20th Oxford-Berlin Young Researcher's Meeting on Applied Stochastic Analysis

9 – 11 December 2024

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1. Welcome

It is our great pleasure to welcome you to the 20th 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)

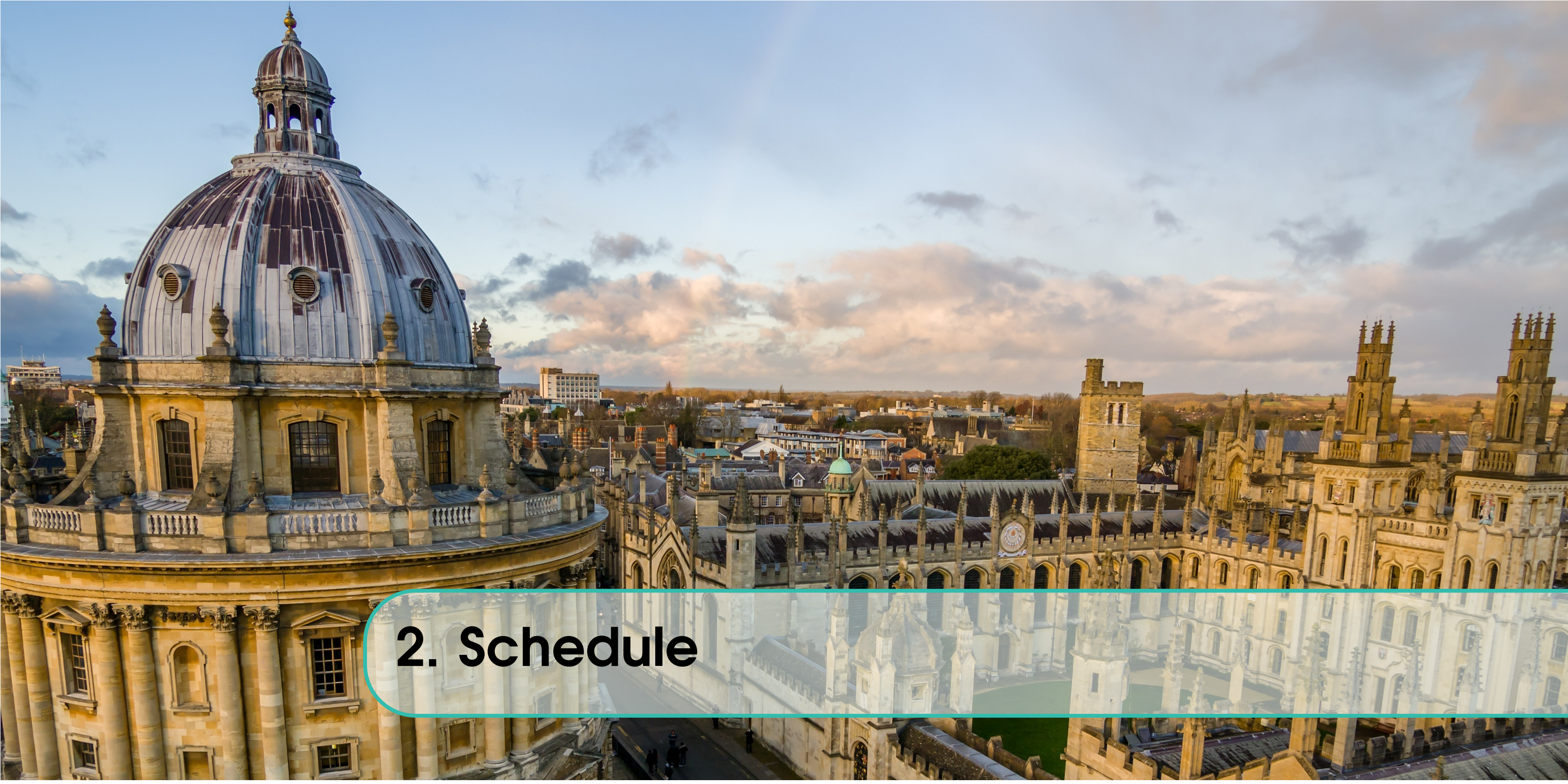
Conference organisers
David McBride (University of Oxford)
Alexandre Bloch (University of Oxford)
Thomas Wagenhofer (TU Berlin)
Fabio Bugini (TU Berlin)

Location
All talks will be held in lecture theatre **L5** 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.

Workshop dinner
This will take place at St Edmund Hall on Tuesday 10th December.

Supporting Institutions

This meeting is generously supported by the DataSıg programme (EPSRC EP/S026347/1).



2. Schedule

Monday, 9th December

9:50 AM–10:00 AM	**Welcome**		
10:00 AM–10:20 AM	Shyam Popat (University of Oxford)	*Working towards a central limit theorem for the Dean–Kawasaki equation*	9
10:20 AM–10:40 AM	Da Li (University of Oxford)	*Weak coupling limit for polynomial stochastic Burgers equations in 2d*	9
10:40 AM–11:00 AM	Oleg Butkovsky (WIAS Berlin)	*Weak uniqueness for singular stochastic equations driven by fractional Brownian motion*	9
11:00 AM–11:30 AM	**Coffee Break**		
11:30 AM–11:50 AM	Franziska Bielert (TU Berlin)	*Rough Functional Itô Formula*	7
11:50 AM–12:10 PM	Timothy Herschell (DataSıg)	*High-degree cubature on Wiener space through unshuffle expansions*	7
12:10 PM–12:30 PM	Darrick Lee (University of Edinburgh)	*The Surface Signature*	7
12:30 PM–02:00 PM	**Lunch Break**		
02:00 PM–02:30 PM	Sorelle Murielle Toukam Tchoumegne (TU Berlin)	*Stochastic Maximum Principle for McKean-Vlasov SDEs with Rough Drift Coefficients*	10
02:30 PM–03:00 PM	Andrew McLeod (University of Oxford)	*Higher Order Lipschitz Functions in Data Science*	12
03:00 PM–03:30 PM	**Coffee Break**		
03:30 PM–03:50 PM	Paul Maurer (INRIA Sophia-Antipolis)	*A kernel comparison approach for rough volatility models via PPDEs and application in turbulence*	14
03:50 PM–4:10 PM	Shiwei Liu (University of Oxford)	*Unleashing the Power of Deeper Layers in LLM*	12

Tuesday, 10th December

10:00 AM–10:20 AM	Yueh-Sheng Hsu (TU Wien)	*Construction and spectrum of the Anderson Hamiltonian with white noise potential on $\mathbb{R}^2$ and $\mathbb{R}^3$*	10
10:20 AM–10:40 AM	Vasily Melnikov (Strathcona High School)	*Finding a limit of a bounded sequence of semimartingales*	10
10:40 AM–11:00 AM	Wei Huang (FU Berlin)	*Stochastic homogenization with SPDE tools*	10
11:00 AM–11:30 AM	**Coffee Break**		
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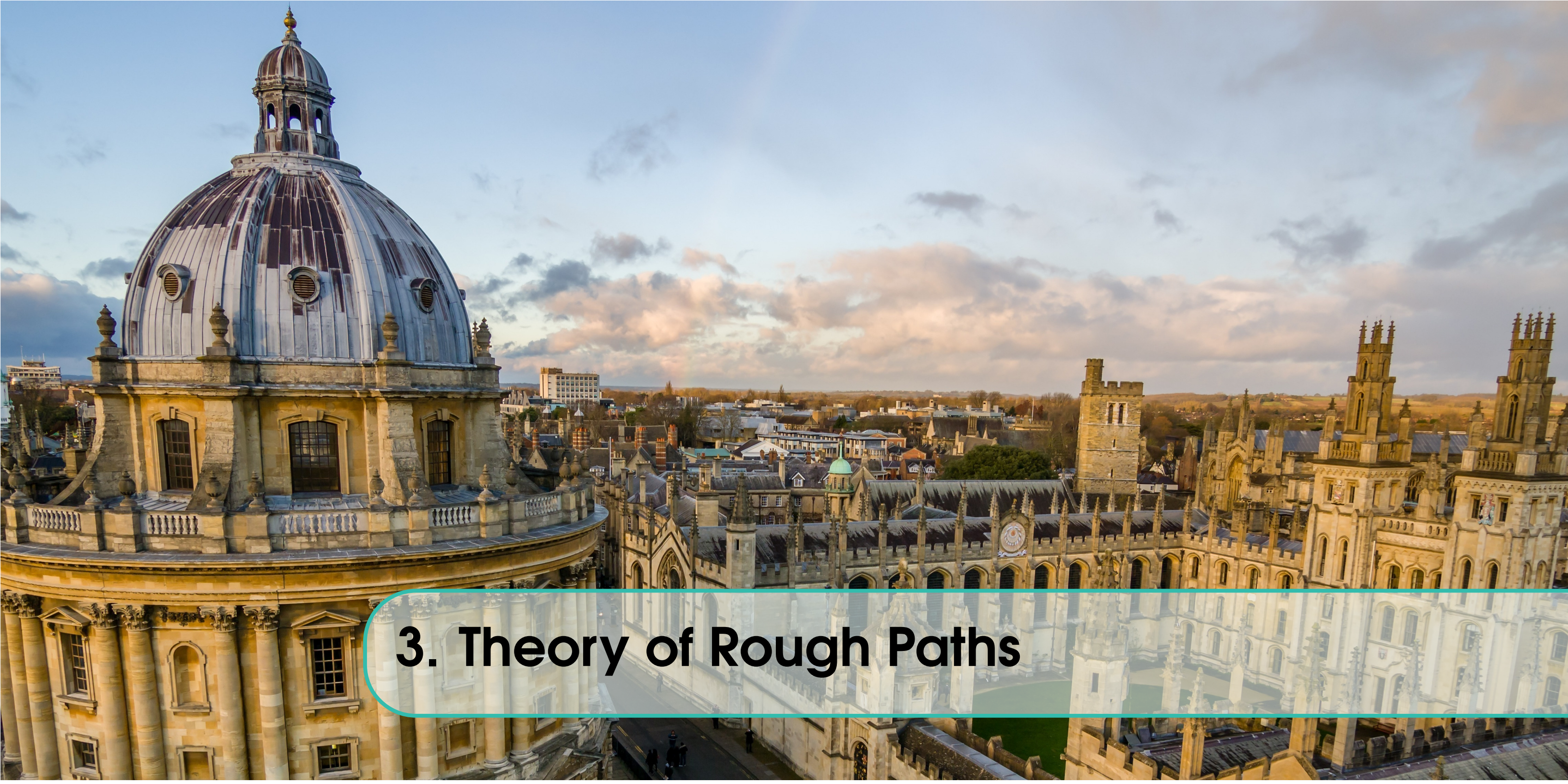
12:00 PM–12:30 PM	Nikolas Tapia (WIAS/HU Berlin)	*Branched Itô formula and intrinsic RDEs*	7
12:30 PM–02:00 PM	**Lunch Break**		
02:00 PM–02:20 PM	Konstantin Riedl (University of Oxford)	*Consensus-Based Bi-Level Optimization: On an Endeavor between Federated Learning, Stochastic Interacting Particle Systems, Optimization, and Robustness*	13
02:20 PM–02:40 PM	Leonard Schmitz (TU Berlin)	*Signature Matrices of Membranes*	8
02:40 PM–03:00 PM	Sijie Fu (University of Warwick)	*Certain coefficients of expected signature of Brownian motion up to the first exit time of a sphere*	8
03:00 PM–03:30 PM	**Coffee Break**		
03:30 PM–03:50 PM	Sebastian Ertel (TU Berlin)	*On the mathematical theory of continuous time Ensemble Kalman Filters*	11
03:50 PM–04:10 PM	Leo Tyrpak (University of Oxford)	*A CLT for a spatial birth and death process with non-local interaction*	11
07:00 PM–09:00 PM	**Dinner at St Edmund Hall**		

Wednesday, 11th December

10:20 AM–10:40 AM	Johannes Rimmele (University of Augsburg)	*Stabilization by rough noise for an epitaxial growth model*	11
10:40 AM–11:00 AM	Yingtong Hou (Université de Lorraine)	*Multi-indice B-series*	11
11:00 AM–11:30 AM	**Coffee Break**		
11:30 AM–11:50 PM	Martin Geller (University of Oxford)	*Geometry of Rough Path Space*	8
11:00 PM–12:10 PM	Thomas Wagenhofer (University of Oxford)		



3. Theory of Rough Paths

3.1 Rough Functional Itô Formula

Franziska Bielert, TU Berlin

Monday 11:30AM–11:50AM

On a rough Itô formula for path-dependent functionals of α-Hölder continuous paths for $\alpha \in (0,1)$. Our approach combines the sewing lemma and a Taylor approximation in terms of path-dependent derivatives.

3.2 High-degree cubature on Wiener space through unshuffle expansions

Timothy Herschell, DataSıg

Monday 11:50PM–12:10PM

We have explored a new approach to developing cubature / quadrature formulas by preserving some the underlying symmetries within Brownian motion (and related stochastic processes). The result was the production of an explicit degree-7 formula (previously this has only been given to degree-5) which can be used in conjunction with modern high-order simulation methods to empirically test the efficacy of these methods with respect to the degree order.

3.3 The Surface Signature

Darrick Lee, University of Edinburgh

Monday 12:10PM–12:30PM

Path development is a representation of paths in terms of matrix groups, which is defined by the solution of a linear controlled differential equation. The path signature is the universal path development: given any path development map, it uniquely factors through the path signature. These representations preserve the underlying concatenation structure of paths. In addition, they satisfy universality and characteristicness properties, allowing us to approximate functions on path space, and characterize the law of stochastic processes. In this talk, we consider the higher dimensional generalization of these constructions to surfaces, preserving both horizontal and vertical concatenations. We discuss the notion of surface development, which satisfies similar universality and characteristicness properties as path development, and the corresponding universal object: the surface signature.

3.4 Branched Itô formula and intrinsic RDEs

Nikolas Tapia, WIAS/HU Berlin

Tuesday 11:40AM–12:00PM

Building on work done by Schwartz, Meyer and Eméry in the 90s on stochastic calculus on manifolds with a connection, and on more recent work by Armstrong, Brigo, Cass and Ferruci (2022), Ferrucci (2023) and Bellingeri, Ferrucci and the speaker (2024), we show a transfer principle for branched rough paths of arbitrary regularity. In particular, we show that by choosing appropriate drifts in each coordinate patch, solutions are characterized by an intrinsic Itô formula. This talk is based on ongoing joint work with Emilio Ferrucci.

3.5 Signature Matrices of Membranes

Leonard Schmitz, WIAS/HU Berlin

Tuesday
02:20PM–
02:40PM

We prove that, unlike in the case of paths, the signature matrix of a membrane does not satisfy any algebraic relations. We derive novel closed-form expressions for the signatures of polynomial membranes and piecewise bilinear interpolations for arbitrary 2-parameter data in d-dimensional space. We show that these two families of membranes admit the same set of signature matrices and scrutinize the corresponding affine variety. This is joint work with Felix Lotter (MPI MiS Leipzig).

3.6 Certain coefficients of expected signature of Brownian motion up to the first exit time of a sphere

Sijie Fu, University of Warwick

Tuesday
02:40PM–
03:00PM

The expected signature of a stochastic process is the rough path analogue of the Laplace transform of the stochastic process. There are relatively few processes where the terms of expected signature can be calculated in a nice way. We will attempt to calculate some terms in the expected signature of Brownian motion up to the first exit time of a sphere, by trying to solve a PDE derived by Lyons and Ni.

3.7 Geometry of Rough Path Spaces

Martin Geller, University of Oxford

Wednesday
11:30AM–
11:50AM

4. Stochastic analysis

4.1 Working towards a central limit theorem for the Dean–Kawasaki equation

Shyam Popat, University of Oxford

Monday 10:00AM–10:20AM

In this short talk, I'll begin by motivating the study of the Dean–Kawasaki equation and explain why kinetic solution theory is needed to study it. Then I will state the well-posedness results of [Popat '24]. Finally, I will share some preliminary results for a central limit theorem and conjectures which are currently work in progress. The results are based on joint work with Benjamin Fehrman.

4.2 Weak coupling limit for polynomial stochastic Burgers equations in 2d

Da Li, University of Oxford

Monday 10:20AM–10:40AM

We explore the weak coupling limit for stochastic Burgers type equation in critical dimension, and show that it is given by a Gaussian stochastic heat equation, with renormalised coefficient depending only on the second order Hermite polynomial of the nonlinearity. We use the approach of Cannizzaro, Gubinelli and Toninelli (2024), who treat the case of quadratic nonlinearities, and we extend it to polynomial nonlinearities. In that sense, we extend the weak universality of the KPZ equation shown by Hairer and Quastel (2018) to the two dimensional generalized stochastic Burgers equation. A key new ingredient is the graph notation for the generator. This enables us to obtain uniform estimates for the generator. This is joint work with Nicolas Perkowski.

4.3 Weak uniqueness for singular stochastic equations driven by fractional Brownian motion

Oleg Butkovsky, WIAS Berlin

Monday 10:40AM–11:00AM

Joint work with Leonid Mytnik (Technion - Israel Institute of Technology). We consider the stochastic differential equation

$$dX_t = b(X_t)dt + dB_t^H,$$

where the drift b is a Schwartz distribution in the space $\mathscr{C}^\alpha$, $\alpha < 0$, and B^H is a fractional Brownian motion of Hurst index $H \in (0, 1/2]$. If $H = 1/2$, both weak and strong uniqueness theories for this SDE have been developed. However, the situation is much more complicated if $H \neq 1/2$, as the main tool, the Zvonkin transformation, becomes unavailable in this setting. The breakthroughs by Catellier and Gubinelli, and later by Le, established strong well-posedness of this SDE via sewing/stochastic sewing arguments. However, weak uniqueness for this SDE remained a challenge for quite some time, since a direct application of stochastic sewing alone does not seem very fruitful. I will explain how a combination of stochastic sewing with certain arguments from ergodic theory allows to show weak uniqueness in the whole regime where weak existence is known, that is, $\alpha > 1/2 - 1/(2H)$. If time permits, we will discuss weak uniqueness for rough SDEs

$$dX_t = \sigma(X_t)dB_t^H,$$

where σ is a Hölder continuous function. The latter is a joint project with Konstantinos Dareiotis (U Leeds).

[1] O. Butkovsky, L. Mytnik (2024). Weak uniqueness for singular stochastic equations. arXiv preprint arXiv:2405.13780.

4.4 Stochastic Maximum Principle for McKean-Vlasov SDEs with Rough Drift Coefficients

Sorelle Murielle Toukam Tchoumegne, TU Berlin

Monday 02:00PM–02:30PM

The main objective of this work is to maximize a performance functional subjected to a controlled stochastic differential equation of mean-field type using the stochastic maximum principle approach. The controlled mean-field stochastic differential equation has a non smooth drift and is driven by a one dimensional Brownian motion. We study the representation of the stochastic (Sobolev) differential flow, via a time-space local time integration formulation and use it to characterize the solution to the optimal control problem through an approximation argument.

4.5 Construction and spectrum of the Anderson Hamiltonian with white noise potential on $\mathbb{R}^2$ and $\mathbb{R}^3$

Yueh-Sheng Hsu, TU Wien

Tuesday 10:00AM–10:20AM

The continuous Anderson Hamiltonian is a random Schrödinger operator having Gaussian white noise as its potential. Like its discrete counterpart, this operator was introduced to study the loss of conductivity in a conductor with impurities, a phenomenon known as Anderson localisation. Unlike the discrete case, defining the operator in the continuous setting is already non-trivial due to the distributional nature of white noise. This has been made possible by recent theories of singular SPDEs. Typically, these constructions via singular SPDEs are able to treat the case where the operator domain is finite-volume, such as a torus. However, in the infinite-volume setting, as the operator is no longer expected to be "bounded from below," the construction becomes even more technical, and the literature is sparse.

In this talk, we will present a new construction of the Anderson Hamiltonian on $\mathbb{R}^2$ and $\mathbb{R}^3$, which relies on the solution theory of its associated parabolic equation. We then deduce that the constructed operator is ergodic and thus has a deterministic spectrum. Furthermore, we identify this deterministic spectrum, which coincides with the entire real line.

Joint work with Cyril Labbé (Université Paris-Cité, LPSM).

4.6 Finding a limit of a bounded sequence of semimartingales

Vasily Melnikov, Strathcona High School

Tuesday 10:20AM–10:40AM

Given a bounded sequence $\{X^n\}_n$ of semimartingales on a time interval $[0,T]$, we find a sequence of convex combinations $\{Y^n\}_n$ and a limiting semimartingale Y such that $\{Y^n\}_n$ converges to Y in a σ-localized modification of the Émery topology. More precisely, $\{Y^n\}_n$ converges to Y in the Émery topology on an increasing sequence $\{D_n\}_n$ of predictable sets covering $\Omega \times [0,T]$. We also prove some technical variants of this theorem, including a version where the complement of $\{D_n\}_n$ forms a disjoint sequence. Applications include a complete characterization of sequences admitting convex combinations converging in the Émery topology, and a supermartingale counterpart of Helly's selection theorem.

4.7 Stochastic homogenization with SPDE tools

Wei Huang, FU Berlin

Tuesday 10:40AM–11:00AM

We look at stochastic homogenisation of Poisson equation with Dirichlet on perforated domains and compare it with potentials with high bumps. Then we use tools from singular SPDEs in the study of Anderson Hamiltonian to analysis this problem. We use exponential ansatz and show that the "renormalisation constant" will result in a "strange term coming from nowhere" in the limit equation, similar to the case of perforated domains. Based on joint work in progress with Immanuel Zachhuber.

4.8 On the mathematical theory of continuous time Ensemble Kalman Filters

Sebastien Ertel, TU Berlin

Tuesday 03:30PM–03:50PM

Ensemble Kalman Filters (EnKFs) are a class of Monte Carlo algorithms devolped in the 90s for high dimensional stochastic filtering problems. Despite their widespread popularity, especially for numerical weather prediction and data assimilation tasks in the geosciences, a mathematical theory investigating these kinds of algorithms has emerged only recently in the last decade. In particular estimating the asymptotic bias for these kinds of algorithms in the case of nonlinear dynamics and mathematical justifications for their usage in these settings, is a longstanding open problem. This talk is therefore concerned with the elementary mathematical analysis of continuous time versions of EnKFs, which are a particular class of mean field interacting Stochastic Differential Equations. Besides elementary well posedness results, we show a quantitative convergence to the mean field limit with (almost) optimal rates and compare/relate this mean field limit to the optimal filter given by the Kushner-Stratonovich equation.

4.9 A CLT for a spatial birth and death process with non-local interaction

Leo Tyrpak, University of Oxford

Tuesday 03:50PM–04:10PM

We look at spatial birth and death process meant to represent the evolution of a population of dandelions. One of the novelties of the model is that fitness of individuals is calculated by looking at the population as a whole similar to the Bolker-Paccala model. We show that this process has a deterministic limit under a certain parameter regime, then present most of a proof for a CLT around that limit and show how this can give us information on the genealogies of such individuals.

4.10 Stabilization by rough noise for an epitaxial growth model

Johannes Rimmele, University of Augsburg

Wednesday 10:20AM–10:40AM

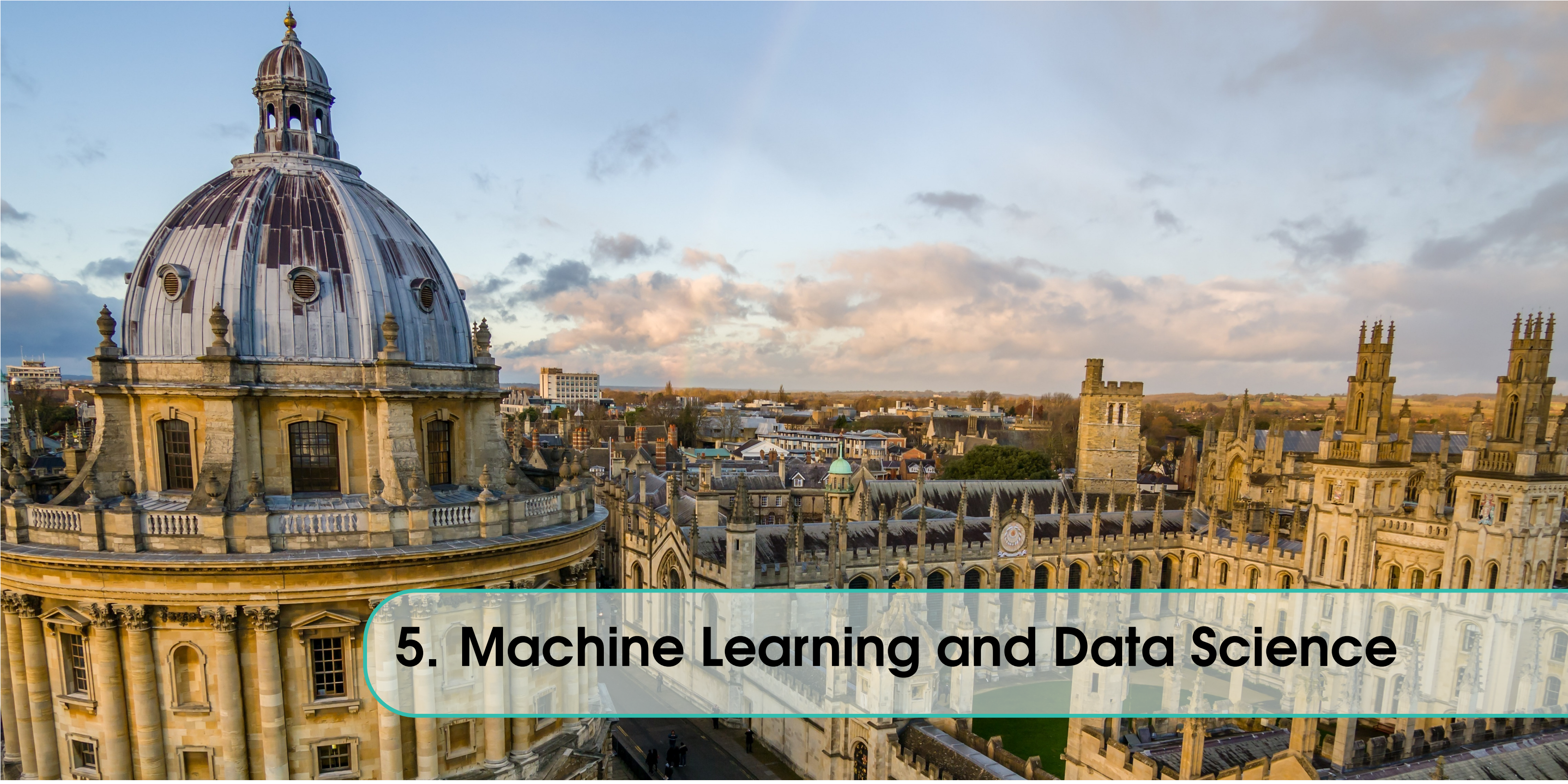
In this article we study a model from epitaxial thin-film growth. It was originally introduced as a phenomenological model of growth in the presence of a Schwoebbel barrier, where diffusing particles on a terrace are not allowed to jump down at the boundary. Nevertheless, we show that the presence of arbitrarily small space-time white noise due to fluctuations in the incoming particles surprisingly eliminates all non- linear interactions in the model and thus has the potential to stabilize the dynamics and suppress the growth of hills in these models.

4.11 Multi-indice B-series

Yingtong Hou, Université de Lorraine

Wednesday 10:40AM–11:00AM

We propose a novel way to study numerical methods for ordinary differential equations in one dimension via the notion of multi-indice. The main idea is to replace rooted trees in Butcher's B-series by multi-indices. The latter were introduced recently in the context of describing solutions of singular stochastic partial differential equations. The combinatorial shift away from rooted trees allows for a compressed description of numerical schemes. Furthermore, such multi-indices B-series uniquely characterize the Taylor expansion of one-dimensional local and affine equivariant maps.



5. Machine Learning and Data Science

5.1 Higher Order Lipschitz Functions in Data Science

Andrew McLeod, University of Oxford

Monday
02:30PM–
03:00PM

The notion of Lip(γ) Functions, for a parameter $\gamma > 0$, introduced by Stein in the 1970s (building on earlier work of Whitney) is a notion of smoothness that is well-defined on arbitrary closed subsets (including, in particular, finite subsets) that is instrumental in the area of Rough Path Theory initiated by Lyons and central in recent works of Fefferman. Lip(γ) functions provide a higher order notion of Lipschitz regularity that is well-defined on arbitrary closed subsets, and interacts well with the more classical notion of smoothness on open subsets. In this talk we will cover the intuition behind Lip(γ) functions and illustrate some fundamental properties that make them an attractive class of function to work with from a machine learning perspective. In particular, models learnt within the class of Lip(γ) functions are well-suited for both inference on new unseen input data, and for allowing cost-effective inference via the use of sparse approximations found via interpolation-based reduction techniques.

5.2 Unleashing the Power of Deeper Layers in LLMs

Shiwei Liu, University of Oxford

Monday
03:50PM-
04:10PM

Large Language Models (LLMs) have demonstrated impressive achievements. However, recent research has shown that their deeper layers often contribute minimally, with effectiveness diminishing as layer depth increases. This pattern presents significant opportunities for model compression.

In the first part of this seminar, we will explore how this phenomenon can be harnessed to improve the efficiency of LLM compression and parameter-efficient fine-tuning. Despite these opportunities, the underutilization of deeper layers leads to inefficiencies, wasting resources that could be better used to enhance model performance. The second part of the talk will address the root cause of this ineffectiveness in deeper layers and propose a solution. We identify the issue as stemming from the prevalent use of Pre-Layer Normalization (Pre-LN) and introduce Mix-Layer Normalization (Mix-LN) with combined Pre-LN and Post-LN as a new approach to mitigate this training deficiency.

5.3 Variance Norms for Kernelized Anomaly Detection

Nikita Zozoulenko, Imperial College London

Tuesday
11:30AM–
11:50AM

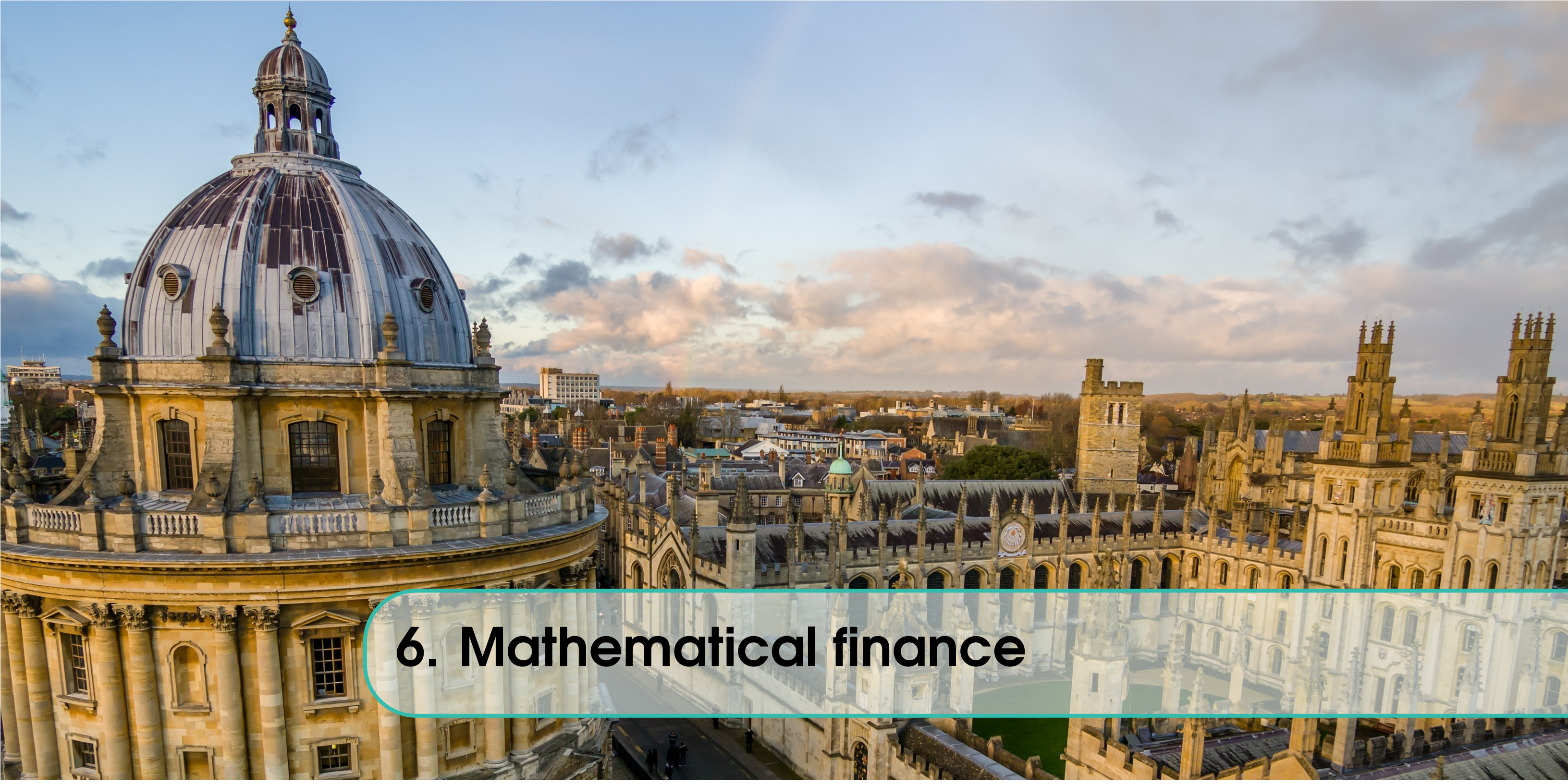
We present a unified theory for Mahalanobis-type anomaly detection on Banach spaces, using ideas from Cameron-Martin theory applied to non-Gaussian measures. This approach leads to a basis-free, data-driven notion of anomaly distance through the so-called variance norm of a probability measure, which can be consistently estimated using empirical measures. Our framework generalizes the classical $\mathbb{R}^d$, functional $(L^2[0,1])^d$, and kernelized settings, including the general case of non-injective covariance operator. Using the variance norm, we introduce the notion of a kernelized nearest-neighbour Mahalanobis distance for semi-supervised anomaly detection. In an empirical study on 12 real-world datasets, we demonstrate that the kernelized nearest-neighbour Mahalanobis distance outperforms the traditional kernelized Mahalanobis distance for multivariate time series anomaly detection, using state-of-the-art time series kernels such as the signature, global alignment, and Volterra reservoir kernels. Moreover, we provide an initial theoretical justification of nearest-neighbour Mahalanobis distances by developing concentration inequalities in the finite-dimensional Gaussian case.

5.4 Consensus-Based Bi-Level Optimization: On an Endeavor between Federated Learning, Stochastic Interacting Particle Systems, Optimization, and Robustness

Konstantin Riedl, University of Oxford

Tuesday 02:00PM–02:20PM

Consensus-Based Bi-Level Optimization: On an Endeavor between Federated Learning, Stochastic Interacting Particle Systems, Optimization, and Robustness Bi-level optimization problems, where one wishes to find the global minimizer of an upper-level objective function over the globally optimal solution set of a lower-level objective, arise in a variety of scenarios throughout science and engineering, machine learning, and artificial intelligence. In this paper, we propose and investigate, analytically and experimentally, consensus-based bi-level optimization (CB^{2}O), a multi-particle metaheuristic derivative-free optimization method designed to solve bi-level optimization problems when both objectives may be nonconvex. Our method leverages within the computation of the consensus point a carefully designed particle selection principle implemented through a suitable choice of a quantile on the level of the lower-level objective, together with a Laplace principle-type approximation w.r.t. the upper-level objective function, to ensure that the bi-level optimization problem is solved in an intrinsic manner. We give an existence proof of solutions to a corresponding mean-field dynamics, for which we first establish the stability of our consensus point w.r.t. a combination of Wasserstein and L^2 perturbations, and consecutively resort to PDE considerations extending the classical Picard iteration to construct a solution. For such solution, we provide a global convergence analysis in mean-field law showing that the solution of the associated nonlinear nonlocal Fokker-Planck equation converges exponentially fast to the unique solution of the bi-level optimization problem provided suitable choices of the hyperparameters. The practicability and efficiency of our CB^{2}O algorithm is demonstrated through extensive numerical experiments in the settings of constrained global optimization, sparse representation learning, and robust (clustered) federated learning.



6. Mathematical finance

6.1 A kernel comparison approach for rough volatility models via PPDEs and application in turbulence

Paul Maurer, INRIA Sophia-Antipolis

Monday 03:30PM–03:50PM

Rough volatility models, where the instantaneous volatility is driven by a fractional Brownian motion, have garnered significant interest due to their high accuracy in pricing financial derivatives. These models also find applications in physics, particularly for modeling Lagrangian intermittency in turbulence. We present an approach that leverages functional Itô calculus and path-dependent PDEs to compare, under weak error, two such models based on a distance between the Volterra kernels used in the volatility processes. We propose two potential applications: one involving the Markovian approximation of these models, and the other focusing on the approximation of local multifractality in the context of intermittency in turbulence.

7. Participants

Alif Aqsha (University of Oxford)
Anton Baeza (Nice Université Côte d'azur)
Franziska Bielert (TU Berlin)
Alexandre Bloch (University of Oxford)
Thomas Blore (University of Oxford)
Luca Bonengel (University of Oxford)
Fabio Bugini (TU Berlin)
Oleg Butkovsky (WIAS)
Marco Cacace (TU Wien)
Archi De (University of Oxford)
Edward Du (University of Oxford)
Sebastian Ertel (TU Berlin)
Emilio Ferrucci (University of Oxford)
Peter Friz (TU and WAIS Berlin)
Sijie Fu (University of Warwick)
Elena Gal (University of Oxford)
Ioannis Gasteratos (TU Berlin)
Martin Geller (University of Oxford)
William Gibson (University of Oxford)
Mie Kano Glückstad (University of Oxford)
Lin Hao He (University of Oxford)
Timothy Herschell (University of Oxford)
Stefanie Hesse (HU Berlin)
Yingtong Hou (Université de Lorraine)
Yueh-Sheng Hsu (TU Wien)
Wei Huang (FU Berlin)
Andrea Iannucci (Imperial College London)
Yifan Jiang (University of Oxford)
Darrick Lee (University of Edinburgh)
Da Li (University of Oxford)
Shiwei Liu (University of Oxford)
Terry Lyons (University of Oxford/Alan Turing Institute)
Paul Maurer (INRIA Sophia-Antipolis)
David McBride (University of Oxford)
Andrew McLeod (University of Oxford)
Vasily Melnikov (Strathcona High School)
Sarah-Jean Meyer (University of Oxford)
Aurélien Minguella (Université de Lorraine)
Peter Paulovics (University of Oxford)
Jaka Pelaic (University of Oxford)
Luca Pelizzari (WAIS and TU Berlin)
Jost Pieper (University of Durham)
Andrea Pitrone (University of Oxford)
Shyam Popat (University of Oxford)
Yordan P. Raykov (University of Nottingham)
Konstantin Riedl (University of Oxford)
Johannes Rimmele (University of Augsberg)
William Salkeld (University of Nottingham)
Leonard Schmitz (TU Berlin)
Max Scott (University of Bath)
Nikolas Tapia (WIAS and HU Berlin)
Sorelle Murielle Toukam Tchoumegne (TU Berlin)
Vlad Tuchilus (University of Oxford)
Leo Tyrpak (University of Oxford)
Thomas Wagenhofer (TU Berlin)
Serafina Wald (University of Bonn)
Lingyi Yang (University of Oxford)
Nikita Zozoulenko (Imperial College London)