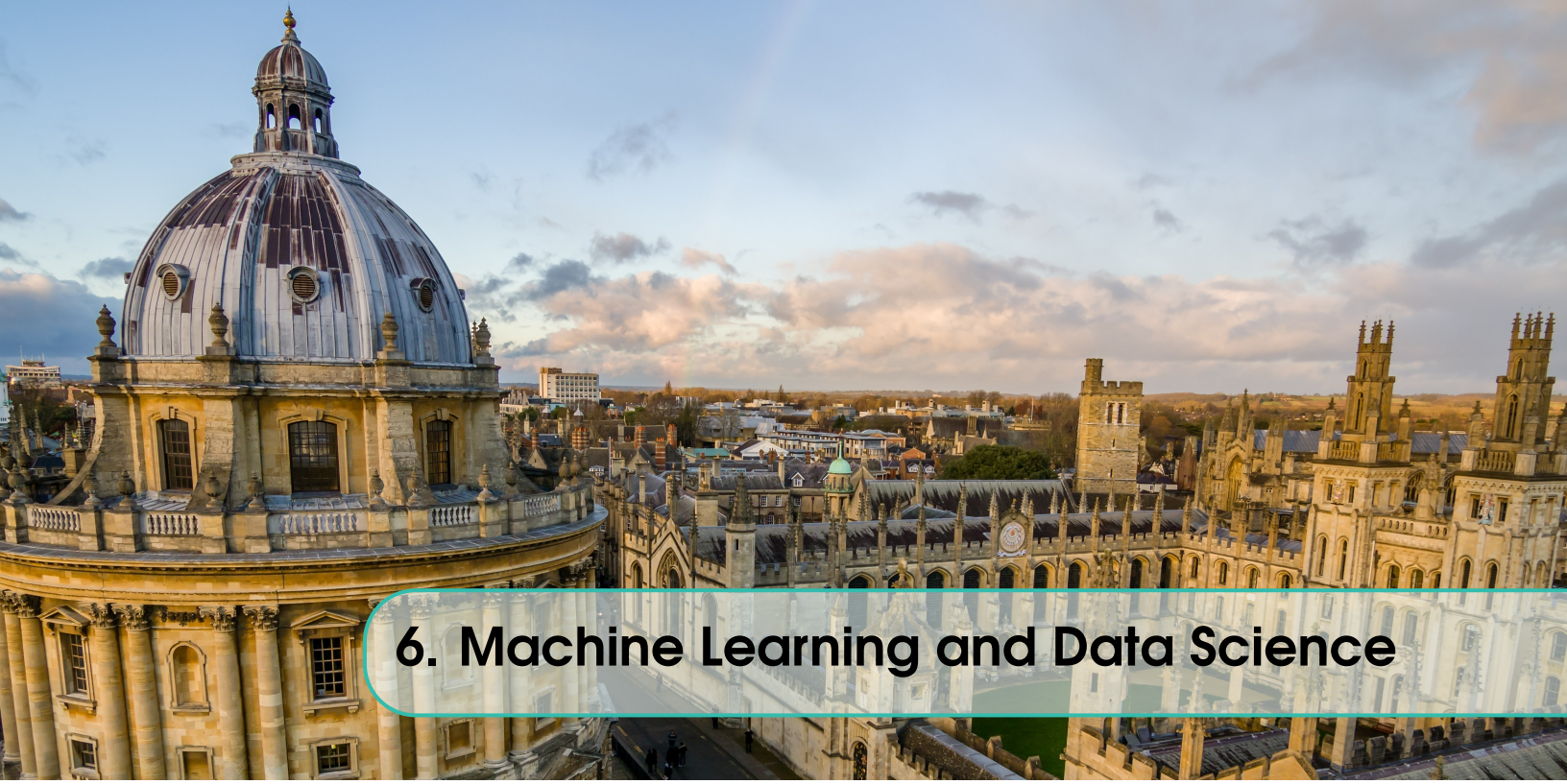
We consider a microstructure foundation for models driven by Poisson random measures. The model is chosen such that, after suitable rescaling, the joint price-volatility process converges weakly to a rough Bergomi model with Hurst parameter $H$ between 0 and $\frac{1}{2}$. Our main results are twofold. First, we establish weak convergence of the joint log-stock and volatility process in an appropriate Skorokhod space. To derive this, we utilize practical C-tightness-criteria, developed by U. Horst, W. Xu and R. Zhang. Second, we derive weak error rates for moments of the log-stock. We show that a carefully chosen kernel approximation yields a weak rate of order $\frac{1}{3} + \frac{3H}{4}$ (for $H$ small). This result is obtained via a moment representation for price processes driven by both Poisson noise and Brownian motion. This is a joint work with Paul Hager and Ulrich Horst.

## 5.4 Liquidity Provision and Rebate Design in Option Markets

***Zihan Guo, University of Oxford***

Saturday
10:20AM–
10:55AM

We develop a new framework for addressing market making and rebate design problems in option markets. A single market maker trades multiple European call options in a local-stochastic-volatility option market with both make and take strategies, modelled respectively as continuous and impulse controls. Her objective is to maximize, over all admissible make-take strategies, her net profit, consisting of option portfolio value and cumulative rebate revenue, while subject to a penalty on residual portfolio delta and vega. Further, we demonstrate how an exchange can incentivize a market maker to improve market liquidity by setting suitable fee rebates, thereby resolving its own liquidity attraction problem. To this end, we propose a three-step rebate design scheme, with flexibility to accommodate specific liquidity targets imposed by an exchange. Numerical results are provided to validate the effectiveness of the proposed scheme.



# 6. Machine Learning and Data Science

## 6.1 Signature Tensors of Piecewise Polynomial Paths

***Felix Lotter, MPI MiS Leipzig***

Friday
9:45AM–
10:20AM

Piecewise polynomial paths are central objects in the interpolation of discrete data. Their signature values depend algebraically on the underlying parameters. As a result, problems arising in applications, such as path recovery or redundancies in the signature, become problems of algebraic geometry and representation theory. In this talk, I report on early work in progress with Carlos Améndola, Leonard Schmitz and Rosa Preiß, investigating the signature tensors of piecewise polynomial paths through the lens of nonlinear algebra.

## 6.2 Distilling Score-based Diffusion Models with Signatures

***Lingyi Yang, University of Oxford***

Friday
10:20AM–
10:55AM

Diffusion models have achieved state-of-the-art results in generative modelling but remain computationally intensive at inference time, often requiring many discretisation steps. In this talk, I present Sig-DEG (Signature-based Differential Equation Generator), which distils pre-trained diffusion models and can universally approximate the backward diffusion process at a coarse temporal resolution. Inspired by high-order approximations of stochastic differential equations, Sig-DEG leverages partial signatures to efficiently summarise Brownian motion over sub-intervals. Distillation is formulated as a supervised learning task: Sig-DEG is trained to match the outputs of a fine-resolution diffusion model on a coarse time grid. At inference, Sig-DEG enables fast generation, since the partial signatures can be simulated exactly without requiring fine-grained Brownian paths. Experiments demonstrate that Sig-DEG attains competitive generation quality while delivering up to 100x faster inference than the teacher model, highlighting the effectiveness of signature-based approximations for efficient generative modeling.

## 6.3 Scalable Rough-path Computations with RoughPy

***Sam Morley, University of Oxford***

Thursday
3:10PM–
3:45PM

Adopting rough path-based techniques for dealing with stream data requires both efficiency and scalability. RoughPy delivers efficiency but currently cannot deliver the scale. Building for scale requires a different approach compared to delivering small, isolated computations. It requires new mathematical insight supported by "kernels" that perform millions of computations simultaneously, and an infrastructure for organising and distributing work. This talk is about our recent work to provide a JAX implementation of RoughPy's streams to provide a tool that is well suited to addressing the demands of modern machine learning.

## 6.4 Canonical Graph Embedding Functions on Weighted Graphs

*David McBride, University of Oxford*

Saturday
9:45AM–
10:20AM

# 7. Participants

Alex Allmont (University of Oxford)
Alif Aqsha (University of Oxford)
Alexandre Bloch (University of Oxford)
Peter Crew (University of Bath)
Jannis Dause (TU Berlin)
Filippo de Feo (TU Berlin)
Bernhard Eisvogel (FU Berlin/Wias)
Mahdi Essekelli (University of Oxford)
Peter Friz (TU and WAIS Berlin)
Wen Ge (University College London)
Martin Geller (University of Oxford)
Lukas Gräfner (University of Warwick)
Zihan Guo (University of Oxford)
Linhao He (University of Oxford)
Timothy Herschell (University of Bath)
Zhenyu Huang (University of Oxford)
Farhad Huseynli (University of Oxford)
Jean-David Jacques (University of Potsdam)
Jakob Kellermann (WIAS Berlin)
Jack Leland (University of Oxford)
Mahin Khandaker (University of Oxford)
Kaan Kocaslan (TU Berlin)
Giacomo La Scala (University of Oxford)
Da Li (University of Oxford)
Matteo Ravot Licheri (TU Berlin)
Ilya Losev (University of Oxford)
Felix Lotter (MPI MiS Leipzig)
Terry Lyons (University of Oxford/Alan Turing Institute)
Adrien Mathieu (University of Oxford)
David McBride (University of Oxford)
Felix Medwed (University of Potsdam)
Sam Morley (University of Oxford)
Peter Paulovics (University of Oxford)
Jost Pieper (Durham University)
Andrea Pitrone (University of Oxford)
Rosa Preiß (TU Berlin)
Zhongmin Qian (University of Oxford)
Janine Steck (University of Oxford)
Yuchen Sun (TU Berlin)
Vlad Tuchilus (University of Oxford)
Carlos Villanueva Mariz (FU Berlin)
Thomas Wagenhofer (TU Berlin)
Jethro Warnett (University of Oxford)
Roman Wüthrich (TU Berlin)
Lingyi Yang (University of Oxford)
Yuanqiong Zheng (University of Oxford)