German Probability & Statistics Days Mannheim

27th **September** – 1st **October** 2021

Institute of Mathematics, University of Mannheim

Notice: This is the version of November 5, 2021. Please check for the latest version on here.

Welcome to Mannheim (virtually)

Continuing the series of conferences established in 1993, the 15th German Probability and Statistics Days (GPSD) 2021 are taking place "in" Mannheim from September 27th to October 1st 2021. Many meetings and conferences needed to be postponed in 2020 and 2021. To gather the community at least virtually the Germany Probability and Statistics Days will be held online.

The GPSD conferences are organized biannually with the support of the DMV-Fachgruppe Stochastik e.V. The series of conferences provides an important forum for presenting and discussing the latest developments in the field for both young and senior researchers in Germany, Europe and beyond. In 14 specialized sections on probability, statistics and their applications in physics, biology, finance, insurance and data science researchers will discuss over 250 contributed prerecorded and invited live talks at the 15th GPSD. Virtual social events and further interactions will offer opportunities to have informal discussions and meet new colleagues.

It would have been our greatest pleasure to welcome you all in the vivid city of Mannheim at the heart of the Rhine-Neckar metropolitan region. Although only virtually, we hope that you will enjoy this conference in probability and statistics – and look forward to an inspiring meeting!

Local organizers in Mannheim

Leif Döring

Andreas Neuenkirch

David Prömel

Claudia Schillings

Martin Schlather

Martin Slowik

Organisation committee – DMV-Fachgruppe Stochastik

Natalie Neumeyer (Universität Hamburg)
Frank Aurzada (TU Darmstadt)
Claudia Kirch (Universität Magdeburg)
Martin Keller-Ressel (TU Dresden)
Christoph Thäle (Ruhr-Universität Bochum)

Contents

Programme Overview

	Montag	Dienstag	Mittwoch	Donnerstag	Freitag
12:00-13:30	Finance: Modelling 1	Spatial stochastics 2	Spatial stochastics 3	Spatial stochastics 4	Spatial stochastics 5
	Nonparametric stat. 1	Stat. methodology 1	Limit theorems 3	Limit theorems 4	Stoch. processes 6
	Stoch. processes 1	Nonparametric stat. 3	Stoch. in biology 2	Stoch. processes 5	Stoch. in biology 4
	Stoch. analysis 1	Finance: Modelling 3	S(P)DEs 2	Nonparametric stat. 4	S(P)DEs 5
	Stoch. in biology 1	Stoch. analysis 3	Stat. methodology 3	Stoch. analysis 6	Stat. learning 3
13:45-15:15	Limit theorems 1	Limit theorems 2	Stoch. in biology 3	Nonparametric stat. 5	Stoch. in biology 5
	Spatial stochastics 1	Stoch. in physics 1	Stoch. processes 3	Finance: Modelling 6	Time series 3
	Stoch. optimization 1	Stat. methodology 2	Stat. learning 1	S(P)DEs 4	Stat. learning 4
	Nonparametric stat. 2	Stoch. optimization 2	Finance: Modelling 4	Limit theorems 5	Finance: Modelling 7
	Finance: Modelling 2	Stoch. analysis 4	Stoch. analysis 5		Stoch. in physics 3
	Stoch. analysis 2	Time series 1			
15:30-17:00	Opening + Plenary Talk	Finance: Statistics	S(P)DEs 3	Plenary Talk	
		Stoch. processes 2	Stoch. processes 4		
		Stoch. in physics 2	Time series 2		
		Stoch. optimization 3	Finance: Modelling 5		
		S(P)DEs 1	Stoch. optimization 4		
			Stat. learning 2		
Social Event 20:00 -	Pub Quiz			Escape Room	

Plenary talks

Caroline Uhler

Caroline is associate professor at MIT. Her research focuses is on machine learning, statistics and computational biology, in particular on causal inference, generative modeling and applications to genomics.

Your dreams may come true with MTP2

Mon, 15:30
zoom room 7
live

Caroline Uhler

Massachusetts Institute of Technology

We study probability distributions that are multivariate totally positive of order two (MTP2). Such distributions appear in various applications from ferromagnetism to Brownian motion tree models used in phylogenetics to factor analysis models used in finance. We first describe some of the intriguing properties of such distributions with respect to conditional independence, graphical models, and parameter estimation. We end with an application to covariance matrix estimation for portfolio selection.

Ronan Eldan

Ronen is professor at the Weizmann Institute of Science. He research interests include high dimensional phenomena in appearing probability theory, functional analysis, metric geometry, computational geometry, mathematical physics or learning theory.

Analysis of high-dimensional systems via pathwise techniques

Thu, 15:30
zoom room 7
live

Ronen Eldan

Weizmann Institute of Science

A common motif in high dimensional probability and geometry is that the behavior of objects of interest is often dictated by their marginals onto a fixed number of directions. This is manifested in the fact that several classical functional inequalities are dimension-free (hence, have no explicit dependence on the dimension), the extremizers of those inequalities being functions that only depend on a fixed number of variables. Another related example comes from statistical mechanics, where Gibbs measures can often be decomposed into measures which exhibit a "product-like" structure.

In this talk, we present an analytic approach that helps reveal phenomena of this nature. The approach is based on pathwise analysis: We construct stochastic processes, driven by Brownian motion, associated with the high-dimensional object which allow us to make the object more tractable, for example, through differentiation with respect to time.

I will try to explain how this approach works and will briefly discuss several results that stem from it, including functional inequalities of Gaussian space, concentration inequalities in high-dimensional convexity as well results related to decomposition Gibbs measures into pure states.

1. Stochastic analysis

Chairs: Max von Renesse, Mathias Beiglböck

Live Sessions

Session 1 (Monday, 12:00) - zoom room 3

- **Karen Habermann** (live invited talk): A polynomial expansion for Brownian motion and its fluctuation process
- **Youness Boutaib**: A short review of rough paths on manifolds
- **Dominic Tobias Schickentanz**: Brownian Motion Conditioned to Spend Limited Time Below a Barrier
- **Pietro Siorpaes**: Pathwise local times and Tanaka–Meyer formulae for càdlàg paths

Session 2 (Monday, 13:45)- zoom room 3

- **Sascha Troscheit** (live invited talk): Dimension theory and quasi-symmetric embeddability in random geometry
- **Oleg Butkovsky** (live invited talk): Regularization by noise via stochastic sewing with random controls
- **Wolfgang Bock** (live invited talk): Stochastic Quantization of the fractional Edwards measure representation

Session 3 (Tuesday, 12:00)- zoom room 5

- **Sima Mehri** (live invited talk): A stochastic Gronwall lemma and wellposedness of path dependent SDEs driven by martingale noise
- **Alexander Kalinin**: Support characterization for regular path-dependent stochastic Volterra integral equations
- **Yue Wu**: The random periodic solution of a stochastic differential equation with a monotone drift and its numerical approximation
- **Francesco Mattesini**: Asymptotics of transportation cost for the occupation measure of fractional Brownian motion

Session 4 (Tuesday, 13:45)- zoom room 5

- **Martin Slowik** (live invited talk): On gradient estimates of the heat kernel for random walks in time-dependent random environments
- **Patricia Alonso Ruiz**: Heat semigroup approach to isoperimetric inequalities in Dirichlet spaces
- **Max Nendel**: Wasserstein perturbations of Markovian transition semigroups
- **Jonas Blessing**: Stochastic representations for viscous Hamilton-Jacobi equations

Session 5 (Wednesday, 13:45)- zoom room 3

- **Vitalii Konarovskyi** (live invited talk): Sticky-reflected stochastic heat equation driven by colored noise
- **Aleksandra Zimmermann** (invited live talk): A finite volume scheme for a stochastic heat equation driven by multiplicative noise
- **Benjamin Gess** (live invited talk): The stochastic thin film equation

Session 6 (Thursday, 12:00)- zoom room 5

- **Martin Herdegen** (live invited talk): Bubbles in discrete time models
- **Stefan Tappe**: Infinite dimensional affine processes
- **Paul Eisenberg**: Abstract polynomial processes
- **Julian Wendt**: Large ranking games with diffusion control
- **Daniel Bartl** (live invited talk): The Wasserstein space of stochastic processes

Invited Talks

The Wasserstein space of stochastic processes

Session 6
Thu, 12:00
live

Daniel Bartl
Universität Wien

When interpreting $P(R^N)$ as the laws of stochastic processes, the adapted Wasserstein distance AW is a convenient refinement of the classical Wasserstein distance: it is useful for applications in different fields and it provides a natural compatible metric for the weak adapted topology that has independently been discovered by a number of authors from different areas. Notably, $(P(R^N), AW)$ is not complete. We show that its completion consists precisely in the space FP of filtered processes, i.e. stochastic processes together with a general filtration. Specifically, (FP, AW) is a geodesic space, isometric to a classical Wasserstein space, and martingales form a closed displacement convex subspace. In contrast to other topologies on the class of processes, probabilistic operations such as the Doob decomposition, or optimal stopping problems and Snell-envelopes are continuous w.r.t. AW. (Joint work with Mathias Beiglboeck and Gudmund Pammer.)

Stochastic Quantization of the fractional Edwards measure

Session 2
Mon, 13:45
live

Wolfgang Bock
TU Kaiserslautern

In this talk, we use the combination of Dirichlet form methods and white noise. analysis to construct a Markov process, which has the Edwards density w.r.t. the fractional white noise for HD<1 as invariant measure. In particular we provide a Fukushima decomposition and prove that the constructed process solves a stochastic differential equation in infinite dimension for quasi-all starting points in a probabilistically weak sense. The equilibrium measure, which is by construction the fractional Edwards measure, is specified to be an extremal Gibbs state and therefore, the constructed stochastic dynamics is time ergodic

---

Regularization by noise via stochastic sewing with random controls

Session 2
Mon, 13:45
live

Oleg Butkovskyi
Weierstrass Institute for Applied Analysis and Stochastics

I would like to present a new tool in stochastic analysis, stochastic sewing with random controls, which seems to be quite powerful for studying regularization by noise of SDEs and SPDEs. This technique extends deterministic sewing with controls of Peter Friz and Huilin Zhang and stochastic sewing of Khoa Le. Our first example is the stochastic differential equation

$$dX_t = \delta_0(X_t)dt + dB_t^H,$$

where $delta_0$ is the Dirac delta function, B^H is a fractional Brownian motion, $H \in (0,1)$. For $H = 1/2$ this equation becomes a skew Brownian motion and its strongexistence and uniqueness was shown in [2] using the Zvonkin-Veretennikov transformation method. If $H \neq 1/2$, then the Zvonkin-Veretennikov transformation method is not applicable. On the other hand, one can conjecture from simple general considerations, that this equation should have a unique strong solution for $H < 1/2$ as well. This conjecture was proven in [3,4] but only for $H < 1/4$. Stochastic sewing with random controls allowed us to obtain strong existence and uniqueness for $H < 1/3$. If time permits, I will show how the same proof technique and related ideas allows to show existence and uniqueness of solution of stochastic heat equation with L_p drift for $p \geq 1$:

$$\partial_t u = \Delta u + b(u) + \dot{W},$$

where $\dot{W}$ is a space-time white noise. This extends [5], where this result was obtained only for $p > 2$. (Joint work with Siva Athreya, Khoa Le, and Leonid Mytnik)

Large deviations for conservative, stochastic PDE and non-equilibrium fluctuations

Session 5
Wed, 13:45
live

Benjamin Gess
Universität Bielefeld & MPI MIS Leipzig

Macroscopic fluctuation theory provides a general framework for far from equilibrium thermodynamics, based on a fundamental formula for large fluctuations around (local) equilibria. This fundamental postulate can be informally justified from the framework of fluctuating hydrodynamics, linking far from equilibrium behavior to zero-noise large deviations in conservative, stochastic PDE. In this talk, we will give rigorous justification to this relation in the special case of the zero range process. More precisely, we show that the rate function describing its large fluctuations is identical to the rate function appearing in zero noise large deviations to conservative stochastic PDE. The proof is based on the well-posedness of the skeleton equation – a degenerate parabolic-hyperbolic PDE with irregular coefficients, the proof of which extends DiPerna-Lions' concept of renormalized solutions to nonlinear diffusions.

A polynomial expansion for Brownian motion and its fluctuation process

Session 1
Mon, 12:00
live

Karen Habermann
University of Warwick

We derive a polynomial expansion for Brownian motion expressed in terms of shifted Legendre polynomials by considering Brownian motion conditioned to have vanishing iterated time integrals of all orders. We further discuss the fluctuations for this expansion and show that they converge in finite dimensional distributions to a collection of independent zero-mean Gaussian random variables whose variances follow a scaled Semicircle.

Bubbles in discrete time models

Session 6
Thu, 12:00
live

Martin Herdegen
University of Warwick

We introduce a new definition of speculative bubbles in discrete-time models based on the discounted stock price losing mass at some finite drop-down under an equivalent martingale measure. We provide equivalent probabilistic characterisations of this definition and give examples of discrete-time martingales that are speculative bubbles and those that are not. In the Markovian case, we provide sufficient analytic conditions for the presence of speculative bubbles. We also show that the existence of speculative bubbles is directly linked to the existence of a non-trivial solution to a linear Volterra integral equation of the second kind involving the Markov kernel. Finally, we show that our definition of speculative bubbles in discrete time is consistent with the strict local martingale definition of speculative bubbles in continuous time in the sense that a properly discretised strict local martingale in continuous time is a speculative bubble in discrete time. This talk is based on joint work with Dörte Kreher.

Sticky-reflected stochastic heat equation driven by colored noise

Session 5
Wed, 13:45
live

Vitalii Konarovskyi
Universität Hamburg

We will discuss the existence of a sticky-reflected solution to the heat equation on the space interval [0,1] driven by colored noise. The process can be interpreted as an infinite-dimensional analog of the sticky-reflected Brownian motion on the real line but, in this case, the solution obeys the ordinary stochastic heat equation, except the points where it reaches zero. The solution has no noise at zero and a drift pushes it to stay positive. The proof of the existence is based on a new approach that can be applied to some other types of SPDEs with discontinuous coefficients.

A stochastic Gronwall lemma and well-posedness of path-dependent SDEs driven by martingale noise

Session 3
Tue, 12:00
live

Sima Mehri

University of Warwick

We show existence and uniqueness of solutions of stochastic path-dependent differential equations driven by cadlag martingale noise under joint local monotonicityand coercivity assumptions on the coefficients with a bound in terms of the supremum norm. In this set-up, the usual proof using the ordinary Gronwall lemma together with the Burkholder-Davis-Gundy inequality seems impossible. In order to solve this problem, we state a new and quite general stochastic Gronwall lemma for cadlag martingales using Lenglart's inequality.

On gradient estimates of the heat kernel for random walks in time-dependent random environments

Session 4
Tue, 13:45
live

Martin Slowik

Universität Mannheim

We consider a random walk among time-dependent random conductances. In recent years the long-time behaviour of this model under diffusive rescaling has been intensively studied, and – depending on the assumptions on the law of the environment – is fairly well understood. In this talk, I will discuss how to obtain first and second space derivatives of the annealed transition density using entropy estimates. This is work in progress jointly with Jean-Dominique Deuschel (TU Berlin) and Takashi Kumagai (RIMS Kyoto).

Dimension theory and quasi-symmetric embeddability in random Geometry

Session 2
Mon, 13:45
live

Sascha Troscheit

Universität Wien

The continuum random tree and Brownian map are some of the most important random metric spaces and represent the "typical" tree and metric on the sphere, respectively. In this talk I will present recent advances in the dimension theory of self-similar sets and explain how fractal geometry can be used to shed light on general embedding problems. In particular, I will show that the Assouad dimension of these metric spaces is infinite and explain how this restricts the nature of any Embeddings.

A finite volume scheme for a stochastic heat equation driven by nonlinear multiplicative noise

Session 5
Wed, 13:45
live

Aleksandra Zimmermann

Universität Duisburg-Essen

We consider a stochastic heat equation driven by nonlinear multiplicative noise on a bounded polygonal domain of $\mathbb{R}^2$ with homogeneous Neumann bound- ary conditions and a random initial datum. The stochastic force term is given by a stochastic integral in the sense of It^o. For this equation, we propose a space-time discretization by a finite volume scheme and show convergence. From the a-priori estimates, we obtain weak convergence of the approximate solutions and weakconvergence is not sufficient to pass to the limit in the nonlinear multiplicative stochastic term. However, our results allow us to show tightness of laws of approximate solutions and using the theorems of Prokhorov and Skorokhod we can establish convergence towards a martingale solution. Since pathwise uniqueness is available, we use the Gyöngy-Krylov characterization of convergence in probability to show (stochastically) strong convergence of the scheme.

Contributed Talks

Heat semigroup approach to isoperimetric inequalities in Dirichlet spaces

Session 4
Tue, 13:45

Patricia Alonso Ruiz

Texas A&M University

The classical isoperimetric problem consists in finding among all sets with the same volume (measure) the one that minimizes the surface area (perimeter measure). In the Euclidean case, balls are known to solve this problem. To formulate the isoperimetric problem, or an isoperimetric inequality in more general settings requires in particular a good notion of perimeter measure.

In this talk we present a natural definition of sets of finite perimeter in Dirichlet spaces that involves the heat semigroup associated to an intrinsic stochastic process in the space, extending the classical counterpart of perimeter to a large class of metric measure spaces. The approach follows ideas original to Ledoux in the Euclidean space, who established the connection of isoperimetric problems and functions of bounded variation (BV) via heat semigroups.

The main assumption on the underlying space will be a non-negative curvature type condition that we call weak Bakry-Émery and is satisfied in many examples of interest, also in fractals such as (infinite) Sierpinski gaskets and carpets.

The results are part of joint work with F. Baudoin, L. Chen, L. Rogers, N. Shanmugalingam and A. Teplyaev.

Stochastic representations for viscous Hamilton-Jacobi equations

Session 4
Tue, 13:45

Jonas Blessing

University of Konstanz

We provide a stochastic representation for viscous Hamilton-Jacobi equations with quadratic nonlinearity. In exponential Orlicz hearts the unique solution is represented by a strongly continuous convex semigroup corresponding to a Brownian motion with uncertain drift. The existence and uniqueness of the semigroup is guaranteed by several abstract results on nonlinear semigroups. Finally on the so called symmetric Lipschitz set the generator can be explicitly determined and linked with the viscous Hamilton-Jacobi equation yielding a solution with values in a second order Sobolev space. The talk is based on joint work with Michael Kupper.

A short review of rough paths on manifolds

Session 1
Mon, 12:00

Youness Boutaib

RWTH Aachen University

Smooth manifolds are not the suitable context for trying to generalize the concept of rough paths on a manifold. Indeed, when one is working with smooth maps instead of Lipschitz maps and trying to solve a rough differential equation (RDE), one loses the quantitative estimates controlling the convergence of the Picard sequence. In this talk, we first review the foundations of the Lipschitz geometry, introduced by Cass, Litterer and Lyons, along with the main findings that encompass the classical theory of rough paths in Banach spaces. Then we give what we believe to be a minimal framework for defining rough paths on a manifold that is both less rigid than the classical one and emphasized on the local behaviour of rough paths. Time allowing, we will give an application of such concepts to prove a controllability result for RDEs.

Abstract polynomial processes

Session 6
Thu, 12:00

Paul Eisenberg

WU Wien

Polynomial process are stochastic process where conditional expectations of polynomials of the state of the process are polynomials of lower degree of the earlier state. This is similar to the Markov property but with a different invariance condition. In this talk we investigate the situation where we generalise polynomials to arbitrary functions but we keep some graded structure. The main purpose of our work is to understand structural implications for the process itself.

This talk is based on joint work with Fred Benth and Nils Detering.

Support characterization for regular path-dependent stochastic Volterra integral equations

Session 3
Tue, 12:00

Alexander Kalinin

LMU Munich

We consider a stochastic Volterra integral equation with regular path-dependent coefficients and a Brownian motion as integrator in a multidimensional setting. Under an imposed absolute continuity condition, the unique solution is a semimartingale that admits almost surely Hölder continuous paths. Based on functional Itô calculus, we prove that the support of its law in Hölder norms can be described by a flow of mild solutions to ordinary integro-differential equations that are constructed by means of the vertical derivative of the diffusion coefficient.

Asymptotics of transportation cost for the occupation measure of fractional Brownian motion

Session 3
Tue, 12:00

Francesco Mattesini

WWU Münster and MPI MiS Leipzig

We establish sharp upper and lower bounds for the Kantorovich optimal transport distance between the uniform measure and the occupation measure of a path of a fractional Brownian motion with Hurst index H in a d-dimensional torus. A similar problem has been recently studied for Markovian Gaussian processes taking values on a compact connected Riemmanian manifold. We give new insights in the case of fractional Brownian motion taking care of the absence of the Markovian structure by means of recently introduced PDE techniques and compare our results with the ones already known. In particular we show that a phase transition between rates occurs if $d = 1/H + 2$, in analogy with the random Euclidean bipartite matching problem, i.e. when the occupation measure is replaced by i.i.d. uniform points (formally given by infinite H).

Joint work with M. Huesmann (WWU Münster) and D. Trevisan (Università degli studi di Pisa)

Wasserstein perturbations of Markovian transition semigroups

Session 4
Tue, 13:45

Max Nendel
Bielefeld University

We deal with a class of infinite-dimensional time-homogeneous Markov processes with transition probabilities bearing a nonparametric uncertainty. Following the ideas of Bartl, Eckstein, and Kupper (2020), the uncertainty is modelled by considering perturbations of the transition probabilities within a proximity in Wasserstein distance. As a limit over progressively finer time periods, on which the level of uncertainty scales proportionally, we obtain a convex semigroup satisfying a nonlinear PDE in a viscosity sense. A remarkable observation is that, in standard situations, the nonlinear transition operators arising from nonparametric uncertainty coincide with the ones related to parametric drift uncertainty. On the level of the generator, the uncertainty is reflected as an additive perturbation in terms of a convex functional of first order derivatives. We additionally provide sensitivity bounds for the convex semigroup relative to the reference model. The results are illustrated with Wasserstein perturbations of Lévy processes, infinite-dimensional Ornstein-Uhlenbeck processes, geometric Brownian motions, and Koopman semigroups.

The talk is based on joint work with Sven Fuhrmann and Michael Kupper.

Brownian Motion Conditioned to Spend Limited Time Below a Barrier

Session 1
Mon, 12:00

Dominic Tobias Schickentanz
Technische Universität Darmstadt

We condition a Brownian motion with arbitrary starting point $y \in \mathbb{R}$ on spending at most 1 time unit below 0 and provide an explicit description of the resulting process. In particular, we provide explicit formulas for the distributions of its last zero $g = g^y$ and of its occupation time $\Gamma = \Gamma^y$ below 0 as functions of y. This generalizes a result of Benjamini and Berestycki from 2011, which covers the special case $y = 0$. Additionally, we study the behavior of the distributions of g^y and Γ^y, respectively, for $y \to \pm\infty$. The talk is based on joint work with Frank Aurzada.

Pathwise local times and Tanaka–Meyer formulae for càdlàg paths

Session 1
Mon, 12:00

Pietro Siorpaes
Imperial College London

We develop three different concepts of local times and "Foellmer integral" for (deterministic) càdlàg paths, and prove the corresponding pathwise Tanaka–Meyer formulae. We show that a.e. sample path of any semimartingale admits a pathwise local time in each sense, and that all coincide with the classical semimartingale local time, strengthening the legitimacy of each definition. Along the way, we prove that the normalized number of downcrossings converges to the local time for any càdlàg semimartingale X, generalizing results which were only known when X=M+A, where M is a continuous local martingale, and A a cadlag process of finite variation.

Infinite dimensional affine processes

Session 6
Thu, 12:00

Stefan Tappe

Albert Ludwig University of Freiburg

The goal of this talk is to investigate infinite dimensional affine diffusion processes on the canonical state space. This includes an existence proof for such processes, where we regard affine processes as solutions to infinite dimensional stochastic differential equations with values in Hilbert spaces. Several examples of infinite dimensional affine processes accompany our findings.

This talk is based on joint work with Thorsten Schmidt and Weijun Yu.

Large ranking games with diffusion control

Session 6
Thu, 12:00

Julian Wendt

Friedrich-Schiller-Universität Jena

We consider a symmetric game with the following features: each player can control the fluctuation intensity of an individual dynamic state process up to some time horizon; the players whose final states are among the best $\alpha \in (0,1)$ of all states receive a fixed prize. Within the mean field limit version of the game we compute an explicit equilibrium, a threshold strategy that consists in choosing the maximal fluctuation intensity when the state is below a given threshold, and the minimal intensity eise. We show that for large n the n-tupel of the threshold strategy provides an approximate Nash-equilibrium of the n-player game. We also derive the rate at which the approximate equilibrium reward and the best response reward converge to each other, as the number of players n tends to infinity.

The random periodic solution of a stochastic differential equation with a monotone drift and its numerical approximation

Session 3
Tue, 12:00

Yue Wu

University of Oxford

We study the existence and uniqueness of the random periodic solution for a stochastic differential equation (SDE) with a one-sided Lipschitz condition (also known as monotonicity condition) and the convergence of its numerical approximation via the backward Euler-Maruyama method. The existence of the random periodic solutions are shown as the limits of the pull-back flows of the SDE and discretized SDE respectively. We establish a convergence rate of the strong error for the backward Euler-Maruyama method and obtain the weak convergence result for the approximation of the periodic measure.

2. Spatial stochastics and random structures

Chairs: Peter Mörters, Matthias Reitzner

Live Sessions

Session 1 (Monday, 13:45) - zoom room 4

- **Gilles Bonnet** (live invited talk): Weak convergence of the intersection point process of Poisson hyperplanes
- **Carina Betken**: Central limit theory for geometric functionals of Poisson cylinder processes
- **Alexander Hinsen**: A shape theroem for first passage percolation on the Poisson-Gilbert disk model
- **Ghulam Qadir**: Flexible Modeling of Variable Asymmetries in Cross-Covariance Functions for Multivariate Random Fields
- **Mathias Sonnleitner**: Random sections of p-ellipsoids, optimal recovery and Gelfand numbers of diagonal operators
- **Johannes Wieditz**: Characteristic and necessary minutiae in fingerprints

Session 2 (Tuesday, 12:00)- zoom room 3

- **Jan Swart** (live invited talk): Frozen percolation on the Marked Binary Branching Tree
- **David Criens**: A parabolic Harnack principle for balanced difference equations in random environments
- **Peter Nejjar**: Cutoff Profile of ASEP on a Segment
- **Maximilian Nitzschner**: Disconnection for the harmonic crystal with random conductances
- **Marco Seiler**: On the contact process in a time evolving edge random environment
- **Weile Weng**: Quenched functional CLT for random walks in random environments with bounded cycle representation

Session 3 (Wednesday, 12:00)- zoom room 2

- **Daniel Hug** (live invited talk): Skeletons and shapes related to Poisson hyperplanes in hyperbolic space
- **Anna Gusakova**: Limit theorems for random convex chain and random polygone in polygone
- **Christian Hirsch**: Simplicial percolation
- **Kathrin Meier**: Central limits for generalized descents and inversions in permutations and finite Weyl group elements
- **Moritz Otto**: Limit laws for large kth-nearest neighbor balls
- **Federico Pianoforte**: Exponential approximation of the minimum interpoint distance in Kolmogorov distance

Session 4 (Thursday, 12:00)- zoom room 3

- **Mathew Penrose** (live invited talk): Coverage and connectivity in stochastic geometry
- **Andrej Depperschmidt**: Local limit theorem for random walk on oriented percolation
- **Peter Gracar**: Characterizing the infinite component of the weight-dependent random graph in 1D
- **Arne Grauer**: Chemical distance in weight-dependent random connection models
- **Nannan Hao**: Graph distances in scale-free percolation
- **Lukas Lüchtrath**: Percolation phase transition in weight-dependent random conncection models

Session 5 (Friday, 12:00)- zoom room 3

- **Alexander Holroyd** (live invited talk): Random matching and fairness
- **Thomas Finn**: Non-equilibrium multi-scale analysis and coexistence in competing first-passage percolation
- **Nico Heizmann**: Internal diffusion limited aggregation on the Sierpinski gasket
- **Konrad Kolesko**: Limit theorems for general branching processes
- **Bas Lodewijks**: Fine asymptotics of high degrees in weighted random recursive trees with i.i.d. bounded weights
- **Alexis Prévost**: Critical exponents for a percolation model on transient graphs
- **Quan Shi**: Diffusion limits of random walks on integer compositions and their applications

Invited Talks

Weak convergence of the intersection point process of Poisson hyperplanes

Session 1
Mon, 13:45
live

Gilles Bonnet

Ruhr-Universität Bochum

I will present the result of the article "Weak convergence of the intersection point process of Poisson hyperplanes", accepted for publication in Annales de l'Institut Henri Poincaré (B) Probabilités et Statistique. This paper deals with the intersection point process of a stationary and isotropic Poisson hyperplane process in $\mathbb{R}^d$ of intensity t>0, where only hyperplanes that intersect a centred ball of radius R>0 are considered. Taking $R = t - dd + 1$ it is shown that this point process converges in distribution, as $t \to \infty$, to a Poisson point process on $\mathbb{R}^d \setminus 0$ whose intensity measure has power-law density proportional to $|x| - (d+1)$ with respect to the Lebesgue measure. A bound on the speed of convergence in terms of the Kantorovich-Rubinstein distance is provided as well. In the background is a general functional Poisson approximation theorem on abstract Poisson spaces. Implications on the weak convergence of the convex hull of the intersection point process and the convergence of its f-vector are also discussed, disproving and correcting thereby a conjecture of Devroye and Toussaint [J. Algorithms 14.3 (1993), 381–394] in computational geometry.

Random matching and fairness

Session 5
Fri, 12:00
live

Alexander Holroyd

University of Bristol

What is fairness, and to what extent is it practically achievable? I'll talk about a simple mathematical model under which one might hope to understand such questions. Red and blue points occur as independent homogeneous Poisson processes of equal intensity in Euclidean space, and we try to match them to each other. We would like to minimize the sum of some function (say, a power, gamma) of the distances between matched pairs. This does not make sense, because the sum is infinite, so instead we satisfy ourselves with minimizing *locally*. If the points are interpreted as agents who would like to be matched as close as possible, the parameter encodes a measure of fairness - large gamma means that we try to avoid occasional very bad outcomes (long edges), even if that means inconvenience to others - small gamma means everyone is in it for themselves.

In dimension 1 we have a reasonably complete picture, with a phase transition at gamma = 1. For gamma < 1 there is a unique minimal matching, while for gamma > 1 there are multiple matchings but no stationary solution. In higher dimensions, even existence is not clear in all cases.

Based on joint work with Svante Janson and Johan Wastlund.

Skeletons and shapes related to Poisson hyperplanes in hyperbolic space

Session 3
Wed, 12:00
live

Daniel Hug

Karlsruher Institut für Technologie

A Poisson process of hyperplanes in Euclidean space induces a tessellation of space into convex cells. The union of the k-faces of these cells is the k-skeleton of the tessellation. For the intersection of the k-skeleton with an expanding observation window W, the asymptotic behaviour of its k-dimensional volume has been studied. In particular, variance asymptotics and central limit theorems are known. Moreover, the shape of the Crofton cell or the typical cell of the tessellation has been explored under the condition of large size (Kendall's problem). In this talk, we discuss corresponding problems in d-dimensional hyperbolic space, where new phenomena can be observed.

Coverage and connectivity in stochastic geometry

Session 4
Thu, 12:00
live

Mathew Penrose
University of Bath

Consider a random uniform sample of size n over a smooth d-dimensional compact manifold A with boundary, embedded in R^m, with $m \geq d \geq 2$. The coverage threshold T_n is the smallest r such that the union Z of geodetic balls of radius r centred on the sample points covers A. The connectivity threshold K_n is twice the smallest r required for Z to be connected. These thresholds are random variables determined by the sample, and are of interest, for example, in wireless communications, set estimation, and topological data analysis. We discuss new results on the large-n limiting distributions of T_n and K_n. When A has unit volume, with θ denoting the volume of the unit ball in R^d, these take the form of weak convergence of $n\theta T_n^d - (2-2/d)\log n - a_d \log(\log n)$ to a Gumbel-type random variable with cumulative distribution function

$$F(x) = \exp(-b_d e^{-x} + c_d(\text{perimeter}(A))e^{-x/2}),$$

for suitable constants a_d, c_d with $b_d = \mathbf{1}\{d=2\}$. The corresponding result for K_n takes the same form with different constants a_d, c_d.

Frozen percolation on the Marked Binary Branching Tree

Session 2
Tue, 12:00
live

Jan Swart
The Czech Academy of Sciences

In frozen percolation, edges of an infinite graph are activated at i.i.d. uniformly distributed times. At its activation time, an edge becomes open provided its endvertices are not burnt; in the opposite case, the edge freezes. Here, at the times of some fixed (deterministic) set of possible burning times, all vertices that are part of an infinite open cluster are burnt. I will discuss the question whether frozen percolation is well defined, unique in distribution, or even almost surely unique. The answer turns out to depend subtly on the graph and the set of possible burning times. Detailed results have recently been proved for frozen percolation on the Marked Binary Branching Tree, but several questions remain open.

Contributed Talks

Central limit theory for geometric functionals of Poisson cylinder processes

Session 1
Mon, 13:45

Carina Betken
Ruhr-Universität Bochum

We consider the union set of a stationary Poisson process of cylinders in $\mathbb{R}^n$, where by a cylinder we understand any set of the form $X \times E$, where E is an m-dimensional linear subspace of $\mathbb{R}^n$ and $X \subset E^{\perp}$ is a compact subset in the orthogonal complement of E. The concept jointly generalises those of a Boolean model and a Poisson hyperplane or m-flat process. Using techniques from Malliavin-Stein method we develop a quantitative central limit theory for a broad class of geometric functionals, including volume, surface area and intrinsic volumes.

A parabolic Harnack principle for balanced difference equations in random environments

Session 2
Tue, 12:00

David Criens
University of Freiburg

We consider difference equations in balanced, i.i.d. environments which are not necessary elliptic. In the talk we present a parabolic Harnack inequality (PHI) for non-negative solutions to the discrete heat equation satisfying a (rather mild) growth condition, and we identify the optimal Harnack constant for the PHI. By way of an example, we also explain that a growth condition is necessary and that our growth condition is sharp. The talk is based on joint work with Noam Berger (TU Munich).

Local limit theorem for random walk on oriented percolation

Session 4
Thu, 12:00

Andrej Depperschmidt
Universität Erlangen-Nürnberg

We consider a directed random walk on the backbone of the supercritical oriented percolation cluster in dimensions $d+1$ with $d \geq 3$ being the spatial dimension. For this random walk we prove an annealed local central limit theorem and a quenched local limit theorem. The latter shows that the quenched transition probabilities of the random walk converge to the annealed transition probabilities reweighted by a function of the medium centred at the target site. This function is the density of the unique measure which is invariant for the point of view of the particle, is absolutely continuous with respect to the annealed measure and satisfies certain concentration properties.

Non-equilibrium multi-scale analysis and coexistence in competing first-passage percolation

Session 5
Fri, 12:00

Thomas Finn
University of Bath

We study a natural competition model on Z^d called first-passage percolation in a hostile environment that consists of two competing processes FPP_1 and FPP_λ. FPP_1 initially occupies only the origin and spreads through the edges of Z^d at rate 1. FPP_λ is initially dormant in seeds that are placed according to a product of Bernoulli measures of parameter p. Once FPP_1 attempts to occupy a seed, the occupation is suppressed, and the seed is activated. Activated seeds then spread FPP_λ at rate $\lambda > 0$. Once FPP_1 or FPP_λ occupies a site, it is occupied by that process henceforth. We discuss results for the model and a recent proof that establishes a regime of coexistence, in which both processes simultaneously occupy infinite connected components with positive probability. A major difficulty of the model is the surprising lack of monotonicity, in that adding a seed could lead to FPP_1 occupying more sites. A key contribution of our work is the introduction of a technique called multi-scale analysis with non-equilibrium feedback that can analyse systems that lack equilibrium dynamics and monotonicity.

Based on joint work with Alexandre Stauffer.

Characterizing the infinite component of the weight-dependent random graph in 1D

Session 4
Thu, 12:00

Peter Gracar
University of Cologne

We consider a broad range of spatially embedded random graphs, defined on the 1 dimensional Poisson point process, which combine scale-free degree distributions and long-range effects. Every point is assigned an independent weight and given the weight and position of the points, an edge is formed between any pair independently with a probability depending on the two weights and the distance between the points. Short edges and connections to vertices with large weights are made to be more likely than their counterparts. We study the existence of an infinite component and whether the component can survive a random attack where a proportion of edges is removed. We show that in addition to the percolation phase transition above which the graph remains topologically unchanged under random attack, a cross-over occurs at a second parameter regime, under which no infinite component is possible. Joint work with Lukas Lüchtrath and Christian Mönch

---

Chemical distance in weight-dependent random connection models

Session 4
Thu, 12:00

Arne Grauer
University of Cologne

We study geometric random graphs defined on the points of a Poisson process in d-dimensional space, which additionally carry independent random marks. Edges are established at random using the marks of the endpoints and the distance between points in a flexible way. Our framework includes a large class of graph models with scale-free distribution and edges spanning large distances. We give a sharp criteria for the absence of ultrasmallness of the graphs and in the ultrasmall regime establish a limit theorem for the chemical distance of two points. Here the boundary of the ultrasmall regime and the limit theorem depends not only on the power-law exponent of the graph but also on a geometric quantity, the influence of the spatial distance of two typical points on the probability of an edge connecting them. The talk is based on joint work with Peter Gracar and Peter Mörters.

Limit theorems for random convex chain and random polygone in polygone.

Session 3
Wed, 12:00

Anna Gusakova
Ruhr University, Bochum

In this talk we consider two probabilistic models in the plane.

The first model is called a random convex chain and it can be constructed as follows. Let us consider a triangle T with vertices $(0,0)$, $(0,1)$ and $(1,0)$ and n independent points uniformly distributed in T. The boundary of the convex hull of those random points together with $(0,1)$ and $(1,0)$ form the so called convex chain. We will be interested in the number of vertices N_n of a convex chain. In this talk we will show that the sequence of probability generating functions of N_n forms a sequence of orthogonal polynomials. As a consequence, we show that N_n has ultra-log-concave distribution and we derive a number of probabilistic limit theorems.

As a second model we will also consider the number of vertices of the convex hull of independent vectors uniformly distributed in a given convex polygon. In this talk we derive the optimal speed of convergence in the CLT.

This talk is based on joint work with Chritoph Thäle and Matthias Reitzner.

Graph distances in scale-free percolation

Session 4
Thu, 12:00

Nannan Hao
LMU Munich

Scale-free percolation is a spatial random graph model with vertex set $\mathbb{Z}^d$. Vertices x and y are connected with probability depending on i.i.d. vertex weights and the Euclidean distance. Depending on the various parameters involved, we get a rich phase diagram. We study graph distances (in comparison to Euclidean distances). Our main attention is on a regime where graph distances are (poly-)logarithmic in the Euclidean distance. We obtain improved bounds on the logarithmic exponents. In the light tail regime, the correct exponent is identified.

Internal diffusion limited aggregation on the Sierpinski gasket

Session 5
Fri, 12:00

Nico Heizmann
TU Chemnitz

Internal diffusion limited aggregation (IDLA) is a random aggregation model on a graph G, whose clusters are formed by random walks started in the origin (some fixed vertex) and stopped upon visiting a previously unvisited site. IDLA originated as a model for chemical annihilation processes. Surfaces on which such chemical processes are used on are characteristically rough. This roughness can be modeled by prefractal graphs. The topic of this talk are the asymptotic shape and the fluctuations of IDLA on a typical prefractal graph: the Sierpinski gasket graph.

A shape theroem for first passage percolation on the Poisson-Gilbert disk model

Session 1
Mon, 13:45

Alexander Hinsen

WIAS - Weierstraß-Institut für Angewandte Analysis und Stochastik

We consider first passage percolation on the super-critical Poisson-Gilbert disk model in $\mathbb{R}^d$ with $d \geq 2$. Here, the vertices are given by a homogeneous Poisson point process. Two vertices are connected if their Euclidian distance is smaller than a fixed $r > 0$ and assigned an i.i.d. passage time. We denote by H_t the set of all points such that there is a path of edges to the origin on which the sum of their passage times does not exceed t. We will prove that H_t/t converges to a ball almost surely. This is joint work with Benedikt Jahnel, Daniel Valesin, Lucas R. de Lima and Cristian Coletti.

Simplicial percolation

Session 3
Wed, 12:00

Christian Hirsch

University of Groningen

This talk introduces weak and strong simplicial percolation as models for continuum percolation based on random simplicial complexes in Euclidean space. Weak simplicial percolation is defined through infinite sequences of k-simplices sharing a (k-1)-dimensional face. In contrast, strong simplicial demands the existence of an infinite k-surface, thereby generalizing the lattice notion of plaquette percolation.

We discuss the sharp phase transition for weak simplicial percolation and derive several relationships between weak simplicial percolation, strong simplicial percolation, and classical vacant continuum percolation. If time permits, we will see how sharp phase transition in simplicial percolation helps when proving CLTs in topological data analysis.

This talk is based on joint work with Daniel Valesin.

Limit theorems for general branching processes

Session 5
Fri, 12:00

Konrad Kolesko

Justus-Liebig-Universität Gießen

For a branching random walk $\{S(u)\}_{u\in\mathbb{T}}$ with nonnegative increments and a function $\phi : [0,\infty) \mapsto \mathbb{R}$ we define a general branching process $\mathcal{Z}_t^\phi$ by

$$\mathcal{Z}_t^\phi := \sum_{u\in\mathbb{T}} \phi(t - S(u)).$$

Nerman showed in 1981 that, under some mild assumptions including the existence of the Malthusian parameter $\alpha > 0$, the process $\mathcal{Z}_t^\varphi$ rescaled by $e^{-\alpha t}$ converges almost surely to a constant c (depending on ϕ and reproduction point process) times the limit of Nerman's martingale W.

We establish an asymptotic expansion of $\mathcal{Z}_t^\varphi$ as $t \to \infty$ up to a Gaussian fluctuation.

Our result unifies and extends various earlier limit theorems for specific branching processes available in the literature.

Fine asymptotics of high degrees in weighted random recursive trees with i.i.d. bounded weights.

Session 5
Fri, 12:00

Bas Lodewijks
University of Bath

In this talk I will discuss the properties of high degrees in weighted random recursive trees, when the i.i.d. weights are almost surely bounded. In this case, it is known that the maximum degree grows as $\log(n)/\log(1+\mu)$, where μ is the mean of the weights. Under additional assumptions on the weight distribution, we are able to obtain higher-order corrections for the maximum degree as well as near-maximum degrees. This work recovers and extends results known for random recursive trees.

Percolation phase transition in weight-dependent random conncection models

Session 4
Thu, 12:00

Lukas Lüchtrath
University of Cologne

We investigate a large class of weighted random graphs on the points of a Poisson process in d-dimensional space, which combine scale-free degree distributions and long-range effects. Given the weight and position of the points, an edge between any pair of points is formed independentely with a probability depending on the two weights of the points and their distance. We give preferences to short edges and connections to vertices with large weights. We consider natural examples for such random graphs and show that there exists a parameter regime where no subcritical phase for these graphs exists. We show that this can only happen if a sufficiently small power law exponent of the degree distribution is combined with a strong long range effect showing the significant effect of clustering to the graphs' topology. In other words, we fully characterize the parameter regime where there is a non-trivial percolation phase transition and show how it depends on the degree distribution as well as on geometric model parameters.

The talk is based on joint work with Peter Gracar and Peter Mörters.

Central limits for generalized descents and inversions in permutations and finite Weyl group elements

Session 3
Wed, 12:00

Kathrin Meier
Ruhr-University Bochum

We start introducing generalized descents and generalized inversions in permutations as antichains and order ideals in the root poset for permutations. We provide mean and variance for antichains and use a dependency graph method to conclude a central limit theorem. We then generalize this result to antichains in root posets for finite Weyl groups. We finally discuss a possible central limit theorem for order ideals. This is joint work in progress with Christian Stump, generalizing the study of d-descents by Pike and Bona.

Cutoff Profile of ASEP on a Segment

Session 2
Tue, 12:00

Peter Nejjar
Bonn University

We study the mixing behavior of the Asymmetric Simple Exclusion Process (ASEP) on a segment of length N. The main result is that for particle densities in $(0,1)$, the total-variation cutoff window of ASEP is $N^1/3$ and the cutoff profile is $1-F_{\mathrm{GUE}}$, where F_{GUE} is the Tracy-Widom distribution function. This also gives a new proof of the cutoff itself, shown earlier by Labbé and Lacoin.

Disconnection for the harmonic crystal with random conductances

Session 2
Tue, 12:00

Maximilian Nitzschner
New York University - Courant Institute

This talk gives an introductory overview of level-set percolation of the discrete Gaussian free field on the Euclidean lattice in three and more dimensions, equipped with uniformly elliptic random conductances. For a compact set A, we also introduce the "disconnection event" that the level-set of the field below a given level disconnects the discrete blow-up of A from the boundary of an enclosing box, and present recently obtained quenched asymptotic upper and lower bounds on the probability of this event.

Based on joint work with Alberto Chiarini (TU Eindhoven).

Limit laws for large kth-nearest neighbor balls

Session 3
Wed, 12:00

Moritz Otto
University of Magdeburg

Let $X_1, \dots, X_n$ be a sequence of independent random points in $\mathbb{R}^d$ with common Lebesgue density f. Under some conditions on f, we obtain a Poisson limit theorem, as $n \to \infty$, for the number of large probability kth-nearest neighbor balls of $X_1, \dots, X_n$. Our result generalizes previuos work which refers to the special case $k = 1$. Our proof is completely different since it employs the Chen-Stein method instead of the method of moments. Moreover, we obtain a rate of convergence for the Poisson approximation.

Exponential approximation of the minimum interpoint distance in Kolmogorov distance

Session 3
Wed, 12:00

Federico Pianoforte
University of Bern

In this talk, we present some general criteria for the approximation of the minimum (or maximum) of a collection of random variables by a suitable random variable in the Kolmogorov distance. As an application of our findings, we consider a stationary Poisson process η_t on $\mathbb{R}^d$ with intensity $t > 0$, and we show that a transform of the minimum interpoint Euclidean distance between the points of η_t with midpoint in $[0, 1]^d$ converges to an exponential random variable at a rate of $1/t$ in the Kolmogorov distance.

Critical exponents for a percolation model on transient graphs

Session 5
Fri, 12:00

Alexis Prévost
University of Cambridge

"We consider the percolation problem induced by the level sets of the Gaussian free field on the cable system associated to the underlying transient graph. On a large class of graphs, this model exhibits a phase transition at level zero, and we are interested in its near-critical behavior. An essential role will be played by a certain capacity functional of the level sets, which appear naturally in a differential formula associated with this model. In particular, one can explicitly compute the law of the capacity of bounded clusters, and deduce asymptotics for various quantities in the critical or near-critical regime, such as the percolation probability or two points function. Finally, I will present the expected set of critical exponents for this model, which is probably valid for a class of similar percolation problems. The talk is based on joint work with Alexander Drewitz and Pierre-François Rodriguez."

Flexible Modeling of Variable Asymmetries in Cross-Covariance Functions for Multivariate Random Fields

Session 1
Mon, 13:45

Ghulam Qadir

Heidelberg Institute for Theoretical Studies

The geostatistical analysis of multivariate spatial data for inference as well as joint predictions (co-kriging) ordinarily relies on modeling of the marginal and cross-covariance functions. While the former quantifies the spatial dependence within variables, the latter quantifies the spatial dependence across distinct variables. The marginal covariance functions are always symmetric; however, the cross-covariance functions often exhibit asymmetries in the real data. Asymmetric cross-covariance implies change in the value of cross-covariance for interchanged locations on fixed order of variables. Such change of cross-covariance values is often caused due to the spatial delay in effect of the response of one variable on another variable. These spatial delays are common in environmental processes, especially when dynamic phenomena such as prevailing wind and ocean currents are involved. Here, we propose a novel approach to introduce flexible asymmetries in the cross-covariances of stationary multivariate covariance functions. The proposed approach involves modeling the phase component of the constrained cross-spectral features to allow for asymmetric cross-covariances. We show the capability of our proposed model to recover the cross-dependence structure and improve spatial predictions against traditionally used models through multiple simulation studies. Additionally, we illustrate our approach on a real trivariate dataset of particulate matter concentration (PM2.5), wind speed and relative humidity. The real data example shows that our approach outperforms the traditionally used models, in terms of model fit and spatial predictions.

On the contact process in a time evolving edge random environment

Session 2
Tue, 12:00

Marco Seiler

Georg-August-Universität Göttingen

Recently, there has been an increasing interest in interacting particle systems on evolving random graphs, respectively in time evolving random environments. We study the contact process on (infinite) connected graphs with bounded degree in a general time evolving edge random environment called the the background process and described by an autonomous Markov process. This background process determines which edges are open and which are closed. The infection can only spread along open edges, but recoveries occur as usually independently at a constant rate. We consider the case where the dynamics of the background process is described through an ergodic finite range spin system and discuss sufficient conditions, posed on these dynamics, such that it is possible to study for example the influence of the initial configuration of the system on the critical value for survival, the connection between the phase transition of survival and the phase transition of ergodicity and non-ergodicity or if it is possible to prove complete convergence. We will also state a few possible background processes which satisfy these conditions such as dynamical percolation. Here, an edge is updated independently of all other edges at a certain rate and at an update event, the edge is opened or closed at random, independently of its former state. This special case was already considered by Linker and Remenik in 2019. Their focus was mainly on the critical value for survival when the environment is started stationary and its asymptotic behaviour for slow and fast update speed.

This is joint work with Anja Sturm.

Diffusion limits of random walks on integer compositions and their applications

Session 5
Fri, 12:00

Quan Shi

University of Mannheim

A composition of a positive integer n is a sequence of positive integers that sum to n. In this talk, I will introduce a family of interval-partition-valued diffusions that arise as limits of random walks on integer compositions. These infinite-dimensional diffusions have Poisson–Dirichlet (pseudo-)stationary distributions. This model is closely related to Pitman–Dubins Chinese restaurant processes and random walks on integer partitions studied by Borodin–Olshanski and Petrov. I will also talk about some applications in population genetics and continuum-tree-valued dynamics. This talk is based on joint work with Noah Forman, Douglas Rizzolo, and Matthias Winkel.

Random sections of p-ellipsoids, optimal recovery and Gelfand numbers of diagonal operators

Session 1
Mon, 13:45

Mathias Sonnleitner

Johannes Kepler University Linz

We present bounds on the circumradius of random sections of small codimension of generalized ellipsoids and compare them with the minimal radius in the case of polynomially decaying semi-axes. We rephrase this also in terms of recovering vectors from such ellipsoids and explain how this is connected to known results on the Gelfand numbers of diagonal operators. This is joint work with A. Hinrichs and J. Prochno.

Quenched functional CLT for random walks in random environments with bounded cycle representation

Session 2
Tue, 12:00

Weile Weng

TU Berlin

We consider a special type of model for non-reversible random walks in random environments on $\mathbb{Z}^d$ ($d \geq 2$): the probability space for the random environment is invariant and ergodic with respect to spacial shifts; and almost every environment can be represented as a collection of oriented nearest-neighbor cycles with uniformly bounded length, and with weights that only depend on each cycle. In particular, such random environment is doubly stochastic. The model is motivated by the quest to investigate quenched functional CLT in non-reversible RWRE without imposing uniform ellipticity condition. In this 10-minute talk, we will introduce the model, and outline the proof strategy. This is joint work with Jean-Dominique Deuschel (TU Berlin) and Martin Slowik (University of Mannheim).

Characteristic and necessary minutiae in fingerprints

Johannes Wieditz

Georg-August University Göttingen

Session 1
Mon, 13:45

Fingerprints feature a ridge line pattern inducing an undirected orientation field (OF) which usually features some singularities. In fingerprint recognition, a fingerprint is usually reduced to a point pattern consisting of minutiae, i.e. points where the ridge lines end or fork. Whenever the OF features divergent ridge lines (e.g. near singularities), a nearly constant ridge frequency (RF) necessitates the generation of more ridge lines, originating at minutiae. We call these the necessary minutiae. A statistical analysis reveals that fingerprints feature additional minutiae which occur at rather arbitrary locations. We call these the random minutiae or, since they may convey fingerprint individuality beyond OF and RF, the characteristic minutiae.

In consequence, a minutiae point pattern is assumed to be a realization of the superposition of two stochastic point processes modelling the necessary and the characteristic minutiae, respectively. We propose a Bayesian approach using an MCMC-based minutiae separating algorithm (MiSeal) which allows for estimation of the underlying model parameters as well as of the posterior probabilities of minutiae being characteristic. In a proof of concept, we provide evidence that for two different prints with similar OF the characteristic minutiae convey fingerprint individuality giving rise for improvements in matching algorithms for commercial and forensic applications using characteristicness of minutiae.

3. Limit theorems, large deviations and extremes

Chairs: Anja Janssen, Hanna Döring

Live Sessions

Session 1 (Monday, 13:45)- zoom room 5

- **Martin Wendler** (live invited talk): Convergence of U-Processes in Hölder Spaces with Application to Robust Change-Point Detection
- **Martin Möhle**: A restaurant process with cocktail bar
- **Osvaldo Angtuncio Hernandez**: On the profile of trees with a given degree sequence
- **Rafal Lochowski**: Moments and tails of hitting times of Bessel processes and convolutions of elementary mixtures of exponential distributions

Session 2 (Tuesday, 13:45)- zoom room 1

- **Jan Nagel** (live invited talk): Sum rules via large deviations: polynomial potentials and the multi-cut regime
- **Mátyás Barczy**: Limit theorems for Bajraktarevic and Cauchy quotient means of independent identically distributed random variables
- **Ecaterina Sava-Huss**: Interpolating between random walk and rotor walk
- **Michael Juhos**: The asymptotic volume of intersections of p-ellipsoids
- **Lorenz Frühwirth**: Large deviation principles for lacunary sums

Session 3 (Wednesday, 12:00)- zoom room 1

- **Claudia Küppelberg** (live invited talk): Consistent estimation of a latent tree based on extreme observations
- **Daniel Willhalm**: Upper large deviations for power-weighted edge lengths in spatial random networks
- **Xiaochuan Yang**: Component count of random geometric graphs in the intermediate regime
- **Frank Röttger**: Total positivity in graphical extremes

Session 4 (Thursday, 12:00)- zoom room 1

- **Marco Oesting** (live invited talk): Evaluation of binary classifiers for extremes
- **Imma Valentina Curato**: Central limit theorems for stationary random fields under weak dependence with application to ambit and mixed moving average fields
- **Carolin Kleemann**: Maximum interpoint distance of high-dimensional random vectors
- **Carolin Forster**: Non-stationary max-stable models with an application to heavy rainfall data

Session 5 (Thursday, 13:45)- zoom room 1

- **Giovanni Peccati** (live invited talk): Quantitative two-scale stabilization on the Poisson space
- **Yuki Ueda**: On rate of convergence towards free extreme value distributions
- **Tabea Glatzel**: The speed of random walk on Galton-Watson trees with vanishing conductances
- **Yanjia Bai**: Refined Large Deviation Principle for Branching Brownian Motion Conditioned to Have a Low Maximum

Invited Talks

Consistent estimation of a latent tree based on extreme observations

Session 3
Wed, 12:00
live

Claudia Küppelberg
Technische Universität München

The Latent River Problem has emerged as a flagship problem for causal discovery in extreme value statistics. We provide a simple and efficient algorithm QTree, to solve the Latent River Problem that outperforms existing methods. QTree returns a directed graph and achieves almost perfect recovery on the Upper Danube, the existing benchmark dataset, as well as on new data from the Lower Colorado River in Texas. It can handle missing data, and has an automated parameter tuning procedure. In our paper, we also show that, under a Bayesian network model for extreme values with propagating noise, the QTree algorithm returns for $n \to \infty$ a.s. the correct tree.

Sum rules via large deviations: polynomial potentials and the multi-cut regime

Session 2
Tue, 13:45
live

Jan Nagel
Technische Universität Dortmund

A sum rule is an identity connecting the entropy of a measure with the coefficients involved in the construction of its orthogonal polynomials, or Jacobi coefficients. In previous works we developed a probabilistic method to prove sum rules using large deviation theory. We consider the weighted spectral measure of random matrices and prove a large deviation principle when the size of the matrix tends to infinity. The measure may be described by its spectral information or its Jacobi coefficients. This allows to write the rate function in two different ways, which leads to the sum rule.In this talk I present an extension to unitarily invariant random matrices in the multi-cut case, when the limit of the spectral measure is supported by several disjoint interval. In this case we can still prove a large deviation principle for the weighted spectral measure. Additionally, if the potential is a polynomial, we have an alternative description for the rate function in terms of the Jacobi coefficients. The talk is based on a joint work with Fabrice Gamboa and Alain Rouault.

Evaluation of binary classifiers for extremes

Session 4
Thu, 12:00
live

Marco Oesting
Universität Stuttgart

Machine learning classification methods usually assume that all possible classes are sufficiently present within the training set. Due to their inherent rarities, extreme events are always under-represented and classifiers tailored for predicting extremes need to be carefully designed to handle this under-representation. In this talk, we address the question of how to assess and compare classifiers with respect to their capacity to capture extreme occurrences. To this end, we propose and study a risk function adapted to extremal classifiers that allows us to cover both the cases of asymptotic dependence and independence between input and response variables. Furthermore, we show that the empirical risk estimator is asymptotically normal. A simulation study compares different classifiers and indicates their performance with respect to our risk function.This is joint work with Juliette Legrand and Philippe Naveau.

Quantitative two-scale stabilization on the Poisson space

Session 5
Thu, 13:45
live

Giovanni Peccati

Université du Luxembourg

I will illustrate some new quantitative bounds, quantifying the proximity to Gaussian of functionals of Poisson random measures. These bounds are based on the notion of "two-scale stabilization", and allow one to recover quantitative versions of central limit theorems based on the notion of "weak geometric stabilization" (Penrose and Yukich, 2001). Some geometric applications - in particular, to random forests and models of combinatorial optimization - will be briefly described. Based on joint work with R. Lachièze-Rey and X. Yang.

Convergence of U-Processes in Hölder Spaces with Application to Robust Change-Point Detection

Session 1
Mon, 13:45
live

Martin Wendler

Otto-von-Guericke-Universität Magdeburg

Two-sample U-statistics with are natural candidates for the two-sample problem (testing the hypothesis that the marginal distribution in two samples is the same). To detect a changed segment (a so called epidemic changes) in a time series, we use a weighted maximum of such U-statistics with different starting and end points of the possible changed segment. To study the asymptotic behavior of test statistic obtained this way, we need a functional limit theorems for general U-processes in Hölder spaces under short-range dependence. Under the alternative, we show that the test is consistent. We also study the finite sample behavior via simulations and apply the statistics to a real data example. We demonstrate that our test does perform better than weighted CUSUM tests if the data is heavy tailed. Joint work with Alfredas Račkauskas.

Contributed Talks

On the profile of trees with a given degree sequence

Session 1
Mon, 13:45

Osvaldo Angtuncio Hernandez
University Duisburg-Essen

A degree sequence is a sequence $s = (N_i, i \geq 0)$ of non-negative integers satisfying $1 + \sum i N_i = \sum N_i < \infty$. We are interested in the uniform distribution $\mathbb{P}_s$ on rooted plane trees whose degree sequence equals s, giving conditions for the convergence of the profile (sequence of generation sizes) as the size of the tree goes to infinity. This provides a more general formulation and a probabilistic proof of a conjecture due to Aldous (1991). Our formulation contains and extends results in this direction obtained previously by Drmota and Gittenberger (1997) and Kersting (2011). A technical result is needed to ensure that trees with law $\mathbb{P}_s$ have enough individuals in the first generations, and this is handled through novel path transformations and fluctuation theory of exchangeable increment processes. As a consequence, we obtain a boundedness criterion for the inhomogeneous continuum random tree introduced by Aldous, Miermont and Pitman (2004).

Refined Large Deviation Principle for Branching Brownian Motion Conditioned to Have a Low Maximum

Session 5
Thu, 13:45

Yanjia Bai
University of Bonn

Conditioning a branching Brownian motion to have an atypically low maximum leads to a suppression of the branching mechanism. In this note, we consider a branching Brownian motion conditioned to have a maximum below $\sqrt{2}\alpha t (\alpha < 1)$. We study the precise effects of an early/late first branching time and a low/high first branching location under this condition. We do so by imposing additional constraints on the first branching time and location. We obtain large deviation estimates, as well as the optimal first branching time and location given the additional constraints.

Limit theorems for Bajraktarevic and Cauchy quotient means of independent identically distributed random variables

Session 2
Tue, 13:45

Mátyás Barczy
University of Szeged, Hungary

We derive strong laws of large numbers and central limit theorems for Bajraktarevic, Gini and exponential- (also called Beta-type) and logarithmic Cauchy quotient means of independent identically distributed (i.i.d.) random variables. The exponential- and logarithmic Cauchy quotient means of i.i.d. random variables behave asymptotically normal with the usual square root scaling just like the geometric means of the given random variables. Somewhat surprisingly, the multiplicative Cauchy quotient means of i.i.d. random variables behave asymptotically in a rather different way: in order to get a non-trivial normal limit distribution a time dependent centering is needed. This is a joint work with Pal Burai. The talk is based on the paper:

Barczy, M. and Burai, P. (2021): Limit theorems for Bajraktarevic and Cauchy quotient means of independent identically distributed random variables. To appear in Aequationes mathematicae. Available also on Arxiv: 1909.02968

Central limit theorems for stationary random fields under weak dependence with application to ambit and mixed moving average fields

Session 4
Thu, 12:00

Imma Valentina Curato

Ulm University

We obtain central limit theorems for stationary random fields employing a novel measure of dependence called θ-lex weak dependence. We show that this dependence notion is more general than strong mixing, i.e., it applies to a broader class of models. Moreover, we discuss hereditary properties for θ-lex and η-weak dependence and illustrate the possible applications of the weak dependence notions to the study of the asymptotic properties of stationary random fields. Our general results apply to mixed moving average fields (MMAF in short) and ambit fields. We show general conditions such that MMAF and ambit fields, with the volatility field being an MMAF or a p-dependent random field, are weakly dependent. For all the models mentioned above, we give a complete characterization of their weak dependence coefficients and sufficient conditions to obtain the asymptotic normality of their sample moments. Finally, we give explicit computations of the weak dependence coefficients of MSTOU processes and analyze under which conditions the developed asymptotic theory applies to CARMA fields.

Non-stationary max-stable models with an application to heavy rainfall data

Session 4
Thu, 12:00

Carolin Forster

University of Stuttgart

In recent years, max-stable processes have become a popular choice for modeling spatial extremes because they arise as the asymptotic limit of rescaled maxima of independent and identically distributed random processes. Apart from few exceptions for the class of extremal-t processes, existing literature mainly focuses on models with stationary dependence structures. In this talk, we propose a novel non-stationary approach that can be used for both Brown-Resnick and extremal-t processes – two of the most popular classes of max-stable processes – by including covariates in the corresponding variogram and correlation functions, respectively. We apply our new approach to extreme precipitation data in Germany and compare the results to existing stationary models in terms of Takeuchi's information criterion (TIC). Our results indicate that, for this case study, non-stationary models are more appropriate than stationary ones.

Large deviation principles for lacunary sums

Session 2
Tue, 13:45

Lorenz Frühwirth

Karl-Franzens Universität Graz

Lacunary sums show under certain regularity assumptions the same behaviour as sums of iid random variables. In this talk we consider the asymptotics of different lacunary sums on a large deviation scale.

The speed of random walk on Galton-Watson trees with vanishing conductances

Session 5
Thu, 13:45

Tabea Glatzel
TU Dortmund

We consider random walks on Galton-Watson trees with random conductances. That is, given a Galton-Watson tree, the edges are assigned positive random conductances and the random walk traverses an edge with a probability proportional to its conductance. On these trees, the distance of the walker to the root satisfies a law of large numbers with limit the effective velocity, or speed of the walk. The speed is given as an expectation of ratios of effective conductances which means that it cannot be explicity computed. We study the regularity of the speed as a function of the distribution of conductances. In particular, we investigate how the speed changes when the conductances on a positive fraction of edges tend to zero. In this case the limit of the speed is smaller than the speed of the random walk as usually defined on trees with positive extinction probability.

The asymptotic volume of intersections of p-ellipsoids

Session 2
Tue, 13:45

Michael Juhos
Kar-Franzens-Universität Graz

Motivated by classical works of Schechtman and Schmuckenschläger on intersections of ℓ_p-balls and recent ones in information-based complexity relating random sections of ellipsoids and the quality of random information in approximation problems, we study the threshold behavior of the asymptotic volume of intersections of generalized p-ellipsoids. The non-critical behavior is determined under a spectral flatness (Wiener entropy) condition on the semi-axes. In order to understand the critical case at the threshold, we prove a central limit theorem for q-norms of points sampled uniformly at random from a p-ellipsoid, which is obtained under Noether's condition on the semi-axes.

Maximum interpoint distance of high-dimensional random vectors

Session 4
Thu, 12:00

Carolin Kleemann
Ruhr-Universität Bochum

A limit theorem for the largest interpoint distance of p i.i.d. points on $\mathbb{R}^n$ to the Gumbel distribution is proven, where the number of points $p = p_n$ tends to infinity as the dimension of the points $n \to \infty$. The proof is based on the Chen-Stein Poisson approximation method and uses the sum structure of the interpoint distances. Therefore, an asymptotic distribution of a more general object is derived.

Moments and tails of hitting times of Bessel processes and convolutions of elementary mixtures of exponential distributions

Session 1
Mon, 13:45

Rafal Lochowski
Warsaw School of Economics

I will present explicit estimates of right and left tails and exact (up to universal, multiplicative constants) estimates of tails and moments of hitting times of Bessel processes. The latter estimates are obtained from more general estimates of moments and tails established for convolutions of elementary mixtures of exponential distributions.

A restaurant process with cocktail bar

Session 1
Mon, 13:45

Martin Möhle

University of Tübingen

In addition to the features of the two-parameter Chinese restaurant process (CRP), the restaurant under consideration has a cocktail bar and hence allows for a wider range of (bar and table) occupancy mechanisms. The model depends on three real parameters α, θ_1 and θ_2 fulfilling certain conditions. Results known for the two-parameter CRP are carried over to this model. We study the number of customers at the cocktail bar, the number of customers at each table and the number of occupied tables after n customers have entered the restaurant. For $\alpha > 0$ the number of occupied tables, properly scaled, is asymptotically three-parameter Mittag–Leffler distributed as n tends to infinity. We provide representations for the two- and three-parameter Mittag-Leffer distribution leading to effcient random number generators for these distributions. The proofs draw heavily from methods known for exchangeable random partitions, martingale methods known for generalized Pólya urns and results known for the two-parameter CRP.

Keywords: Occupied tables, Pólya urn, random partition, restaurant process, three-parameter Mittag-Leffler distribution

---

Total positivity in graphical extremes

Session 3
Wed, 12:00

Frank Röttger

Université de Genève

Engelke and Hitz (2020) introduce a general theory for conditional independence and graphical models for extremes. Similarly to Gaussian distributions, they show that for Hüsler-Reiss distributions, extremal conditional independencies are encoded through a transformation of the corresponding parameter matrix.

Multivariate total positivity of order 2 (MTP2) is a strong form of positive dependence that induces many interesting properties in graphical modeling. A multivariate Gaussian distribution is MTP2 when its precision matrix is an M-matrix, i.e., when all the non-diagonal entries in the inverse covariance matrix are non-positive. We introduce the notion of extremal MTP2 (EMTP2) and show that a Hüsler-Reiss distribution is EMTP2 if and only if the inverse Farris transform of its parameter matrix is the inverse of a diagonally dominant M-matrix. Furthermore, we prove that an extremal tree model is EMTP2 if and only if its bivariate marginals are EMTP2. This implies that all Hüsler-Reiss tree models are EMTP2, while in comparison Gaussian tree models are only EMTP2 if their covariance matrices are non-negative.

Similar to Lauritzen et al. (2019) we construct a coordinate descent algorithm to find a pseudo maximum likelihood estimator under the EMTP2 constraint and show that it enforces a sparse extremal graphical model. We apply this method to real data.

This is joint work with Sebastian Engelke and Piotr Zwiernik.

References:

Sebastian Engelke and Adrien S. Hitz. Graphical models for extremes. Journal of the Royal Statistical Society: Series B (Statistical Methodology), 82(4): 871-932, 2020.

Steffen Lauritzen, Caroline Uhler, and Piotr Zwiernik. Maximum likelihood estimation in Gaussian models under total positivity. Ann. Statist., 47(4): 1835-1863, 2019.

Interpolating between random walk and rotor walk

Session 2
Tue, 13:45

Ecaterina Sava-Huss

University of Innsbruck, Austria

We consider a stochastic process on the integers which interpolates between classical random walk and deterministic walk, and we investigate its scaling limit. We conclude with several open problems. This is based on joint work with Lionel Levine and Wilfried Huss.

On rate of convergence towards free extreme value distributions

Session 5
Thu, 13:45

Yuki Ueda
Hokkaido University of Education

In this talk, we give a rate of convergence in the Kolmogorov distance between a distribution of the renormalized maximum of freely independent, identically distributed non-commutative random variables and the free extreme distribution via the Stein's method.

Upper large deviations for power-weighted edge lengths in spatial random networks

Session 3
Wed, 12:00

Daniel Willhalm
University of Groningen

We study large-volume asymptotics of the sum of power-weighted edge lengths $\sum_{e\in E}|e|^\alpha$ in a spatial random network constructed on a Poisson point process in a bounded sampling window and for α larger than the dimension d. We develop a framework such that, for suitable graphs, we can study the upper large deviations for this functional, i.e., the probability that it exceeds its expectation by a factor of $(1+r)$. A graph fits in the framework under some monotonicity and continuity conditions of the score function, representing the power-weighted edge lengths of one node. The rate function is given as an optimization problem and conditioned on this unlikely event, statements are possible about how the graph is structured. In particular, there is a condensation phenomenon, meaning that the excess is caused by a negligible portion of Poisson points. The upper large deviations and the statements about condensation are applied to the k-nearest neighbor graph and the relative neighborhood graph.

Component count of random geometric graphs in the intermediate regime

Session 3
Wed, 12:00

Xiaochuan Yang
University of Bath

We consider the number of components of random geometric graphs in the intermediate regime where the connection radius r and the average number of points n satisfy $nr^d \to \infty$ and $nr^d/\log n \to 0$. We obtain i) a concentration bound ii) a central limit theorem with explicit error bounds. Based on a joint work with Mathew Penrose (Bath).

4. Finance, insurance and risk: Modelling

Chairs: Kathrin Glau, Thomas Mikosch

Live Sessions

Session 1 (Monday, 12:00)- zoom room 1

- **Kathrin Glau** (live invited talk): Large-scale Least-squares Monte Carlo method
- **Maximilian Diehl**: Evolution of a Life Insurer's Balance Sheet and Robust Strategies for Investing and Financing
- **Marek Oheim**: Unisex Tariffs in Life Insurance
- **Andrew Allan**: A càdlàg rough path foundation for robust finance

Session 2 (Monday, 13:45)- zoom room 1

- **Agnes Handwerk** (live invited talk): From mathematicization in economics to modern financial mathematics
- **Laura Körber**: Merton's optimal investment problem with jump signals
- **Francesca Primavera**: Lévy type signature models
- **Wei Xu**: The Microstructure of Stochastic Volatility Models with Self-Exciting Jump Dynamics

Session 3 (Tuesday, 12:00)- zoom room 1

- **Paul Embrechts** (live invited talk): The public communication and understanding of risk
- **Josef Anton Strini**: Approximation of Gerber-Shiu functions
- **Domagoj Demeterfi**: Chebyshev interpolation to accelerate credit exposure calculations
- **Cassandra Milbradt**: A cross border market model with limited transmission capacities

Session 4 (Wednesday, 13:45)- zoom room 1

- **Mario Wüthrich** (live invited talk): LocalGLMnet: interpretable deep learning for tabular data
- **Linus Wunderlich**: The deep parametric PDE method for option pricing
- **Matteo Gambara**: Consistent recalibration equity models
- **Yufei Zhang**: A fast iterative algorithm for mean-field control problems with non-smooth costs

Session 5 (Wednesday, 15:30)- zoom room 1

- **Luitgard Veraart** (live invited talk): When does portfolio compression reduce systemic risk?
- **Simon Pojer**: Ruin Probabilities in a Markovian Shot-Noise Environment
- **Thorsten Schmidt**: No arbitrage in insurance
- **Stephan Eckstein**: Calculating robust price bounds using generative adversarial nets

Session 6 (Thursday, 13:45)- zoom room 3

- **Laurence Carassus** (live invited talk): Quasi-sure essential supremum and applications to finance
- **Julia Ackermann**: Optimal trade execution in a stochastic order book model
- **Evgueni Kivman**: Small impact analysis in stochastically illiquid markets
- **Johannes Wiesel**: Entropic Optimal Transport: Convergence of Potentials

Session 7 (Friday, 13:45)- zoom room 2

- **Birgit Rudloff** (live invited talk): Time consistency of the mean-risk-problem
- **Nilusha Karunathunge Gamage**: Equilibrium Pricing Model for Index Insurance
- **Emanuel Rapsch**: Towards Energy Transition: Designing Incentives for a Game of Change
- **Shijie Xu**: Statistical Consistent Term Structures Are Flat

Invited Talks

Quasi-sure essential supremum and applications to finance

Session 6
Thu, 13:45
live

Laurence Carassus

Léonard de Vinci Pôle Universitaire

A notion of essential supremum is developed when the uncertainty is measured by a family of non-dominated and non-compact probability measures. It provides new perspectives on super-replication and allows the Absence of Instantaneous Profit (AIP) to be characterized.

The public communication and understanding of risk

Session 3
Tue, 12:00
live

Paul Embrechts

ETH Zurich

This talk is based on a new book co-authored with Valerie Chavez-Demoulin (UNIL Lausanne) and Marius Hofert (University of Waterloo). I plan to give a short overview of the topics treated. As the book is aimed at a more general audience, through examples, I will comment on the understanding and communication of risk in some particular examples.

Large-scale Least-squares Monte Carlo method

Session 1
Mon, 12:00
live

Kathrin Glau

Queen Mary University of London

Approximating multivariate functions in finance is traditionally approached through least-squares Monte Carlo Simulation. Its implementation faces a computational bottleneck when increasing the number of basis functions in order to achieve higher accuracies. In order to overcome this burden, we propose a new combined methodology. Its key feature is exploiting recent developments in weighted sampling and leveraging the randomized extended Kaczmarz algorithm to solve large-scale least-squares problems

---

From mathematicization in economics to modern financial mathematics

Session 2
Mon, 13:45
live

Agnes Handwerk

Freie Journalistin

As a journalist, I have studied the influence of economic theory on the development of financial mathematics as an independent discipline. For this research I interviewed leading mathematicians like Hans Föllmer. When he was a student of probability theory in the 1960s he and many of his generation searched for applications of pure mathematics: they became protagonists of an important period which started in the 1970s. After his studies Hans Föllmer was lecturer in the United States and taught introductions to the martingale theory. One of his students at that time was David Kreps. A few years later they met again at the Mathematische Forschungsinstitut in Oberwolfach when Kreps gave a talk on his article on applications of martingale theory in finance. This article was co-authored with Harrison and Pliska and became very influential. Their results gave the development a tremendous boost and motivated many mathematicians to participate in the formation of the (mathematical) theory of finance and insurance. In my talk I will report how the personal collaboration between mathematicians and economists, and a general development brought forth the theory of financial mathematics. This talk is based on my book: "Von der Mathematisierung in der Ökonomie zur modernen Finanzmathematik" published by Springer Nature in spring 2021.

Time consistency of the mean-risk-problem

Session 7
Fri, 13:45
live

Birgit Rudloff

Vienna University of Economics and Business

The mean-risk problem is a well known and extensively studied problem in Mathematical Finance. Its aim is to identify portfolios that maximize the expected terminal value and at the same time minimize the risk. The usual approach in the literature is to combine the two to obtain a problem with a single objective. This scalarization, however, comes at the cost of time inconsistency. In this work we show that these difficulties disappear by considering the problem in its natural form, that is, as a vector optimization problem. As such the mean-risk problem can be shown to satisfy under mild assumptions an appropriate notion of time consistency. It holds that the upper images, whose boundaries are the efficient frontiers, recurse backwards in time. This proposed set-valued Bellman's principle seems to be the appropriate notion for a vector optimization problem. This recursion can be used to compute the efficient frontiers backwards in time. We briefly discuss that the proposed set-valued Bellman's principle turns out to be useful also for other applications, like dynamic Nash games or superhedging under transaction costs.

When does portfolio compression reduce systemic risk?

Session 5
Wed, 13:45
live

Luitgard Veraart

London School of Economics

We analyse the consequences of portfolio compression on systemic risk. Portfolio compression is a post-trading netting mechanism that reduces gross positions while keeping net positions unchanged and it is part of the financial legislation in the US (Dodd-Frank Act) and in Europe (European Market Infrastructure Regulation). We derive necessary structural conditions for portfolio compression to be harmful and discuss policy implications. In particular, we show that the potential danger of portfolio compression comes from defaults of firms that conduct portfolio compression. If no defaults occur among those firms that engage in compression, then portfolio compression always reduces systemic risk.

LocalGLMnet: interpretable deep learning for tabular data

Session 4
Wed, 15:30
live

Mario Wüthrich

ETH Zurich

n this presentation we discuss the LocalGLMnet architecture which is tailored to the needs of many applied disciplines using regression modeling. The LocalGLMnet starts from a classical generalized linear model (GLM), and it makes this GLM more flexible by learning the regression parameters with a neural network. Like this we receive a network architecture that is flexible, interpretable, that allows for variable selection and that allows for the study of interactions. We demonstrate this on an explicit example and we give an outlook of potential applications and extensions. This is joint work with Ronald Richman.

Contributed Talks

Optimal trade execution in a stochastic order book model

Session 6
Thu, 13:45

Julia Ackermann
University of Giessen

We analyze an optimal trade execution problem in a financial market with stochastic liquidity. To this end we set up a limit order book model in continuous time where both order book depth and resilience may evolve randomly in time. We allow for trading in both directions and for càdlàg semimartingales as execution strategies. We find that, under appropriate assumptions, the minimal execution costs are characterized by a quadratic BSDE. We further identify conditions under which an optimal execution strategy exists and investigate qualitative aspects of optimal strategies such as appearance of strategies with infinite variation. This talk is based on a joint work with Thomas Kruse and Mikhail Urusov.

A càdlàg rough path foundation for robust finance

Session 1
Mon, 12:00

Andrew Allan
ETH Zürich

Using rough path theory, we provide a pathwise foundation for stochastic Itô integration, which covers most commonly applied trading strategies and mathematical models of financial markets, including those under Knightian uncertainty. To this end, we introduce the so-called Property (RIE) for càdlàg paths, which is shown to imply the existence of a càdlàg rough path and of quadratic variation in the sense of Föllmer. We prove that the corresponding rough integrals exist as limits of left-point Riemann sums along a suitable sequence of partitions. This allows one to treat integrands of non-gradient type, and gives access to the powerful stability estimates of rough path theory. Based on joint work with Chong Liu and David Prömel.

Chebyshev interpolation to accelerate credit exposure calculations

Session 3
Tue, 12:00

Domagoj Demeterfi
Queen Mary University of London

In this talk, we present a practical method based on Chebyshev interpolation to speed up exposure calculations for derivative trades. Credit exposure measures the potential loss to a party if its counterparty defaults on a financial derivative deal. Calculating exposure typically requires frequent evaluation of an expensive derivative pricer. The central idea of our approach is to replace the costly pricer with its polynomial approximation in numerical computations, which can significantly reduce the required runtime. We assess the performance of the proposed approach by comparing it with a direct exposure calculation method called full re-evaluation. We consider four different types of equity derivatives (European, digital, barrier, and Bermudan option) in different option pricing models (Black-Scholes-Merton, Merton's jump-diffusion, and Heston's stochastic volatility model).

Evolution of a Life Insurer's Balance Sheet and Robust Strategies for Investing and Financing

Session 1
Mon, 12:00

Maximilian Diehl

Technische Universität Kaiserslautern

We devise a stochastic asset-liability management model for a life insurance company allowing for different strategies for investing in the capital market and (re-) financing the due obligations. We analyze its influence on the balance sheet within a low-interest rate environment and compare the strategies regarding chances and risks in the presence of transaction costs. Here, the goal consists of investigating optimal and robust strategies. Furthermore, a flexible procedure for the generation of insurers' compressed contract portfolios that respects the given biometric structure is presented. The introduced balance sheet model is in line with the principles of double-entry bookkeeping as required in accounting. We especially focus on the incorporation of new business, i.e. the addition of newly concluded contracts and thus of insured in each period. Efficient simulations are retained by integrating new policies into existing cohorts according to contract-related criteria. We prove new results on the consistency of the balance sheet equations. In simulation studies for several scenarios regarding the business form of today's life insurers and the expected inflow of new customers, we utilize these to analyze the short- and long-term behavior as well as the stability of the components of the balance sheet for different asset-liability approaches.

Calculating robust price bounds using generative adversarial nets

Session 5
Wed, 15:30

Stephan Eckstein

Universität Hamburg

To calculate robust price bounds, one has to identify risk-neutral distributions that correspond to extreme cases given the constraints on the market, leading for instance to the martingale optimal transport problem. This talk presents a method to solve such optimization problems using neural networks and a MinMax approach. This is in close relation to generative adversarial nets, and we showcase how techniques from this field can be used to both justify this approach theoretically, as well as solve the problems numerically. We also give results on adapting this technique to causal optimal transport.

Equilibrium Pricing Model for Index Insurance

Session 7
Fri, 13:45

Nilusha Karunathunge Gamage

Technische Universität Kaiserslautern

The main objective of this work is to build an equilibrium pricing model for index insurance. Index insurance is a simplified form of insurance in which indemnity payments are based on values obtained from an index that serves as a proxy for losses. There are many studies about different aspects of index insurance for agriculture risk. But only a few studies discuss the index insurance in an equilibrium framework. The market equilibrium by considering both demand and supply of an area based index insurance is discussed in (2).

We consider risk averse farmers and a risk averse insurer for our equilibrium model. We derive the equilibrium demand and price by assuming exponential utility functions for both insureds and insurer. Due to the heterogeneity among the farmers they are exposed to different levels of basis risk. Basis risk is one of the most unfavorable features of index insurance and it is the difference between insurance payout and actual loss of the insured. In our work we study how this basis risk affects the market equilibrium. In addition to that we analyze subsidies on the equilibrium premium to increase the demand for index insurance. Motivated by the idea behind the model in (1), we build up an equilibrium model by considering two groups of farmers.

Our numerical results show that equilibrium demand increases as the basis risk decreases. The analysis of premium subsidies shows that a group of low risk averse farmers does not always require higher subsidy rate than a group of high risk averse farmers to reach a given level of demand. According to the equilibrium model for two risk groups, the low risk group subsidizes the high risk group when both groups pay the same premium.

(1) Sass, J. and Seifried, F. T. (2014). Insurance markets and unisex tariffs: is the european court of justice improving or destroying welfare? Scandinavian Actuarial Journal, 2014(3):228–254

(2) Shen, Z. and Odening, M. (2013). Coping with systemic risk in index-based crop insurance. Agricultural Economics, 44(1):1–13

Consistent recalibration equity models

Session 4
Wed, 13:45

Matteo Gambara
ETH Zürich

Consistent Recalibration models (CRC) have been introduced to capture in necessary generality the dynamic features of term structures of derivatives' prices. Several approaches have been suggested to tackle this problem, but all of them, including CRC models, suffered from numerical intractabilities mainly due to the presence of complicated drift terms or consistency conditions. We overcome this problem by machine learning techniques, which allow to store the crucial drift term's information in neural network type functions. This yields first time dynamic term structure models which can be efficiently simulated.

Small impact analysis in stochastically illiquid markets

Session 6
Thu, 13:45

Evgueni Kivman
Humboldt-Universität zu Berlin

We consider an optimal liquidation problem with instantaneous price impact and stochastic resilience for small instantaneous impact factors. Within our modelling framework, the optimal portfolio process converges to the solution of an optimal liquidation problem with general semi-martingale controls when the instantaneous impact factor converges to zero. Our results provide a unified framework within which to embed the two most commonly used modelling frameworks in the liquidation literature and show how liquidation problems with portfolio processes of unbounded variation can be obtained as limiting cases in models with small instantaneous impact as well as a microscopic foundation for the use of semi-martingale liquidation strategies. Our convergence results are based on novel convergence results for BSDEs with singular terminal conditions and novel representation results of BSDEs in terms of uniformly continuous functions of forward processes.

Merton's optimal investment problem with jump signals

Session 2
Mon, 13:45

Laura Körber
TU Berlin

Modelling the information flow is a crucial part in financial decision making. In fact, the point in time when an investor gets access to new information as well as their possibilities to react determine the chosen investment strategy and its outcome. In this talk, we therefore present a new framework of stochastic control using the theory of Meyer-σ-fields allowing for more flexibility in the information structure. As an illustration, we look at Merton's problem of optimal investment and introduce a jump signal. By means of dynamic programming, we solve the problem explicitly and determine the investor's optimal strategy in dependence of the arriving jump signal. Finally, we discuss the value of improving the signal's quantity and quality in the particular case of Gaussian jumps.

A cross border market model with limited transmission capacities

Session 3
Tue, 12:00

Cassandra Milbradt
Humboldt-Universität zu Berlin

The integrated Cross Border Intraday (XBID) market summarizes the limit orders of 22 European countries in a shared order book. This heavily increases the liquidity in contrast to single national intraday electricity markets with continuous trading. As a starting point of an appropriate model for the XBID market we consider the reduced form representation of two limit order book (LOB) models. In this model, each LOB is represented by the bid and ask prices and the queue length, i.e. the number of orders at the best bid and ask price. We extend this model in two ways: First, in order to describe possible cross border trading, we include interactions between the two order books to the market microstructure. Second, since in the XBID market there is limited transmission capacity, we need to restrict the number of possible cross border trades. In doing so, it is crucial to keep track of the origin of an incoming order and to count the number of cross border trades in both directions. Latter is done by introducing a two-sided capacity process to the microscopic description. If the order arrival time and the size of an individual order converges to zero, we show that the discrete-time model can be approximated in the limit by a continuous-time regime switching process. The heavy traffic limit switches between an active regime in which the national order books are coupled and an inactive regime in which traders can only execute market orders against limit orders with the same origin.

Unisex Tariffs in Life Insurance

Session 1
Mon, 12:00

Marek Oheim
TU Kaiserslautern

Gender-specific premiums were banned from the European insurance market, by the end of 2012, as a consequence of a ruling of the European Court of Justice. In order to analyze the effects of these mandatory unisex tariffs, we set up a market model which is inspired by a paper of Sass and Seifried (2014). Afterwards, we provide studies on the equilibrium premiums of classic life insurance products in monopolistic and competitive insurance markets. In our model we can show that unisex tariffs might result in a complete dropout of one gender from the insurance market. Since calculating unisex premiums can be very costly, we present a regression approach based on neural networks to circumvent this concern.

References:

J. Sass, F.T. Seifried (2014). Insurance markets and unisex tariffs: Is the European Court of Justice improving or destroying welfare? Scandinavian Actuarial Journal. 2014, 228-254.

Ruin Probabilities in a Markovian Shot-Noise Environment

Session 5
Wed, 15:30

Simon Pojer
Graz University of Technology

For several decades there have been efforts to generalize the classical risk model introduced by Lundberg over 100 years ago. To resolve one of the disadvantages of the Cramér-Lundberg model, namely the constant jump intensity of the Poisson process, we consider a risk model with a counting process whose intensity is a Markovian shot-noise process. Due to this structure, we can apply the theory of PDMPs on a multivariate process containing the intensity and the reserve process, which allows us to identify a family of martingales. Eventually, we exploit change of measure techniques to derive an upper bound for the ruin probability in this model. Assuming a recurrent structure of the shot-noise process, even the asymptotic behaviour of the ruin probability can be determined.

Lévy type signature models

Session 2
Mon, 13:45

Francesca Primavera
University of Vienna

Signature models have recently entered the field of Mathematical Finance. However, despite the presence of jumps in financial data, the signature models for asset prices proposed so far have only dealt with the continuous-path setting. Based on recent results on the signature of càdlàg paths, we define signature-based models which include jumps. The approach that we follow consists of parameterizing the model itself or its characteristics as linear functions of the signature of an augmented Lévy process, interpreted as market's primary underlying process. We discuss the validity of first principles like absence of arbitrage and solve the hedging problem by adopting a local risk minimization approach. Finally, we prove that the signature of a generic multivariate Lévy process is a polynomial process on the extended tensor algebra and derive its expected value via polynomial technology. We show that this result, when applied to the market's primary process, is efficient in terms of calibration to market data. The talk is based in an ongoing joint work with Christa Cuchiero and Sara Svaluto-Ferro.

Towards Energy Transition: Designing Incentives for a Game of Change

Session 7
Fri, 13:45

Emanuel Rapsch
Technische Universität (TU) Berlin

In the economics of the energy transition, an important question is which policy mechanism a regulator should design in order to stimulate irreversible investment of firms in a market economy. Typically, the firms face a common trend (e.g. technological, consumer preference-related) whose future realisation is exposed to substantial uncertainty. This uncertainty, however, is not sufficiently observable from the regulator's perspective.

Following real options and principal-agent theory, we propose a stylised model for quantifying that uncertainty and, hence, its impact on both the firms' timing decisions and the regulator's policy. Mathematically, we interpret this objective in terms of a stopping game problem under common noise. Subgame-perfect feedback Nash equilibria can be described in terms of a convenient coupled system of differential equations. Such equilibria may be manifold, and hence the ability of the regulator to influence the game's output depends on the situation.

This can be illustrated via concrete examples arising in markets facing the energy transition, for instance the automotive industry. The model captures key features related to the strategic problem under uncertainty. If time permits, an outlook on the following "inversion" of the model may be given: with the roles of firms and consumers being switched, the homogeneity of the players yields a (controlled) mean-field game problem of stopping, a subject that has seen important contributions in the very last years.

This project is based on a collaboration with my doctoral supervisor Christoph Belak.

No arbitrage in insurance

Session 5
Wed, 15:30

Thorsten Schmidt
Universität Freiburg

In this work we study the valuation of insurance contracts from a fundamental viewpoint. We start from the observation that insurance contracts are inherently linked to financial markets, be it via interest rates, or – as in hybrid products, equity-linked life insurance and variable annuities – directly to stocks or indices. By defining portfolio strategies on an insurance portfolio and combining them with financial trading strategies we arrive at the notion of insurance-finance arbitrage (IFA). A fundamental theorem provides two sufficient conditions for presence or absence of IFA, respectively. For the first one it utilizes the conditional law of large numbers and risk-neutral valuation. As a key result we obtain a simple valuation rule, called QP-rule, which is market consistent and excludes IFA. Utilizing the theory of enlargements of filtrations we construct a tractable framework for general valuation results, working under weak assumptions. The generality of the approach allows to incorporate many important aspects, like mortality risk or dependence of mortality and stock markets which is of utmost importance in the recent corona crisis. For practical applications, we provide an affine formulation which leads to explicit valuation formulas for a large class of hybrid products.

Approximation of Gerber-Shiu functions

Session 3
Tue, 12:00

Josef Anton Strini
Graz University of Technology

We formulate an approach to approximate Gerber-Shiu or discounted penalty-functions in renewal risk models incorporating simulated data. The associated partial-integro-differential equation is solved using numerical methods, since explicit solutions can only be achieved under restrictive assumptions. The convergence of the resulting procedure is shown via a sequence of approximating piecewise-deterministic Markov processes (PDMPs). This approach allows us to make use of estimated PDMP characteristics and to examine its effect on the resulting Gerber-Shiu functions. We observe that the hazard rate estimator is the main cause of instability. Finally, comparing our results to those obtained via Monte-Carlo simulation, we realize that the impact on the latter of the estimation procedure is quite small.

Entropic Optimal Transport: Convergence of Potentials

Session 6
Thu, 13:45

Johannes Wiesel
Columbia University

We study the potential functions that determine the optimal density for ϵ-entropically regularized optimal transport, the so-called Schrödinger potentials, and their convergence to the counterparts in classical optimal transport, the Kantorovich potentials. In the limit $\epsilon \to 0$ of vanishing regularization, strong compactness holds in L^1 and cluster points are Kantorovich potentials. In particular, the Schrödinger potentials converge in L^1 to the Kantorovich potentials as soon as the latter are unique. These results are proved for all continuous, integrable cost functions on Polish spaces. In the language of Schrödinger bridges, the limit corresponds to the small-noise regime. This talk is based on joint work with Marcel Nutz.

The deep parametric PDE method for option pricing

Session 4
Wed, 13:45

Linus Wunderlich
Queen Mary University of London

We present the deep parametric PDE method to approximate multi-asset option prices simultaneously for a range of times, states and option parameters of interest. We use an unsupervised learning approach with deep neural networks to numerically solve the high-dimensional parametric partial differential equation. Motivated by the deep Galerkin method, the loss function is only based on the partial differential equation. After a single training phase, the option price for different time, state and parameter values can be computed in millisecond. We evaluate the performance with examples of up to 25 dimensions and present an application in counterparty credit risk.

Statistical Consistent Term Structures Are Flat

Session 7
Fri, 13:45

Shijie Xu
University of Liverpool

This talk is concerned with finite dimensional models for the entire term structure for energy futures. For the term structure of interest rate markets, it has essentially been shown by D. Filipović and J. Teichmann that finite dimensional models are flat. With a realtively simple example, we show that this does not hold for energy markets. Finite dimensional term structure are in our context built from a finite dimensional diffusion process and a function from the finite dimensional space to the set of all curves which will be identified with the energy term structure. From a practical perspective, it is desirable that once the function from the finite dimensional space is fixed, the diffusion coefficient of the process is estimated from data. This requires that the given function is compatible with any attainable diffusion coefficient coming from the statistical procedure. We show that this compatibility implies flatness. This talk is based on joint work with Paul Krühner (WU Vienna).

The Microstructure of Stochastic Volatility Models with Self-Exciting Jump Dynamics

Session 2
Mon, 13:45

Wei Xu
Humboldt-Universität zu Berlin

We provide a general probabilistic framework within which we establish scaling limits for a class of continuous-time stochastic volatility models with self-exciting jump dynamics. In the scaling limit, the joint dynamics of asset returns and volatility is driven by independent Gaussian white noises and two independent Poisson random measures that capture the arrival of exogenous shocks and the arrival of self-excited shocks, respectively. Various well-studied stochastic volatility models with and without self-exciting price/volatility co-jumps are obtained as special cases under dierent scaling regimes. We analyze the impact of external shocks on the market dynamics, especially their impact on jump cascades and show in a mathematically rigorous manner that many small external shocks may trigger endogenous jump cascades in asset returns and stock price volatility.

A fast iterative algorithm for mean-field control problems with nonsmooth costs

Session 4
Wed, 13:45

Yufei Zhang

London School of Economics

A PDE-based accelerated gradient algorithm is proposed to seek optimal feedback controls of McKean-Vlasov dynamics subject to nonsmooth costs, whose coefficients involve mean-field interactions both on the state and action. It exploits a forward-backward splitting approach and iteratively refines the approximate controls based on the gradients of smooth costs, the proximal maps of nonsmooth costs, and dynamically updated momentum parameters. At each step, the state dynamics is realized via a particle approximation, and the required gradient is evaluated through a coupled system of nonlocal linear PDEs. A portfolio liquidation problem with trade crowding and nonsmooth transaction costs is presented, which shows that compared with existing pure data-driven algorithms, our algorithm captures important structures of the optimal feedback control, and achieves a robust performance with respect to parameter perturbation.

5. Finance, insurance and risk: Statistics

Chairs: Jeanette Wörner, Johanna Ziegel

Live Sessions

Session 1 (Tuesday, 15:30)- zoom room 1

- **Kirstin Strokorb** (live invited talk): Conditional Independence in Extremes
- **Julia Steinmetz**: Asymptotic Theory and Bootstrap Inference for Mack's model
- **Tobias Fissler**: Backtesting CoVaR using Multi-Objective Elicitability
- **Paolo Colusso**: Learning Multivariate Financial Data with Tensor Completion and Deep Learning
- **Julian Sester**: A deep learning approach to data-driven model-free pricing and to martingale optimal transport
- **Fatlinda Avdullai**: Artificial Neural Network and Time Series Approaches to Forecast the Triggering Factor for Private Health Insurance Tarifs
- **Natalia Nolde** (live invited talk): Reverse stress testing and multivariate extremes

Invited Talks

Reverse stress testing and multivariate extremes

Session 1
Tue, 15:30
live

Natalia Nolde
University of British Columbia

Reverse stress testing of a financial portfolio aims to identify scenarios for risk factors that lead to a specified adverse portfolio outcome, typically a large portfolio loss. The stress scenarios of interest naturally need to be probable yet extreme. In order to capture movements of risk factors that result in large portfolio losses, we propose two methods to estimate stress scenarios using extrapolation ideas based on techniques from multivariate extreme value theory. Such methods allow to deal with data scarcity in the joint tail regions while allowing for more flexible model assumptions focused on extremes. We study asymptotic behaviour of the proposed estimators, investigate their finite-sample performance in simulation studies and apply them to real data in a case study.

Conditional Independence in Extremes

Session 1
Tue, 15:30
live

Kirstin Strokorb
Cardiff University

Statistical modelling of complex dependencies in extreme events requires meaningful sparsity structures in multivariate extremes. In this context two perspectives on conditional independence and graphical models have recently emerged: One that focuses on threshold exceedances and multivariate pareto distributions, and another that focuses on max-linear models and directed acyclic graphs. What connects these notions is the exponent measure that lies at the heart of each approach. In this work we develop a notion of conditional independence defined directly on the exponent measure (and even more generally on measures that explode at the origin) that extends recent work of Engelke and Hitz (2019), who had been confined to homogeneous measures with density. We prove easier checkable equivalent conditions to verify this new conditional independence in terms of a reduction to simple test classes, probability kernels and density factorizations. This provides a pathway to graphical modelling among general multivariate (max-)infinitely distributions. Structural max-linear models turn out to form a Bayesian network with respect to our new form of conditional independence. Joint work (in progress) with Sebastian Engelke and Jevgenijs Ivanovs

---

Contributed Talks

Artificial Neural Network and Time Series Approaches to Forecast the Triggering Factor for Private Health Insurance Tariffs

Session 1
Tue, 15:30

Fatlinda Avdullai
Technische Universität Kaiserslautern

The possibility for premium adjustments in German private health insurance depends on the so-called triggering factor which is a linear extrapolation of total claim quotients of the last three years. To predict its value as early as possible is important for risk management purposes. We therefore propose and compare various frameworks ranging from time series via regression to neural networks and hybrid approaches to forecast the triggering factor. While among the traditional methods regression with seasonal ARIMA errors performs best, an artificial neural network combined with time series forecasting models or trained on deseasonalized and detrended data performs best overall.

Learning Multivariate Financial Data with Tensor Completion and Deep Learning

Session 1
Tue, 15:30

Paolo Colusso
EPFL

Machine learning methods require an efficient handling of massive datasets. In many situations in finance, however, data only come in small sizes. At the other hand of the spectrum, the size of the data can be too large to be tractable in learning applications. This is for instance the case when training data are the numerical solution to multi-dimensional problems. We propose a method which exploits tensor completion and is conceived to overcome both issues. We represent training data as the entries of high-dimensional tensors: tensor completion allows us to effectively reconstruct, store and process partially observed tensors by a low-rank approximation. It is then possible to exploit the compressed representation within the batch-based training algorithms of deep neural networks. We demonstrate the effectiveness of the method by learning pricing functions for American and basket options. The approach is shown to be accurate, faster than benchmark methods, and suited to both scarce and high-dimensional training data.

Backtesting CoVaR using Multi-Objective Elicitability

Session 1
Tue, 15:30

Tobias Fissler
Vienna University of Economics and Business (WU)

Backtesting risk measure forecasts requires identifiability (for model calibration and validation) and elicitability (for model comparison). We show that the widely-used systemic risk measure conditional value-at-risk (CoVaR), which measures the risk of a position Y given that a reference position X is in distress, fails to be identifiable and elicitable on its own. As a remedy, we establish the joint identifiability of CoVaR together with the value-at-risk (VaR) of the reference position X. While this resembles the situation of the classical risk measures expected shortfall (ES) and VaR concerning identifiability, a joint elicitability result fails. Therefore, we introduce a completely novel notion of multivariate scoring functions equipped with some order, which are therefore called multi-objective scores. We introduce and investigate corresponding notions of multi-objective elicitability, which may prove beneficial in various applications beyond finance. In particular, we prove that conditional elicitability of two functionals implies joint multi-objective elicitability with respect to the lexicographic order on the two-dimensional Euclidean space, which makes it applicable in the context of CoVaR together with VaR. We describe corresponding comparative backtests of Diebold-Mariano type, for two-sided and 'one and a half'-sided hypotheses, which respect the particularities of the lexicographic order and which can be used in a regulatory setting. We demonstrate the viability of these backtesting approaches in simulations and in an empirical application to DAX 30 and S&P 500 returns.

The talk is based on the preprint https://arxiv.org/abs/2104.10673 which is joint work with Yannick Hoga.

A deep learning approach to data-driven model-free pricing and to martingale optimal transport

Session 1
Tue, 15:30

Julian Sester
NTU Singapore

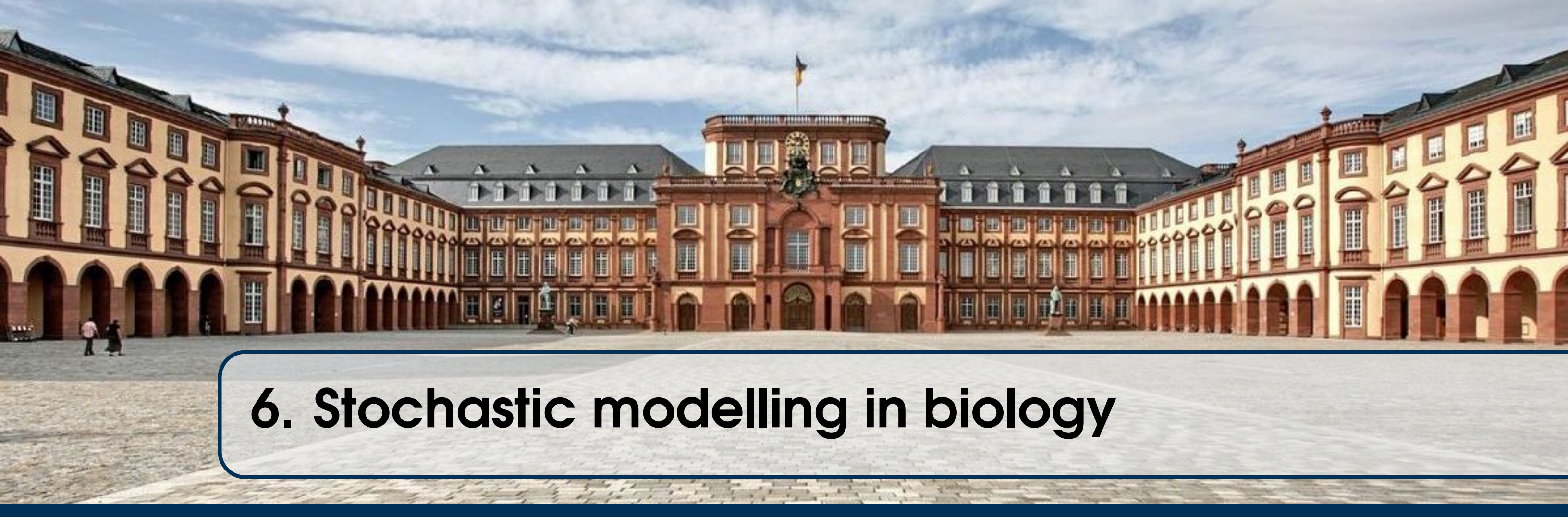
We introduce a novel and highly tractable supervised learning approach based on neural networks that can be applied for the computation of model-free price bounds of, potentially high-dimensional, financial derivatives and for the determination of optimal hedging strategies attaining these bounds. In particular, our methodology allows to train a single neural network offline and then to use it online for the fast determination of model-free price bounds of a whole class of financial derivatives with current market data. We show the applicability of this approach and highlight its accuracy in several examples involving real market data. Further, we show how a neural network can be trained to solve martingale optimal transport problems involving fixed marginal distributions instead of financial market data.

Asymptotic Theory and Bootstrap Inference for Mack's model

Session 1
Tue, 15:30

Julia Steinmetz
TU Dortmund

The distribution-free chain ladder reserving model by Mack (1993) belongs to the most popular approaches in non-life insurance mathematics. As originally proposed, it serves well to determine the first two moments of the reserve distribution, but it does not allow to identify its whole distribution. For predictive inference, Mack's model is usually equipped with a tailor-made bootstrap procedure. For this purpose, the resulting Mack bootstrap proposal requires additional parametric assumptions and postulates a normal distribution for the individual development factors. Although the Mack bootstrap is widely used in applications, no bootstrap consistency results exist that justify this approach. In this paper, we propose a general stochastic framework which allows to derive asymptotic theory for Mack's model. For increasing number of accident years, we establish first central limit theorems for the parameter estimators in Mack's model. In particular, these results enable us to derive also the limiting distributions of the reserve risk, which is split in two random parts that carry the process uncertainty and the estimation uncertainty, respectively. Second, we investigate parametric and non-parametric implementations of the Mack bootstrap and prove bootstrap consistency results. We illustrate our findings in simulations.



6. Stochastic modelling in biology

Chairs: Maite Wilke Berenguer, Martin Möhle

Live Sessions

Session 1 (Monday, 12:00)- zoom room 4

- **Charline Smadi** (live invited talk): Parasite infection in a cell population with deaths
- **Florin Boenkost**: Survival Probabilities of Slightly Supercritical Branching Processes in iid Random Environment
- **Zsófia Talyigás**: Genealogy and spatial distribution of the N-particle branching random walk with polynomial tails
- **Aurélien Velleret**: Asymptotic comparison of clicking ability in the Mueller ratchet

Session 2 (Wednesday, 12:00)- zoom room 5

- **Arno Siri-Jégousse** (live invited talk): Coalescent models for populations under recurrent bottlenecks
- **Iulia Dahmer**: Joint fluctuations of the lengths of Beta(2-alpha,alpha)-coalescents
- **Nils Hansen**: Griffiths Representation for Jump Diffusions with Moment Duality to Coordinated Branching-Coalescing Processes
- **Florian Nie**: The stochastic F-KPP Equation with seed bank and on/off branching coalescing Brownian motion

Session 3 (Wednesday, 13:45)- zoom room 5

- **Jere Koskela** (live invited talk): Non-reversible and gradient-based MCMC for coalescent trees
- **Jad Beyhum**: A nonparametric instrumental approach to endogeneity in competing risks models
- **Helmut Pitters**: The number of cycles in a random permutation and the number of segregating sites jointly converge to the Brownian sheet

Session 4 (Friday, 12:00)- zoom room 5

- **Cornelia Pokalyuk** (live invited talk): Fixation of slightly advantageous alleles in Cannings models
- **Tobias Paul**: Modelling interactions of mutation, dormancy and transfer
- **András Tóbiás**: Host-virus dynamics in the presence of contact-mediated dormancy
- **Jonas Lueg**: Wald Space: Information Geometry for Phylogenetic Trees

Session 5 (Friday, 13:45)- zoom room 5

- **Emmanuel Schertzer** (live invited talk): Probabilistic models related to the SARS-CoV-2 pandemic
- **Henrik Wiechers**: Learning Torus PCA based classification for multiscale RNA backbone structure correction with application to SARS-CoV-2
- **Ibrahim Mbouandi Njiasse**: Stochastic Epidemic Models and Extended Kalman Filter Estimates of Non-Observable States
- **Fanni K. Nedényi**: Limit theorems for the aggregation of random coefficient INAR(1) processes

Invited Talks

Non-reversible and gradient-based MCMC for coalescent trees

Session 3
Wed, 13:45
live

Jere Koskela
University of Warwick

Coalescent-based models of genetic diversity nearly always give rise to intractable likelihoods. Markov chain Monte Carlo methods, typically based on the Metropolis-Hastings algorithm, are gold-standard tools for sampling from corresponding posterior distributions. Their computational cost scales notoriously badly with problem complexity, so that their practical use is restricted to data sets which are small by modern standards. In part, the cost of Metropolis-Hastings methods is due to reversibility: a tendency for the method to backtrack, which slows exploration of the state space. Several non-reversible MCMC methods have been developed in recent years, but they rely on gradients of their target densities and have not been readily implementable for partly discrete state spaces, such as that of coalescent trees. I will demonstrate how one such method, the zig-zag process, can be extended to include discrete variables, and hence implemented for the coalescent. Tests on simple examples show speed ups of several orders of magnitude over Metropolis-Hastings. Similar approaches also render other gradient-based MCMC methods implementable for coalescent processes, and provide a principled framework for adapting MCMC methods.

Fixation of slightly advantageous alleles in Cannings models

Session 4
Fri, 12:00
live

Conelia Pokalyuk
Goethe Universität Frankfurt

The fixation probability of a beneficial allele is a cornerstone in population genetics and the basis for the analysis of more complex scenarios, like adaptation to a changing environment or emergence of drug resistance. In my talk I will present some recent results on fixation probabilities of slightly beneficial alleles within a class of Cannings models (which in the neutral case generalize the prototypic Wright-Fisher model from multinomial to exchangeable offspring numbers). In particular, we will consider Cannings models with skewed offspring distributions. We will see that in this setting the asymptotic probability of fixation scales sublinearly with the selective advantage s, in contrast to a linear scaling in the case of finite offspring variances.

This talk is based on joint works with Matthias Birkner, Florin Boenkost, Iulia Dahmer, Adrián González Casanova and Anton Wakolbinger.

Probabilistic models related to the SARS-CoV-2 pandemic

Session 5
Fri, 13:45
live

Emmanuel Schertzer
Universität Wien

In this talk, we will discuss a few projects initiated by the SMILE group (College de France/Sorbonne Universit ´e) during the SARS-CoV-2 pandemic. I will present a general and tractable framework for modeling and “nowcasting” the epidemic. Our approach is based on a fairly general individual based model capturing the main features of the epidemic (presence of asymptomatics, large heterogeneity in the population etc.). We show that despite the underlying complexity of our microscopic model, the global scale of the epidemic (i.e., when the number of infected gets large) is well captured by a deterministic McKendrick–Van Foerster 1d PDE. I will also show how this approach allows to make some theoretical predictions on contact-tracing data.

Coalescent models for populations under recurrent bottlenecks

Session 2
Wed, 12:00
live

Arno Siri-Jégousse

Universidad Nacional Autónoma de México

In this talk I will introduce modifications of the Wright-Fisher models where bottlenecks frequently appear. I will show that the limit genealogies (after rescaling time) appearing are in the class of exchangeable coalescents. Some of them can be characterized by a measure on the integers, but others are some time-changed Kingman coalescents, depending on the bottlenecks mechanism. These coalescents are dual to some Wright-Fisher diffusion with jumps providing forward limit frequency processes, despite the Markov property being often lost in the forwards models. Motivated by these new examples of exchangeable coalescents, I will study their small-time behavior: how they come down from infinity, and also an asymptotic result on the site frequency spectrum. For some particular examples, it will also be interesting to note some self-similarity and hence a link with Markov additive process via the Lamperti-Kyu transform. This is a joint work with Adián González Casanova, Verónica Miró Pina and Emmanuel Schertzer.

Parasite infection in a cell population with deaths

Session 1
Mon, 12:00
live

Charline Smadi

Université Grenoble Alpes

We introduce a general class of branching Markov processes for the modelling of a parasite infection in a cell population. Each cell contains a quantity of parasites which evolves as a diffusion with positive jumps. The growth rate, diffusive function and positive jump rate of this quantity of parasites depend on its current value. The division rate of the cells also depends on the quantity of parasites they contain. At division, a cell gives birth to two daughter cells and shares its parasites between them. Cells may also die, at a rate which may depend on the quantity of parasites they contain. We study the long time behaviour of the parasite infection. In particular, we are interested in the quantity of parasites in a 'typical' cell and on the survival of the cell population. We specifically focus on the influence of two parameters on the probability for the cell population to survive and/or contain the parasite infection: the law of the sharing of the parasites between the daughter cells at division and the form of the division and death rates of the cells as functions of the quantity of parasites they contain.

This is a joint work with Aline Marguet.

Contributed Talks

A nonparametric instrumental approach to endogeneity in competing risks models

Session 3
Wed, 13:45

Jad Beyhum
KU Leuven

This paper discusses endogenous treatment models with duration outcomes, competing risks and random right censoring. The endogeneity issue is solved using a discrete instrumental variable. We show that the competing risks model generates a non-parametric quantile instrumental regression problem. The cause-specific cumulative incidence, the cause-specific hazard and the subdistribution hazard can be recovered from the regression function. A distinguishing feature of the model is that censoring and competing risks prevent identification at some quantiles. We characterize the set of quantiles for which exact identification is possible and give partial identification results for other quantiles. We outline an estimation procedure and discuss its properties. The finite sample performance of the estimator is evaluated through simulations. We apply the proposed method to the Health Insurance Plan of Greater New York experiment.

Survival Probabilities of Slightly Supercritical Branching Processes in iid Random Environment

Session 1
Mon, 12:00

Florin Boenkost
Frankfurt University

Branching processes in random environment are a natural generalisation of classical branching processes. In classical branching processes each individual generates its offspring independently with the same distribution, whereas in branching processes in random environment the offspring of the individuals are only conditionally independent and identically distributed given the environment. In this talk (based on joint work in progress with Götz Kersting) we will discuss the survival probability of a slightly supercritical branching processes with an iid random environment. More precisely, for each generation a random environment is sampled, such that the random offspring mean $M^{(N)}$ fulfils: $\mathbb{E}[M^{(N)}] = 1+\varepsilon_N$ and $\mathrm{Var} M^{(N)} = \delta_N^2$, for two sequences $\varepsilon_N, \delta_N \downarrow 0$ as $N \to \infty$. Depending on the ratio δ_N^2/ε_N we obtain different asymptotics for the survival probability π_N. In particular, if $\delta_N^2/\varepsilon_N \to \infty$ the process dies out almost surely, if $\delta_N^2/\varepsilon_N \to 0$ the survival probability π_N obeys the asymptotics $\pi_N \sim 2\varepsilon_N/\sigma^2$, where σ^2 is the annealed offspring variance. This is a well known asymptotic for the survival probability of slightly supercritical branching processes, also known as Haldane's formula. Lastly, a brief outlook on the boundary case $\delta_N^2/\varepsilon_N \to c > 0$ is given. The proofs of these asymptotics rely on an analytical expression for the survival probability and exhibits a connection to perpetuities, which allows us to analyse the survival probability in that framework.

Joint fluctuations of the lengths of Beta$(2-\alpha,\alpha)$-coalescents

Session 2
Wed, 12:00

Iulia Dahmer
Johannes Gutenberg-Universität Mainz

In a Beta$(2-\alpha,\alpha)$-n-coalescent tree, $1 < \alpha < 2$, the length $\ell_r^{(n)}$ of order $r \in \{1,\ldots,n\}$ is the sum of the lengths of all branches that support r leaves. For $r = 1$ these branches are external, while for $r \geq 2$ they are internal and carry a subtree with r leaves. We show that for any $s \in \mathbb{N}$ the vector of suitably centered and rescaled lengths of orders $1 \leq r \leq s$ converges (as the number n of leaves of the tree tends to infinity) to a multivariate stable distribution. Joint work with M. Birkner, C. Diehl and G. Kersting.

Griffiths Representation for Jump Diffusions with Moment Duality to Coordinated Branching-Coalescing Processes

Session 2
Wed, 12:00

Nils Hansen

Ruhr-Universitaet Bochum

We investigate a class of branching-coalescent processes that arises by coordinating elementary building blocks of Markov chains on $(\mathbb{N}_0)^2$. We show that these building blocks are all the processes that have as moment dual a diffusion on the unit square. The newly created class of processes includes a wide range of other coordinated processes, including those in [3] and in [1]. Further, they exhibit again moment duality to (generally non-continuous) processes. In the spirit of [2], we find a generator representation for the latter type of process, mimicking that of an ordinary diffusion. NB. As at July 2021, this is work in progress.

References

[1] A. González Casanova, D. Spanò, M. Wilke Berenguer The efective strength of selection in random environment, 2019, arXiv:1903.12121

[2] R. C. Griffths, The Lambda-Fleming-Viot process and a connection with Wright-Fisher diffusion, 2014, arXiv:1207.1007

[3] A. González Casanova, N. Kurt, A. Tobiás Interacting particle systems. arXiv:2001.05802 (2020)

Limit theorems for the aggregation of random coefficient INAR(1) processes

Session 5
Fri, 13:45

Fanni K. Nedényi

ELKH-SZTE, Analysis and Stochastics Research Group, Bolyai Institute, University of Szeged

We discuss the joint temporal and contemporaneous aggregation of N independent copies of strictly stationary INteger-valued AutoRegressive processes of order 1 (INAR(1)) with random coefficient and with idiosyncratic Poisson innovations. We assume that the random coefficient has a density function of a certain form. Different limits of appropriately centered and scaled aggregates are shown to exist when taking first the limit as N, and then the time scale increases to infinity, vice versa, or when both increase to infinity at a given rate. In fact, we give a partial solution to an open problem of Pilipauskaite and Surgailis (2014) by replacing the random coefficient AR(1) process with a certain randomized INAR(1) process.

Wald Space: Information Geometry for Phylogenetic Trees

Session 4
Fri, 12:00

Jonas Lueg

Georg-August-Universität Göttingen

The recently introduced wald space models phylogenetic trees from an evolutionary perspective and is thus based on more biologically principled assumptions than existing spaces: in wald space, trees are close if they induce similar distributions on genetic sequence data. We introduce the space and show that it is contractible and a stratified, geodesic metric space. Finally, we use path-straightening methods to numerically approximate shortest paths between trees and use this for an approximation of a Fréchet mean of trees using Sturms algorithm.

Stochastic Epidemic Models and Extended Kalman Filter Estimates of Non-Observable States

Session 5
Fri, 13:45

Ibrahim Mbouandi Njiasse
Institute of Mathematics, BTU Cottbus-Senftenberg

Lacunary sums show under certain regularity assumptions the same behaviour as sums of iid random variables. In this talk we consider the asymptotics of different lacunary sums on a large deviation scale.

The stochastic F-KPP Equation with seed bank and on/off branching coalescing Brownian motion

Session 2
Wed, 10:0NA

Florian Nie
TU Berlin

We introduce the stochastic F-KPP Equation with seed bank modeling the spread of a beneficial allele in a spatial population where individuals may switch between an active and a dormant state. Moreover, we will briefly discuss some basic properties of the system including duality to an "on/off" version of a branching coalescing Brownian motion, particle system approximations and the existence of compact interfaces.

Modelling interactions of mutation, dormancy and transfer

Session 4
Fri, 12:00

Tobias Paul
Humboldt Universität Berlin

Recently, a toy model for the interaction of mutation and horizontal transfer was proposed by Champagnat, Méléard and Tran (2021). We extend their model to include the effects of competition induced dormancy and recover the convergence of the logarithmic population sizes. While the result remains unchanged, the qualitative behaviour of the limiting functions may exhibit properties of the model without dormancy but also entirely new phenomena. As an example we can observe an interesting non-monotonicity in the success of the dormancy traits depending on the strength of the dormancy initiation probability. Furthermore, we will discuss possible extensions and generalizations of the model. (This is joint work with Jochen Blath and András Tóbiás, TU Berlin)

The number of cycles in a random permutation and the number of segregating sites jointly converge to the Brownian sheet

Session 3
Wed, 13:45

Helmut Pitters
University of Mannheim

Consider a random permutation of $\{1,\dots,\lfloor n^{t_2}\rfloor\}$ drawn according to the Ewens measure with parameter t_1 and let $K(n,t)$ denote the number of its cycles, where $t \equiv (t_1,t_2) \in [0,1]^2$.

Next, consider a sample drawn from a large, neutral population of haploid individuals subject to mutation under the infinitely many sites model of Kimura whose genealogy is governed by Kingman's coalescent. Let $S(n,t)$ count the number of segregating sites in a sample of size $\lfloor n^{t_2}\rfloor$ when mutations arrive at rate $t_1/2$.

Our main result comprises two different couplings of the above models for all parameters $n \geq 2$, $t \in [0,1]^2$ such that in both couplings one has that as $n \to \infty$ the sequence of processes

$$\{\frac{(K(n,s),S(n,t)) - (s_1 s_2, t_1 t_2)\log n}{\sqrt{\log n}}, s,t \in [0,1]^2\}$$

converges weakly to

$$\{(B(s),B(t)), s,t \in [0,1]^2\},$$

where B is a one-dimensional Brownian sheet. This generalises and unifies a number of well-known results.

Genealogy and spatial distribution of the N-particle branching random walk with polynomial tails

Session 1
Mon, 12:00

Zsófia Talyigás
University of Bath

The N-particle branching random walk (N-BRW) is a discrete time branching particle system, which can be viewed as a toy model of an evolving population affected by natural selection. In the N-BRW we have N particles located on the real line at all times. At every time step each particle is replaced by two offspring, and each offspring particle makes a jump of non-negative size from its parent's location, independently from the other jumps, according to a given jump distribution. Then only the N rightmost particles survive; the other particles are removed from the system to keep the population size constant.

Inspired by work of J. Bérard and P. Maillard, we examine the long term behaviour of this particle system in the case where the jump distribution has regularly varying tails and the number of particles is large. In this talk I will explain the ideas behind our result, which says that at a typical large time the genealogy of the population is given by a star-shaped coalescent, and that almost the whole population is near the leftmost particle on the relevant space scale.

Joint work with Sarah Penington and Matthew Roberts.

Host-virus dynamics in the presence of contact-mediated dormancy

Session 4
Fri, 12:00

András Tóbiás
TU Berlin

We investigate a stochastic model for the population dynamics of a host–virus system when the hosts are able to enter into a dormant state upon contact with virus particles, thus evading infection. Such a defense mechanism was recently described in Bautista et al (2015). We begin with an analysis of the effect of the dormancy-related parameters on the probability and time of invasion of a newly arriving virus into the resident host population. Given 'successful' invasion, we then show that a positive probability of long-term persistence of the virus epidemic is equivalent to the existence of a coexistence equilibrium for the corresponding many-particle limiting dynamical system of our model. In the absence of dormancy and for a low probability of recovery, this system exhibits a Hopf bifurcation: If the amount of viruses produced by a single infected cell is high enough, the coexistence equilibrium loses its stability, and the system exhibits periodic or chaotic behaviour. This is a variant of the 'paradox of enrichment' phenomenon that appears also in predator-prey systems. Here, we show that dormancy can prevent this loss of stability in the system for certain parameter ranges. Further, the presence of contact-mediated dormancy enables the host population to maintain high equilibrium sizes (resp. fitness) while still being able to avoid a persistent epidemic, which is not possible in similar systems without dormancy, where high fitness correlates with high risk of the emergence of a persistent epidemic. This adds a new twist to the reproductive trade-off usually associated with costly dormancy traits. The content of this talk is joint work with J. Blath (TU Berlin).

Asymptotic comparison of clicking ability in the Mueller ratchet

Session 1
Mon, 12:00

Aurélien Velleret
Goethe Universität Frankfurt

Since deleterious mutations occur much more frequently than beneficial ones, it is crucial to understand how the fixation of these deleterious mutations is regulated. It is critical for the long-term survival of the population that these events get delayed as much as possible as compared to the rate at which beneficial mutations fix. The ability to prevent the ultimate fixation of deleterious mutations is argued to be an essential benefit of recombination, able to compensate the cost of requiring two parents. But is this regulation in purely asexual populations so inefficient ?

Extending the simplified mathematical model for the so-called Mueller ratchet which has been proposed by Haigh in 1978, we consider the large population limit introduced by Etheridge, Pfaffelhuber and Wakolbinger in 2009 and notably studied by Audiffren and Pardoux in 2013. The main question is to understand the clicking process, where at the clicking time the fittest community of individuals vanish, meaning the fixation of an additional deleterious mutation. For efficicent regulation, the process should display a metastable regime between clicking times. In order to rigorously define this property of metastability, a crucial step is the proof that the probability of having no click for a long time t is optimal with the choice of a typical initial condition up to a constant factor uniform in t. For such an infinite dimensional diffusion, this is especially challenging yet feasible.

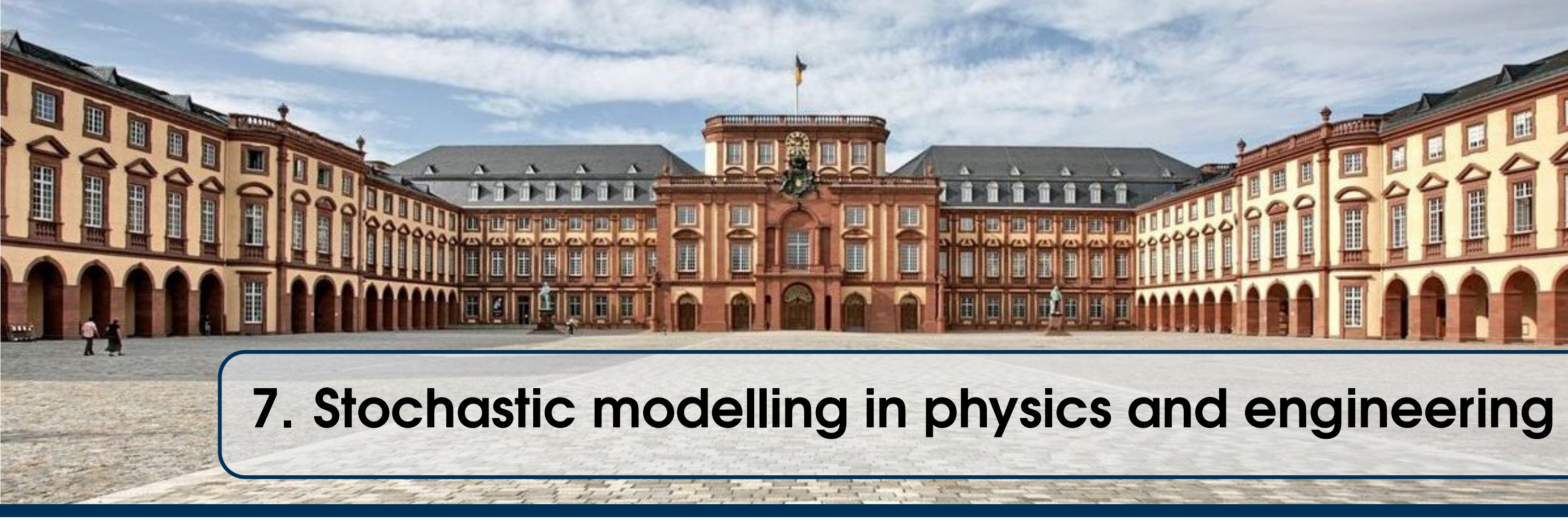
This is joint work with Mauro Mariani and Etienne Pardoux

Learning Torus PCA based classification for multiscale RNA backbone structure correction with application to SARS-CoV-2

Session 5
Fri, 13:45

Henrik Wiechers
Georg August Universität Göttingen

RNA molecules come in multiple function and geometric form to perform various tasks in cells. In order to understand their performance, in particular to enhance, alter or inhibit specific biological processes, the precise geometric structure of RNA molecules is decisive. Frequently, when reconstructing atom centers in biomolecules (popular methods are X-ray chrystallography and cryo-EM), it occurs, however, that atom positions are closer to each other than chemically possible are reconstructed. This is particularly the case for the RNA backbone. Hence, various methods have been developed to correct such so-called clashes. As these methods are usually based on simulations approximating biophysical chemistry, they are computationally expensive. We propose a computationally fast data-driven statistical method: From a clash free training data set, applying torus PCA after clustering, we learn classes of RNA suite shapes. For a given clash suite we determine its neighborhood on a mesoscopic scale involving several suites. For the corrected suite we propose the Frechet mean of the largest class in this neighborhood. As proof of concept, we apply our method to two exemplary suites at helical endings of the frameshift stimulation element of SARS-CoV-2 which are difficult to reconstruct. In contrast to a recently proposed reconstruction featuring 10 different structure models, for each suite, our structure correction unanimously proposes reconstructions within a single class.



7. Stochastic modelling in physics and engineering

Chairs: Silke Rolles, Volker Betz

Live Sessions

Session 1 (Tuesday, 13:45)- zoom room 2

- **Roland Bauerschmidt** (live invited talk): The arboreal gas
- **Jonas Jalowy**: Fluctuations of the magnetization in the Block Potts Model
- **Diana Conache**: Variance of voltages in a lattice Coulomb gas
- **Matthew Dickson**: On the Huang-Yang-Luttinger Loop Soupspaces

Session 2 (Tuesday, 15:30)- zoom room 2

- **Daniel Ueltschi** (live invited talk): Random loop representation of quantum spin chain, and proof of dimerization
- **Peter Mühlbacher**: Rigorous results on efficient sampling from Quantum Heisenberg models
- **Quirin Vogel**: Bose-Einstein condensation and infinite loops
- **Steffen Polzer**: A functional central limit theorem for Polaron path measures
- **Yana Kinderknecht** (Braunschweig): Feynman-Kac Formulae for generalized time-fractional evolution equations

Session 3 (Friday, 13:45)- zoom room 3

- **Lisa Hartung** (live invited talk): Log-correlated fields: Some useful tools
- **Florian Henning**: Coexistence of localized Gibbs measures and delocalized gradient Gibbs measures on trees
- **Sebastian Bergmann**: Gibbs-non-Gibbs transitions in Widom-Rowlinson models on trees
- **Stefan Junk**: Number of open paths in oriented percolation as zero temperature limit of directed polymer
- **Markus Dietz** (Freiberg): On a stochastic arc furnace model

Invited Talks

The arboreal gas

Session 1
Tue, 13:45
live

Roland Bauerschmidt
University of Cambridge

The arboreal gas is the probability measure on unrooted spanning forests of a graph given by weighting each forest by a parameter $\beta > 0$ per edge. Equivalently, this model is Bernoulli bond percolation conditioned to have no cycles. I will explain connections between this model and linearly reinforced walks, e.g., through the existence of an analogous 'Magic Formula'. I will then present results about the behaviour of the arboreal gas in d dimension, including absence of percolation in d=2 for all β, and existence of a phase transition in d>=3 with the fluctuations in the supercritical phase having massless free field behaviour.

Log-correlated fields: Some useful tools

Session 3
Fri, 13:45
live

Lisa Hartung
Johannes Gutenberg University Mainz

In my talk I will introduce examples of log correlated random fields and motivate some question of interest in these models, such as the study of extreme values. Moreover. I will try to give an overview of some (general) techniques used to tackle these questions.

Random loop representation of quantum spin chain, and proof of dimerization

Session 2
Tue, 15:30
live

Daniel Ueltschi
University of Warwick

I will describe a random loop model that is closely related to quantum spin systems with O(n)-invariant interactions. It is an extension of representations proposed by Tóth and Aizenman-Nachtergaele for quantum Heisenberg models. The 2D loop model (and the corresponding 1D quantum spin chain) has a very interesting phase diagram, which I will review.

With Jakob Björnberg, Bruno Nachtergaele, and Peter Mühlbacher, we prove that dimerisation occurs in an open domain of the phase diagram.

Contributed Talks

Gibbs-non-Gibbs transitions in Widom-Rowlinson models on trees

Session 3
Fri, 13:45

Sebastian Bergmann
Ruhr-Universität Bochum

I would like to present a joined work by Christof Külske, Sascha Kissel and myself. We consider a time-evolved Widom-Rowlinson model on the Cayley tree of order d, i.e. a model where sites are occupied according to an activity parameter λ and spins on neighboring occupied sites interact with repulsion strength β according to their spin value. The time evolution affects the spins on occupied sites of the model through site-independent spin flips. Starting with the intermediate Gibbs measure of the model, which is obtained by free boundary conditions, we investigate Gibbsianness of the time-evolved measure by examining its set of bad configurations (discontinuity points of conditional probabilities). The main result I will be presenting, is that on a Cayley tree with $d \geq 4$ at large repulsion strength β and large times t there is a sharp transition in λ where the set of bad configurations changes from measure zero to measure one, thereby showing the existence of a phase transition in λ from almost-sure Gibbsianness to almost-sure non-Gibbsianness of the time-evolved measure.

Variance of voltages in a lattice Coulomb gas

Session 1
Tue, 13:45

Diana Conache
TU München

I will present a result concerning the asymptotic behavior of the variance of the difference of energies for putting an additional electric unit charge at two different locations in the two-dimensional lattice Coulomb gas in the high-temperature regime. The result is obtained by exploiting the duality between this model and a discrete Gaussion model. Our estimates follow from a spontaneous symmetry breaking in the latter model. This is joint work with M. Heydenreich, F. Merkl and S.W.W. Rolles.

On the Huang-Yang-Luttinger Loop Soup

Session 1
Tue, 13:45

Matthew Dickson
LMU Munich

In 1957 Huang, Yang, and Luttinger introduced an approximation of the hard-sphere interaction energy of a Bose gas - expressed solely in terms of the ideal gas momentum eigenstate occupation numbers. Here we consider an analogous interaction energy for a bosonic loop soup model. Large deviation techniques will be used to show a pressure equivalence with the original model, and we will comment on the consequences for the condensation phenomena.

On a stochastic arc furnace model

Session 3
Fri, 13:45

Markus Dietz
Technische Universität Bergakademie Freiberg

Electric arc furnaces are used for melting metals in the steel industry. One of the approaches in modeling characteristics of an electrical network to an electric arc furnace is based on the power balance equation. This results in a nonlinear ordinary differential equation, which describes the relationship between the arc radius and the arc current, both treated as deterministic functions of time. In reality it can be observed that this characteristics are not deterministic. In fact they oscillate with a random time-varying amplitude and a slight shiver. We present a joint work with Hans-Jörg Starkloff and Anna Chekhanova in which we propose a stochastic model based on the deterministic approach. A parameter of the differential equation is modeled as stochastic process, which leads to a random differential equation. The stochastic influence is modeled with help of the stationary Ornstein-Uhlenbeck process. Results are gained by applying Monte Carlo method and polynomial chaos expansion.

Coexistence of localized Gibbs measures and delocalized gradient Gibbs measures on trees

Session 3
Fri, 13:45

Florian Henning
Ruhr-Universität Bochum

We consider spin systems on the d-regular tree taking values in the integers (or an integer lattice), where the interaction is of gradient type, i.e., depends only on the differences of spin values at neighboring vertices.

Due to the unbounded local state space, existence of Gibbs measures (equilibrium distributions) does not directly follow from compactness arguments.

In this talk, we provide an existence criterion for a countably infinite family of tree-automorphism invariant tree-indexed Markov chain Gibbs measures in terms of a pair of p-norms of the associated transfer operator Q (the exponential of the interaction potential). Each of these Gibbs measures describes localization at some element of the local state space. In the particular case of the integers as local state space, the same criterion, applied to some suitable transformed fuzzy transfer operator Q^q on the ring $Z_q = Z/qZ$, also yields existence of a family of gradient Gibbs measures (describing increments along the the oriented edges of the tree) which do not arise as projection of tree-indexed Markov chain Gibbs measures. Applications of our existence theory include the SOS model (Solid on Solid) as well as a heavy tailed model with logarithmically decaying interaction potential.

The talk is based on joint work with Christof Külske, which is accepted for publication in the Annals of Applied Probability.

Fluctuations of the magnetization in the Block Potts Model

Session 1
Tue, 13:45

Jonas Jalowy
Münster University

This talk will be about the block spin mean-field Potts model, in which the spins are divided into s blocks and can take q>1 different values (colors). Each block is allowed to contain a different proportion of vertices and behaves itself like a mean-field Ising/Potts model which also interacts with other blocks according to different "inverse temperatures". Of particular interest is the behavior of the magnetization, which counts the number of colors appearing in the distinct blocks. I will present Central Limit Theorems for the magnetization in the generalized high temperature regime, show a Moderate Deviation Principle for its fluctuations on lower scalings and compare our results to simpler models. In the video, I shall accompany the model, the result and the proof (if time permits) by simulations and illustrations. This is joint work with Matthias Löwe and Holger Sambale. PS: The CLT and MDP fits into the program's S3 likewise.

Number of open paths in oriented percolation as zero temperature limit of directed polymer

Session 3
Fri, 13:45

Stefan Junk

University of Tsukuba

Let N_n denote the number of open paths connecting (0,0) to $n \times Z^d$ in supercritical oriented percolation. It is known that if the origin percolates, then N_n grows exponentially with a deterministic rate $a(p)$. We show that a can be obtained as the zero-temperature limit of the free energy in the directed polymer model with Bernoulli environment. One consequence of our proof is that $a(p)$ is a continuous function of the probability p that a site is open.

Feynman-Kac Formulae for generalized time-fractional evolution equations

Session 2
Tue, 15:30

Yana Kinderknecht

TU Braunschweig

We consider a general class of integro-differential evolution equations which includes the governing equation of the generalized grey Brownian motion and the time- and space-fractional heat equation (such equations arise, e.g., in models of anomalous diffusion). We present a general relation between the parameters of the equation and the distribution of the underlying stochastic processes, as well as discuss different classes of processes providing stochastic solutions of these equations. For a subclass of evolution equations, containing Saigo-Maeda generalized time-fractional operators, we determine the parameters of the corresponding processes explicitly. Moreover, we explain how self-similar stochastic solutions with stationary increments can be obtained via linear fractional Lévy motion for suitable pseudo-differential operators in space. Further, we use these results to construct Feynman-Kac formulae for solutions of a more general class of integro-differential equations.

Rigorous results on efficient sampling from Quantum Heisenberg models

Session 2
Tue, 15:30

Peter Mühlbacher

University of Warwick

I will describe a graphical representation of some quantum Heisenberg models that allows us to compute correlation functions and more. This representation is used to define a cluster algorithm which converges significantly faster than naive Glauber dynamics. Borrowing ideas from the analysis of the Swendsen-Wang algorithm, I will present rigorous results like

- geometric ergodicity ("fast mixing") in the high temperature regime,
- "slow mixing" in the presence of phase coexistence, and
- Li-Sokal type bounds on autocorrelations.

Time permitting, I will present a novel & general spectral comparison technique between Glauber and Swendsen-Wang type dynamics, using Boolean analysis.

A functional central limit theorem for Polaron path measures

Session 2
Tue, 15:30

Steffen Polzer
TU-Darmstadt

The Polaron is a model for a quantum particle interacting with a polar crystal. It has a well known path measure formulation. An important open problem was showing that the path measure satisfies a central limit theorem in infinite volume under diffusive rescaling. We have solved this problem for all coupling parameters by extending a novel method introduced by Mukherjee and Varadhan. The method relies on a representation of the path measure in terms of a queueing process. We express several quantities of physical interest in terms of the relevant queueing process.

Bose-Einstein condensation and infinite loops

Session 2
Tue, 15:30

Quirin Vogel
NYU Shanghai

Elementary particles are either Bosons or Fermions. A gas of Bosons can be represented mathematically by a collection of interacting random loops. At very low temperatures, a gas of Bosons undergoes a phase transitions: the Bose-Einstein Condensate (BEC) appears. Despite the fundamental nature of the problem, a complete understanding of BEC is still at large. It had been conjectured by Richard Feynman that the BEC is represented by “infinite” loops. The recently developed theory of random interlacements provides a framework for a rigorous understanding of a canonical candidate of such paths. We will present the result of a recent preprint, showing this for the free and the mean-field gas. In the last part of the talk, we will examine the discontinuous phase transition for the Bose gas with Huang-Yang-Luttinger hard-core interaction.

8. Stochastic optimization and operations research

Chairs: Nicole Bäuerle, Hanspeter Schmidli

Live Sessions

Session 1 (Monday, 13:45)- zoom room 6

- **Agnès Sulem** (live invited talk): Non-linear mixed optimal control/ stopping (game) problems and applications in finance
- **Tamara Göll**: Nash Equilibria in a Portfolio Optimisation Problem under a Relative Performance Criterion
- **Florian Aichinger**: Merton's portfolio problem for a class of multivariate affine Volterra models
- **Jörn Sass**: Robust Utility Maximization in a Multivariate Financial Market with Stochastic Drift

Session 2 (Tuesday, 13:45)- zoom room 3

- **Julia Eisenberg** (live invited talk): Dividend maximisation with negative and positive preference rates
- **Leonie Violetta Brinker**: Optimal reinsurance strategies for drawdown control
- **Christian Laudagé**: Scalarized utility-based multi-asset risk measures
- **Simon Fischer**: Limit Behavior for Optimal Stopping Problems with Finite Time Hoizon

Session 3 (Tuesday, 15:30)- zoom room 3

- **Fred Espen Benth** (live invited talk): Hedging of volumetric risk in renewable energy markets
- **Ricarda Rosemann**: Regulation of Emission Trading Systems: A Stochastic Control Model
- **Paul Honore Takam**: Stochastic Optimal Control of Thermal Energy Storages

Session 4 (Wednesday, 15:30)- zoom room 5

- **Stefan Thonhauser** (live invited talk): Dividend maximization with a penalty - time inconsistent view
- **Philipp Guth**: One-shot approach for surrogates in PDE-constrained optimization under uncertainty
- **Bernard Effah Nyarko**: Stochastic Optimal Control Methods for the Water Management of Irrigation Systems

Invited Talks

Hedging of volumetric risk in renewable energy markets

Session 3
Tue, 15:30
live

Fred Espen Benth
University of Oslo

Renewable power production by means of wind and photovoltaics (PV) lead to new risk management challenges. In this talk we discuss stochastic models of wind and sun, and analyse how one can hedge the volumetric (production) risk at production sites. Wind and PV production can be modelled through (continuous-time) autoregressive models driven by non-Gaussian noise. Hedging tools exist in the market, in form of wind power forward contracts based on a wind index. We derive a variance-optimal hedge, which is based on the spatial covariation of wind plants and the index. Some thoughts on the same question for PV is presented. The talkis based on joint work with Troels Christensen and Victor Rohde (Aarhus, Denmark) and Karl Larsson and Rikard Green (Oerebro and Lund, Sweden).

Dividend maximisation with negative and positive preference rates

Session 2
Tue, 13:45
live

Julia Eisenberg
Technische Universität Wien

In this talk, we look at a dividend maximisation problem under a Brownian surplus and a Markov-switching preference rate model. The preference rate can attain two values - a positive and a negative. First, we discuss the optimal dividend payout strategy for the setting with a classical ruin concept - the ruin is declared when the surplus becomes negative. In the second part, the setting will be modified by a Parisian ruin with an exponential delay - the ruin is declared if the process stays negative during an exponentially distributed time interval. In the first case, the optimal strategy turns out to be of a barrier type, being a finite barrier during the positive rate phases and infinite barrier (no dividends are paid) during the negative phases. We show that the finite barrier is a monotone function of the regime switching intensities. In the case of the Parisian delay, the optimal strategy depends on the relation between the expected income rate and the parameter of the exponential delay. The cases of long, medium and short expected delays have to be considered separately in order to find explicit expressions for the value function and the optimal strategy (remaining of a barrier type for short and medium delays). If the expected delay is too long, the optimal strategy in the negative state can change from not paying dividends to a band strategy. Joint work with Leonie Brinker.

Non-linear mixed optimal control/ stopping (game) problems and applications in finance

Session 1
Mon, 13:45
live

Agnès Sulem
INRIA Paris

We study the superhedging problem for American options with irregular payoffs in a non-linear and incomplete market model with default. We give a dual representation of the seller's (superhedging) price in terms of the value of a non-linear mixed control/stopping problem, and provide infinitesimal characterizations of the seller's price process as minimal supersolutions of reflected BSDEs. Under some regularity assumptions on the pay-off, we also prove a duality result for the buyer's price in terms of the value of a non-linear control/stopping game problem.

(based on joint works with Miryana Grigorova, University of Leeds and Marie-Claire Quenez, LPSM, Université Paris Denis Diderot).

Dividend maximization with a penalty - time inconsistent view

Session 4
Wed, 15:30
live

Stefan Thonhauser

Technische Universität Graz

We revisit the dividend maximization problem with a penalty which is given by the Laplace transform of the time of ruin. Deliberately, we introduce a time inconsistency for being able to incorporate a particular constraint on admissible dividend strategies. Under certain simplifying conditions we can explicitely derive an equilibrium dividend strategy and the associated value funcion. We discuss properties of this solution, present some (interesting but slightly misleading) numercial examples and link our results to the ones obtaind by Hipp over the last years. The presented results are joined work with Josef Strini (TU Graz, Austria).

Contributed Talks

Merton's portfolio problem for a class of multivariate affine Volterra models

Session 1
Mon, 13:45

Florian Aichinger

Institute for Financial Mathematics and Applied Number Theory, University of Linz

This talk is concerned with portfolio selection for an investor with power utility in a multi-asset financial market in a rough stochastic environment. We investigate Merton's portfolio problem for a class of multivariate affine Volterra models introduced in [Abi Jaber, E., Miller, E., H. Pham, Markowitz portfolio selection for multivariate affine and quadratic Volterra models. SIAM Journal on Financial Mathematics 12(1) (2021), 369-409.], covering the Heston model. Due to the non-Markovianity of the underlying processes the classical stochastic control approach can not be applied in this setting. To overcome this difficulty, we provide a verification argument inspired by [Bäuerle, N., Z. Li, Optimal portfolios for financial markets with Wishart volatility. Journal of Applied Probability 50(4) (2013), 1025-1043.] to show that an appropriate candidate is indeed the optimal portfolio strategy using calculus of convolutions and resolvents. The optimal strategy can then be expressed explicitly in terms of the solution of a multivariate Riccati–Volterra equation. This extends the results obtained by Han and Wong to the multivariate case, avoiding restrictions on the correlation structure linked to the martingale distortion transformation used in [Han, B. and Wong, H. Y., Merton's portfolio problem under Volterra Heston model. Finance Research Letters 39 (2021).]. We also provide a numerical study to illustrate our results. The talk is based on a joint work with Sascha Desmettre (University of Linz).

Optimal reinsurance strategies for drawdown control

Session 2
Tue, 13:45

Leonie Violetta Brinker

Universität zu Köln

A drawdown is the absolute distance of the current surplus to its historical peak. Whilst large and long-lasting drawdowns might manifest existing financial and reputational risks, small and infrequent drawdowns can be considered a sign of economic strength and steadiness. For this reason, minimising drawdowns is desirable for companies – especially in insurance business, where the trust of policyholders is the basis for success. In this talk, we consider the stochastic optimisation problem of minimising the expected duration time of critically large drawdowns. We identify the optimal reinsurance strategies and discuss results and implications of the model.

Stochastic Optimal Control Methods for the Water Management of Irrigation Systems

Session 4
Wed, 15:30

Bernard Effah Nyarko

BTU Cottbus-Senftenberg

In this talk, we consider the management of an irrigation system for crop farming in semi-arid regions which is subject to uncertainties about environmental and weather conditions. Further, we address climate change induced fluctuations of the duration of the dry season. At the beginning of the dry season, the manager of the irrigation scheme has access to a reservoir containing some limited amount of water. The aim is to find an irrigation policy that maximizes the farmer's yield and monetary profit from cultivating crops and simultaneously prevents premature emptying the reservoir and drying out of the command area. Mathematically, the problem is treated as a continuous-time stochastic optimal control problem with state and control constraints and an indefinite time horizon. We find an approximative solution by time-discretization leading to a Markov decision process. For the latter we apply approximative dynamic programming techniques. In particular, we employ the parametric approximation of the post-decision value function.

This is joint work with Ralf Wunderlich (BTU, Cottbus), Nicole Baeuerle (KIT, Karlsruhe) and Olivier Menoukeu Pamen (UL, Liverpool).

Limit Behavior for Optimal Stopping Problems with Finite Time Hoizon

Session 2
Tue, 13:45

Simon Fischer

Christian-Albrechts-Universität zu Kiel

We consider stopping problems of the form

$$V(t,x) = \sup_{t \le \tau \le 0} e_{(t,x)}[g(\tau, W_\tau)],$$

where W is a Brownian motion. We derive a Fredholm type integral equation, that characterizes the continuation set C of the problem. We use that equation to analyze the behavior of C close the time horizon 0. In particular, we find an explicit description for the limit behavior when $t \to -\infty$ for a large class of problems.

Nash Equilibria in a Portfolio Optimisation Problem under a Relative Performance Criterion

Session 1
Mon, 13:45

Tamara Göll

Karlsruhe Institute of Technology

We analyse the optimal investment behaviour of n agents trading in a common complete and arbitrage-free financial market. The objective function of a single agent, first introduced by Lacker and Zariphopoulou ("Mean field and n-agent games for optimal investment under relative performance criteria" , Mathematical Finance, 29(4):1003–1038, 2019), is given in terms of his own, as well as the other n-1 agents' terminal wealth. In this context, we determine Nash equilibria by solving an auxiliary classical portfolio optimisation problem. Moreover, we prove that the Nash equilibrium is unique, which is an open conjecture in Lacker and Zariphopoulou (2019). In the end, we will compare the Nash equilibrium and the optimal solution for a single agent in a more specific setting.

One-shot approach for surrogates in PDE-constrained optimization under uncertainty

Session 4
Wed, 15:30

Philipp Guth

University of Mannheim

In PDE-constrained optimization under uncertainty, the PDE-constraint has a random input field that is typically parametrized by a series expansion. In principle solving the underlying optimization problem thus requires to solve infinitely many PDEs, and in practice a large finite number of PDEs need to be solved for accurate approximation. Our approach replaces the computationally expensive solution of the PDE by a surrogate, which is trained in a one-shot sense. Hence, no training of the surrogate is needed before solving the underlying optimization problem, rather it is trained simultaneously to computing the optimal control parameter. We demonstrate the robustness of the proposed method using different surrogate models in our numerical experiments.

Scalarized utility-based multi-asset risk measures

Session 2
Tue, 13:45

Christian Laudagé
Fraunhofer Institute for Industrial Mathematics ITWM

Financial institutions have to satisfy capital adequacy tests, e.g. Basel III/IV for banks or Solvency II for insurers. At the same time their main concern is to maximize their own benefit, i.e. they aim for maximizing their expected utility. Combining both aspects leads to a portfolio optimization problem under a risk constraint.

In this talk we show an example of a financial stricken situation in which no reallocation of the initial endowment exists such that the capital adequacy test is satisfied. In this case the classical portfolio optimization approach breaks down and a capital increase is needed. We introduce the scalarized utility-based multi-asset (SUBMA) risk measure, which optimizes the hedging costs and the expected utility of an agent simultaneously subject to the capital adequacy test.

We find that the SUBMA risk measure is coherent if the utility function has constant relative risk aversion and the capital adequacy test leads to a coherent acceptance set. In a one-period financial market model we present a sufficient condition for the SUBMA risk measure to be finite-valued. Under further assumptions on the utility function we obtain existence and uniqueness results for the optimal hedging strategies. Finally, we calculate the SUBMA risk measure in a continuous time financial market model for specific capital adequacy tests.

Regulation of Emission Trading Systems: A Stochastic Control Model

Session 3
Tue, 15:30

Ricarda Rosemann
TU Kaiserslautern

The progress of climate change demands a significant reduction on greenhouse gas emissions. To control emissions while minimizing reduction costs, emission trading systems (ETS) have been proposed and introduced for instance in the EU. In an ETS the desired amount of emissions in a predefined time period is fixed in advance; corresponding to this amount, allowances for one ton of greenhouse gas emissions are handed out or auctioned to companies which underlie the system. Companies may trade allowances so that, ideally, emissions are reduced where this can be done at lowest costs. If emissions occur which are not covered by an allowance, they are subject to a penalty at the end of the time period. Emissions depend on non-deterministic parameters such as weather and the state of the economy. Therefore it is natural to view emissions as a stochastic quantity. This introduces a challenge for the companies involved: In planning their abatement actions, they need to avoid penalty payments without knowing their total amount of emissions. In [1], Seifert et al. introduce a stochastic control approach to address this problem: In a continuous model, they use the rate of emission abatement as a control in minimizing the costs that arise from penalty payments and abatement costs. We take the viewpoint of a regulator of an ETS. The introduction of randomness to the system also gives rise to the possibility that the emission goal is not reached. Additionally, as an incentive for investments in low-emission technologies, a certain behavior of the allowance price is desirable. Both quantities are not directly given by the solution to the stochastic control problem. Instead we need to solve an SDE, where the abatement rate enters as the drift term. Due to the nature of the penalty function the abatement rate is not continuous. This is problematic from a theoretical perspective, since classical results on existence and uniqueness of a solution as well as convergence of numerical methods do not apply. We solve this problem by taking into account that the discontinuity only occurs at final time. We may apply the usual results at any time point before and show that this suffices to guarantee existence and uniqueness of a solution, under the additional assumption that the drift and the volatility are bounded. By a similar approach we show that the Euler-Maruyama scheme converges to this solution. We extend the model by considering several consecutive time periods. This enables us to model the transfer of unused allowances to the subsequent time period. In formulating the multiple period model we pursue two different approaches: In the first we assume the value that the company anticipates for an unused allowance to be constant throughout one time period, while in the second approach we simulate it by introducing an additional random variable. Our results indicate that under realistic settings the probability of non-compliance with the emission goal is considerably large. It can be reduced for instance by an increase in the penalty. In the multiple period model we observe that by allowing the transfer of allowances to the subsequent time period, the probability of non-compliance decreases remarkably.

References [1] J. Seifert, M. Uhrig-Homburg and M. Wagner. Dynamic behaviour of CO2 spot prices. Journal of Environmental Economics and Management, 56(2):180-194, September 2008.

Robust Utility Maximization in a Multivariate Financial Market with Stochastic Drift

Session 1
Mon, 13:45

Jörn Sass
Technische Universität Kaiserslautern

When modeling financial markets one is often confronted with model uncertainty in the sense that parameters of the model or the distributions of some factors in the model are only known up to a certain degree. We look at a multivariate continuous-time financial market driven by a Brownian motion.

We investigate how optimal trading strategies for a utility maximization problem behave when we have Knightian uncertainty on the drift, meaning that the only information is that the drift parameter lies in a certain set. This is a robust portfolio optimization setting in which we aim at the best performance given that the true drift parameter is the worst possible parameter for our chosen strategy within this set. If the model uncertainty exceeds a certain threshold simple strategies such as uniform portfolio diversification outperform more sophisticated ones due to being more robust, see Pflug, Pichler and Wozabel (2012) in discrete time. We extended theses results to continuous time, and provide quite explicit strategies and convergence results.

We also study a financial market with a stochastic drift process, combining the worst-case approach with filtering techniques. This leads to local optimization problems, and the resulting optimal strategy needs to be updated continuously in time. We prove a minimax theorem for the local optimization problems and derive the optimal strategy. In this setting we show how an ellipsoidal uncertainty set can be defined based on filtering techniques and we demonstrate that investors need to choose a robust strategy to be able to profit from additional information.

Stochastic Optimal Control of Thermal Energy Storages

Session 3
Tue, 15:30

Paul Honore Takam
BTU Cottbus-Senftenberg

Thermal storage facilities help to mitigate and to manage temporal fluctuations of heat supply and demand for heating and cooling systems of single buildings as well as for district heating systems. We focus on a heating system equipped with several heat-production units using also renewable energies and an underground thermal storage. That storage comprises a given volume under or aside of a building and is filled with soil and insulated to the surrounding ground. The thermal energy is stored by raising the temperature of the soil inside the storage. It is charged and discharged via heat exchanger pipes filled with a moving fluid. Besides the numerous technical challenges and the computation of the spatio-temporal temperature distribution in the storage also economic issues such as the cost-optimal control and management of such systems play a central role. The latter is studied mathematically in terms of a stochastic optimal control problem. There we incorporate uncertainties about randomly fluctuating renewable heat production, environmental conditions driving the heat demand, and energy prices. The dynamics of controlled state process is governed a system of a PDE and several ODEs and SDEs. Model reduction techniques are adopted to cope with the PDE describing the spatio-temporal temperature distribution in the geothermal storage. Finally, time-discretization leads to a Markov decision process for which we apply approximate dynamic programming techniques to determine a cost-optimal control.

This is a joint work with Olivier Menoukeu Pamen and Ralf Wunderlich.

9. Stochastic processes: Theory and statistics

Chairs: Mark Podolskij, Alexander Schnurr

Live Sessions

Session 1 (Monday, 12:00)- zoom room 5

- **Franziska Kühn** (live invited talk): Applications of martingale problems in the theory of Lévy-driven SDEs
- **Sebastian Rickelhoff**: Semimartingales with Killing and Their Fourth Characteristic
- **David Oechsler**: On q-scale functions of spectrally negative Lévy processes
- **Wei Xu**: A Ray-Knight Theorem for Spectrally Positive Stable Processes

Session 2 (Tuesday, 15:30)- zoom room 5

- **Carsten Chong** (live invited talk): Mixed semimartingales: Volatility estimation in the presence of fractional noise
- **Gregor Pasemann**: Statistical analysis of discretely sampled semilinear SPDEs: a power variation approach
- **Florian Hildebrandt**: Nonparametric calibration for stochastic reaction-diffusion equations based on discrete observations
- **Sascha Gaudlitz**: Statistical Inference on the reaction term in semi-linear SPDEs

Session 3 (Wednesday, 13:45)- zoom room 4

- **Ester Mariucci** (live invited talk): Non-asymptotic bounds of the CDF of Lévy processes and applications in statistics
- **Anton Tiepner**: Nonparametric estimation of the first order coefficient in convection-diffusion SPDEs from mutiple local measurements
- **Niklas Dexheimer**: Nonparametric invariant density and drift estimation for stochastic damping Hamiltonian systems
- **Lukas Trottner**: Learning to reflect: A unifying approach for data-driven stochastic control strategies
- **Nina Dörnemann**: Linear spectral statistics of sequential sample covariance matrices

Session 4 (Wednesday, 15:30)- zoom room 4

- **Markus Bibinger** (live invited talk): Inference on jumps in high-frequency order-price models with one-sided noise
- **Dennis Schroers**: A weak law of large numbers for realised covariation in a Hilbert space setting
- **Malon Janssen**: Volatility estimation under one-sided errors
- **Martin Kilian**: Persistence probabilities of fractional processes

Session 5 (Thursday, 12:00)- zoom room 4

- **Andreas Basse-O'Connor** (live invited talk): A Berry-Esseén theorem for partial sums of functionals of heavy-tailed moving averages
- **Albert Rapp**: Long Range Dependence for Stable Random Processes
- **Viet Hoang**: An inverse problem in the context of harmonizable symmetric alpha-stable processes
- **Dan Leonte**: Simulation methods for trawl processes

Session 6 (Friday, 12:00)- zoom room 6

- **Fabian Mies** (live invited talk): Regularity of multifractional moving average processes with random Hurst exponent
- **Bennet Ströh**: Approximations, asymptotics and inference for continuous-time locally stationary processes
- **Farid Mohamed**: Almost periodically stationary processes
- **Laura Jula Vanegas**: Analyzing cross-talk between superimposed signals

Invited Talks

A Berry-Esseén theorem for partial sums of functionals of heavy-tailed moving averages

Session 5
Thu, 12:00
live

Andreas Basse-O'Connor
Aarhus University

In this talk we obtain Berry-Esseén bounds on partial sums of functionals of heavy-tailed moving averages, including the linear fractional stable noise, stable fractional ARIMA processes and stable Ornstein-Uhlenbeck processes. Our rates are obtained for the Wasserstein and Kolmogorov distances, and depend strongly on the interplay between the memory of the process, which is controlled by a parameter a and its tail-index, which is controlled by a parameter b. In fact, we obtain the classical $1/\sqrt{n}$ rate of convergence when the tails are not too heavy and the memory is not too strong, more precisely, when ab>3 or ab>4 in the case of Wasserstein and Kolmogorov distance, respectively.

Inference on jumps in high-frequency order-price models with one-sided noise

Session 4
Wed, 15:30
live

Markus Bibinger
Universität Würzburg

For high-frequency intra-day price processes it is well-known that market microstructure dilutes the underlying dynamics of a semi-martingale model. Different to the classical model for traded prices with additive, centred market microstructure noise, we consider a stochastic boundary model with one-sided noise for best-ask prices from the limit order book. We construct methods to estimate, locate and test for jumps in this model. The different structure of our irregular noise leads us to statistics based on local minima instead of local averages, which have been used for regular noise in the literature. We first discuss inference for a possible jump at some given (stopping) time. We provide a local test and show that we can consistently estimate price jumps. We develop a global test for jumps based on extreme value theory. We establish the asymptotic distribution of a test statistic under the null hypothesis and consistency under the alternative hypothesis. The rate of convergence for local alternatives is faster than in the regular noise model what allows the identification of smaller jumps based on discrete observations. In the process, we establish central limit theorems for spot volatility estimation.

Mixed semimartingales: Volatility estimation in the presence of fractional noise

Session 2
Tue, 15:30
live

Carsten Chong
Columbia University

Our quantitative bounds rely on a new second-order Poincaré inequality on the Poisson space, which we derive through a combination of Stein's method and Malliavin calculus. This inequality improves and generalizes a result by Last, Peccati, Schulte [Probab. Theory Relat. Fields 165 (2016)]. The talk is based on joint work with M. Podolskij and C. Thäle.

Applications of martingale problems in the theory of Lévy-driven SDEs

Session 1
Mon, 12:00
live

Franziska Kühn

Technische Universität Dresden

Consider the stochastic differential equation (SDE)

$$dX_t = \sigma(X_t)\,dL_t, \qquad X_0 \sim \mu$$

driven by a Lévy process $(L_t)_{t\geq 0}$. In the first part of this talk, we explain how existence and uniqueness of weak solutions to the SDE can be equivalently formulated in terms of so-called martingale problems. Using this characterization, we derive an existence result for weak solutions. More precisely, we show that for any continuous function σ which grows at most linearly, i.e. $|\sigma(x)| \leq c(1+|x|)$, there exists a non-exploding weak solution to the SDE. Moreover, we give some remarks on the existence of Markovian solutions to the SDE (for the case that uniqueness of solutions fails to hold).

Non-asymptotic bounds of the CDF of Lévy processes and applications in statistics

Session 3
Wed, 13:45
live

Ester Mariucci

Université Versailles Saint Quentin

We propose new non-asymptotic bounds of the cumulative distribution function of Lévy processes with Lévy density bounded from above by the density of an alpha-stable type Lévy process in a neighborhood of the origin. These bounds are then applied to derive non-asymptotic risk bounds for estimators of the Lévy density from discrete observations. It is a joint work with Céline Duval.

Regularity of multifractional moving average processes with random Hurst exponent

Session 6
Fri, 12:00
live

Fabian Mies

RWTH Aachen

A recently proposed alternative to multifractional Brownian motion (mBm) with random Hurst exponent is studied, which we refer to as Itô-mBm. It is shown that Itô-mBm is locally self-similar. In contrast to mBm, its pathwise regularity is almost unaffected by the roughness of the functional Hurst parameter. The pathwise properties are established via a new polynomial moment condition similar to the Kolmogorov-Centsov theorem, allowing for random local Hölder exponents. Our results are applicable to a broad class of moving average processes where pathwise regularity and long memory properties may be decoupled, e.g. to a multifractional generalization of the Matérn process. The talk is based on joint work with Dennis Loboda and Ansgar Steland.

Contributed Talks

Nonparametric invariant density and drift estimation for stochastic damping Hamiltonian systems

Session 3
Wed, 13:45

Niklas Dexheimer
Aarhus University

We investigate nonparametric invariant density and drift estimation in sup-norm loss for a class of hypoelliptic diffusion processes, so-called stochastic damping Hamiltonian systems, based on continuous observations. Regarding invariant density estimation, we show that the degeneracy of the underlying process implies peculiar variance bounds for the used kernel density estimator, which lead to highly non-classical rates of convergence. Concerning drift estimation we prove uniform moment bounds for stochastic integrals wrt to the velocity process, which are then used to show the classic nonparametric rate of convergence for a Nadaraya–Watson type estimator.

Linear spectral statistics of sequential sample covariance matrices

Session 3
Wed, 13:45

Nina Dörnemann
Ruhr-Universität Bochum

(joint work with Holger Dette) Estimation and testing of a high-dimensional covariance matrix is a fundamental problem of statistical inference with numerous applications in biostatistics, wireless communications and finance. Linear spectral statistics are frequently used to construct tests for various hypotheses. In this work, we consider linear spectral statistics from a sequential point of view. To be precisely, we prove that the stochastic process corresponding to a linear spectral statistic of the sequential empirical covariance estimator converges weakly to a non-standard Gaussian process. As an application we use these results to develop a novel approach for monitoring the sphericity assumption in a high-dimensional framework, even if the dimension of the underlying data is larger than the sample size. Compared to previous contributions in this field, the results of the present work are conceptually different, because the sequential parameter used in the definition of the process also appears in the eigenvalues. This "nonlinearity" results in a substantially more complicated structure of the problem. In particular, the limiting processes are non-standard Gaussian processes, and the proofs of our results (in particular the proof of tightness) require an extended machinery, which has so far not been considered in the literature on linear spectral statistics. As a consequence, we provide a substantial generalization of the classical CLT for linear spectral statistics proven by Bai and Silverstein.

Statistical Inference on the reaction term in semi-linear SPDEs

Session 2
Tue, 15:30

Sascha Gaudlitz
Humboldt Universität Berlin

The well-known Girsanov Theorem for semi-linear SPDEs allows for a MLE for the reaction term. I will analyze its properties in the novel asymptotic regime in which the diffusivity of the system tends to zero. Under general assumptions on the reaction term, the MLE has a rate of convergence that is directly related to the Hilbert-Schmidt norm of the (rescaled) semi-group generating the SPDE. Furthermore, under slightly stronger assumptions, applying Malliavin calculus yields a central limit theorem. This is joint work with Markus Reiß.

Nonparametric calibration for stochastic reaction-diffusion equations based on discrete observations

Session 2
Tue, 15:30

Florian Hildebrandt
Universität Hamburg

In view of a growing number of stochastic partial differential equation (SPDE) models used in the natural sciences as well as in mathematical finance, their data-based calibration has become an increasingly active field of research during the last few years. In this talk, nonparametric estimation for semilinear SPDEs, namely stochastic reaction-diffusion equations in one space dimension, is discussed. We consider observations of the solution field on a discrete grid in time and space with infill asymptotics in both coordinates. Firstly, based on a precise analysis of the Hölder regularity of the solution process and its nonlinear component, we deduce that the asymptotic properties of diffusivity and volatility estimators derived from realized quadratic space-time variations in the linear setup generalize to the semilinear SPDE. Doing so, we obtain a rate-optimal joint estimator of the two parameters. Secondly, we present a nonparametric estimator for the reaction function specifying the underlying equation. The estimate is chosen from a finite-dimensional function space based on a least squares criterion. An oracle inequality with respect to the L^2-risk provides conditions for the estimator to achieve the usual nonparametric rate of convergence. Adaptivity is provided via model selection. The talk is based on joint work with Mathias Trabs.

An inverse problem in the context of harmonizable symmetric alpha-stable processes

Session 5
Thu, 12:00

Viet Hoang
Institute of Stochastics, Ulm University

Real stationary harmonizable symmetric alpha-stable processes are characterized by their control measure. We assume this measure is symmetric and possesses a density function f on R, which we refer to as spectral density. When considering the codifference function, which describes the dependence structure of the stable process, it can be shown that it contains the so-called alpha-sine integral transform of the spectral density f. We show that the alpha-sine transform of f generally admits a series representation for all alpha>-1 involving Fourier transform of f and hypergeometric functions. Based on this series representation we construct a system of linear equations whose solution is the Fourier transform of f at equidistant points. Finally, sampling theory, interpolation and Fourier inversion allow us to approximate the spectral density f. The results are illustrated numerically. (If time allows) We would also like to briefly mention some open problems involving the ergodicity of the process and the estimation of the codifference function (and the involved alpha-sine transform).

Volatility estimation under one-sided errors

Session 4
Wed, 15:30

Malon Janssen
Julius-Maximilians-Universität Würzburg - Lehrstuhl für Angewandte Stochastik

We consider a continuous Itô process $(X_t)_{t\in[0,1]}$, which forms a stochastic boundary of a point process. Based on observations of the point process, a rate-optimal estimator for the total quadratic variation $\langle X, X\rangle_t$ is designed. The problem can be transferred to a discrete-time, regression-type model with one sided noise and observations $Y_i = X_{t_i} + \epsilon_i$, $\epsilon_i \geq 0$. Generalizing the model from Bibinger, Jirak, Reiss (2016), the form of the distribution function of noise is $\delta x^\alpha(1+o(1))$, $x \downarrow 0$, $\delta, \alpha > 0$, with a parameter α. It is shown that $n^{-\frac{1}{2+\alpha}}$ is the optimal convergence rate in a high-frequency framework with n observations. A lower bound can be specified up to logarithmic factors. For practical application, we use a negative Hill estimator for estimating the parameter α. Moreover, we empirically investigate the statistical relevance of the new parameter α and give an application for the estimation of the integrated squared volatility using data from intraday order books.

Analyzing cross-talk between superimposed signals

Session 6
Fri, 12:00

Laura Jula Vanegas
Georg-Augus- Universität Göttingen

We propose and investigate a hidden Markov model (HMM) for the analysis of aggregated, super-imposed two-state signal recordings. A major motivation for this work is that often these recordings cannot be observed individually but only their superposition. Among others, such models are in high demand for the understanding of cross-talk between ion channels, where each single channel might take two different states which cannot be measured separately. As an essential building block we introduce a parametrized vector norm dependent Markov chain model and characterize it in terms of permutation invariance as well as conditional independence. This leads to a hidden Markov chain "sum" process which can be used for analyzing aggregated two-state signal observations within a HMM. Additionally, we show that the model parameters of the vector norm dependent Markov chain are uniquely determined by the parameters of the "sum" process and are therefore identifiable. Finally, we provide algorithms to estimate the parameters and apply our methodology to real-world ion channel data measurements, where we show competitive gating.

Persistence probabilities of fractional processes

Session 4
Wed, 15:30

Martin Kilian
TU Darmstadt

Persistence concerns the event that a real-valued stochastic process has a long excursion staying below (or above) a certain level. Typical questions in this area are: What is the probability of this event? What does the process conditioned on this event look like? These are classical questions for Brownian motion, random walks and Lévy processes, with many applications in applied probability, such as queueing, finance and insurance. Contrary, for fractional processes, research on this type of problems has just begun, as many powerful tools of the Markovian setting are not available anymore. In this talk, we give an overview of the known results and in particular discuss our recent progress for integrated fractional Brownian motion and Riemann-Liouville processes.

Simulation methods for trawl processes

Session 5
Thu, 12:00

Dan Leonte
Imperial College London

Trawl processes are continuous-time, stationary and infinitely divisible processes which can describe a wide range of possible serial correlation patterns in data. This talk presents the elementary properties of trawl processes and introduces a new algorithm for the efficient simulation of monotonic trawl processes. The algorithm accommodates any monotonic trawl shape and any infinitely divisible distribution described via the Lévy seed, requiring only access to samples from the distribution of the Lévy seed. Further, the computational complexity does not scale with the number of spatial dimensions of the trawl.

Almost periodically stationary processes

Session 6
Fri, 12:00

Farid Mohamed
Ulm University

In this talk, we define a new concept of stationarity, namely almost periodically stationary processes. We call a stochastic process $(X_t)_{t\in\mathbb{R}^d}$ almost periodically stationary if for every $\varepsilon > 0$ there exists an L_ε and a $\tau(a,\varepsilon) = \tau \in [a, a+L_\varepsilon]^d$ for all $a \in \mathbb{R}^d$ such that

$$d_n(P_{X_{t_1},\dots,X_{t_n}}, P_{X_{t_1+\tau},\dots,X_{t_n+\tau}}) < \varepsilon$$

for every $t_1,\dots,t_n \in \mathbb{R}^d$, where d_n is the Prokhorov-metric. We derive conditions when the stochastic integral

$$X_t := \int_{\mathbb{R}^d} f(t,s)\,dL(s)$$

is almost periodically stationary, where $f(t,\cdot) \in L^1(\mathbb{R}^d) \cap L^2(\mathbb{R}^d)$ and L is a Lévy basis. Furthermore, we discuss almost periodic Ornstein-Uhlenbeck processes and characterize for a submultiplicative function g the uniform integrability of the process $(g(X_t))_{t\in\mathbb{R}^d}$ dependent on the characteristic triplet of an infinitely divisible random field $(X_t)_{t\in\mathbb{R}^d}$.

On q-scale functions of spectrally negative Lévy processes

Session 1
Mon, 12:00

David Oechsler
TU Dresden

Scale functions are a prominent tool in the analysis and application of spectrally negative Lévy processes (snLp) as many path properties can be expressed by them. However, the usefulness of scale functions depends heavily on the availability of explicit formulae which exist only in rare cases. Splitting snLp into those with either, (i) a nonzero Gaussian component, or (ii) paths of bounded variation, or (iii) neither of both, we introduce series representations for the scale functions in all three cases. This generalises previous results for the cases (i) and (ii), but our main focus lies on the rarely treated case (iii). Here we use methods from Volterra integral equations, Bernstein functions and fractional calculus to obtain new formulae. The obtained series expansions lead to new examples of snLp for which the scale functions are given explicitly, e.g., independent sums of stable processes and compound Poisson processes, and snLp for which the integrated tail function of the Lévy measure is regularly varying at zero. Moreover, in case (iii) we use the series expansion to examine how the smoothness of the scale functions depends on the smoothness of the Lévy measure.

Statistical analysis of discretely sampled semilinear SPDEs: a power variation approach

Session 2
Tue, 15:30

Gregor Pasemann
TU Berlin

We consider a parameter estimation problem for semilinear stochastic partial differential equations (SPDE) from discrete observations, adopting a power variation approach. The varying spatial smoothness of the solution process requires a non-trivial regularity-dependent adjustment. In order to understand this effect systematically, we study representations of the solution process in terms of iteratively integrated fractional Brownian motion. The central limit theorems obtained for this reference process are of independent interest and relate to the SPDE setting. The general theory is applicable to a broad class of models, including stochastic reaction-diffusion equations and the stochastic Burgers equation. This talk is based on joint work with Igor Cialenco and Hyun-Jung Kim.

Long Range Dependence for Stable Random Processes

Session 5
Thu, 12:00

Albert Rapp
Ulm University

We investigate long and short memory in α-stable moving averages and max-stable processes with α-Fréchet marginal distributions. As these processes are heavy-tailed, we rely on the notion of long range dependence based on the covariance of indicators of excursion sets. Sufficient conditions for the long and short range dependence of α-stable moving averages are proven in terms of integrability of the corresponding kernel functions. For max-stable processes, the extremal coefficient function is used to state a necessary and sufficient condition for long range dependence.

Semimartingales with Killing and Their Fourth Characteristic

Session 1
Mon, 12:00

Sebastian Rickelhoff
Universität Siegen

In the classical theory of Markov processes it is natural to add a point of no return to the original state space e.g. if the process is defined via sub-Markovian transition kernels. This point is thought of as being infinitely far away and models a state that the process once reached cannot leave. This "killing state" or "graveyard" is well-understood in the theory of Markov processes. Our aim is to embed such a point into the theory of semimartingales and their characteristics where an equivalent concept as it is used in the Markovian framework has been missing in the literature. Thus, we made it our task to consider processes that leave the original space at a random time and in doing so, reach the "killing state". Moreover, these processes should coincide with a classical semimartingale up to that random time. In contrast to the theory of Markov processes we have to differentiate between two different kinds of killing, for technical reasons. One of these poses problems for the easy generalisation of the classical theory, namely a certain jump to the "graveyard": A semimartingale is uniquely determined by its characteristics (B,C,v) where the random measure v compensates the jumps of the process. For a jump of height infinity, v is not able to do so. So, unfortunately, a semimartingale with killing is not uniquely determined by the original characteristics. Hence, we are in need of a new characteristic which describes the single jump to the "killing state". To this end, it is the idea to not compensate the jump itself but the time it occurs. This results in the predictable, monotone process A which we call the fourth characteristic of a semimartingale. The aim of the current research is to embed the new characteristic into the classical context of semimartingales, Feller- and Hunt-Processes.

A weak law of large numbers for realised covariation in a Hilbert space setting

Session 4
Wed, 15:30

Dennis Schroers
University of Oslo

We generalise the concept of realised covariation to Hilbert space-valued stochastic processes. More precisely, based on high-frequency functional data, we construct an estimator of the trace-class operator-valued integrated volatility process arising in general mild solutions of Hilbert space-valued stochastic evolution equations. We prove a weak law of large numbers for this estimator, where the convergence is uniform on compacts in probability with respect to the Hilbert- Schmidt norm. This is joint work with Fred Espen Benth and Almut Veraart.

Approximations, asymptotics and inference for continuous-time locally stationary processes

Session 6
Fri, 12:00

Bennet Ströh

Ulm University

We introduce a general theory on stationary approximations for locally stationary continuous-time processes. Based on the stationary approximation, we use θ-weak dependence to establish laws of large numbers and central limit type results under different observation schemes. Hereditary properties for a large class of finite and infinite memory transformations show the flexibility of the developed theory and are used to establish asymptotic properties of M-estimators. As examples we consider time-varying Ornstein-Uhlenbeck processes and time-varying Lévy-driven state space models, for which we introduce a localized quasi maximum likelihood estimator. A simulation study shows the applicability of the estimation procedure.

Nonparametric estimation of the first order coefficient in convection-diffusion SPDEs from mutiple local measurements

Session 3
Wed, 13:45

Anton Tiepner

Aarhus University

We extend the recently developed method of estimating parameters in parabolic stochastic partial differential equations (SPDEs) from local measurements to nonparametric lower order coefficients. A modified likelihood approach combined with techniques from nonparametric regression provides us with a consistent and robust estimator for the unknown velocity. We apply ideas for local-polynomial estimators to exploit Hölder-regularity up to a degree of two which leads to a rather unusual convergence rate. We illustrate these results with numerical examples.

Learning to reflect: A unifying approach for data-driven stochastic control strategies

Session 3
Wed, 13:45

Lukas Trottner

University of Mannheim

Stochastic optimal control problems have a long tradition in applied probability, with the questions addressed being of high relevance in a multitude of fields. Even though theoretical solutions are well understood in many scenarios, their practicability suffers from the assumption of known dynamics of the underlying stochastic process, raising the statistical challenge of developing purely data-driven strategies. For the mathematically separated classes of continuous diffusion processes and Lévy processes, we show that developing efficient strategies for related singular stochastic control problems can essentially be reduced to finding rate-optimal estimators with respect to the sup-norm risk of objects associated to the invariant distribution of ergodic processes which determine the theoretical solution of the control problem. From a statistical perspective, we exploit the exponential β-mixing property as the common factor of both scenarios to drive the convergence analysis, indicating that relying on general stability properties of Markov processes is a sufficiently powerful and flexible approach to treat complex applications requiring statistical methods. We show moreover that in the Lévy case—even though per se jump processes are more difficult to handle both in statistics and control theory—a fully data-driven strategy with regret of significantly better order than in the diffusion case can be constructed.

A Ray-Knight Theorem for Spectrally Positive Stable Processes

Session 1
Mon, 12:00

Wei Xu

Humboldt-Universität zu Berlin

We generalize a classical second Ray-Knight theorem to spectrally positive stable processes. It is shown that the local time processes are solutions of certain stochastic Volterra equations driven by Poisson random measure and they belong to a class of fully novel non-Markov branching processes, named as rough continuous-state branching processes. Also, we prove the weak uniqueness of solutions to the stochastic Volterra equations by providing explicit exponential representations of the characteristic functionals in terms of the unique solutions to some associated nonlinear Volterra equations.

10. Time series

Chairs: Carsten Jentsch, Axel Bücher

Live Sessions

Session 1 (Tuesday, 13:45)- zoom room 6

- **Efstathios Paparoditis** (live invited talk): Prediction Bands for Functional Time Series
- **Sven Otto**: Dynamic Factor Model for Functional Time Series: Identification, Estimation, and Prediction
- **Sebastian Kühnert**: Lagged Covariance and Cross-Covariance Operators of Processes in Cartesian Products of Abstract Hilbert Spaces
- **Ines Nüßgen**: Ordinal Pattern Dependence in the Context of Long-Range Dependence
- **Boris Aleksandrov**: Novel Goodness-of-Fit Tests for Binomial Count Time Series

Session 2 (Wednesday, 15:30)- zoom room 6

- **Suhasini Subba Rao** (live invited talk): Graphical models for multivariate nonstationary time series
- **Carina Beering**: A Test of Independence for Locally Stationary Processes Using a Weighted Characteristic Function-based Distance
- **Theresa Eckle**: Testing for isotropy with irregularly spaced spatial data
- **Martin Kroll**: Adaptive spectral density estimation by model selection under local differential privacy
- **Alexander Braumann**: Simultaneous Inference for Autocovariances based on Autoregressive Sieve Bootstrap

Session 3 (Friday, 13:45)- zoom room 6

- **Ivan Kojadinovic** (live invited talk): Open-end nonparametric sequential change-point detection sensitive to changes in the mean
- **Johannes Heiny**: Sequential change point detection in high-dimensional time series
- **Philipp Klein**: Moving sum data segmentation for stochastic processes based on invariance
- **Sebastian Neblung**: Sliding and disjoint blocks estimators for the extremal index

Invited Talks

Open-end nonparametric sequential change-point detection sensitive to changes in the mean

Session 3
Fri, 13:45
live

Ivan Kojadinovic

Université de Pau et des Pays de l'Adour

The aim of online monitoring is to issue an alarm as soon as there is significant evidence in the collected observations to suggest that the underlying data generating mechanism has changed. This work is concerned with open-end, nonparametric procedures that can be interpreted as statistical tests. The proposed monitoring schemes consist of computing the so-called retrospective CUSUM statistic after the arrival of each new observation. After proposing suitable threshold functions for the chosen detectors, the asymptotic validity of the procedures is investigated in the special case of monitoring for changes in the mean, both under the null hypothesis of stationarity and relevant alternatives. To carry out the sequential tests in practice, an approach based on an asymptotic regression model is used to estimate high quantiles of relevant limiting distributions. Monte Carlo experiments demonstrate the good finite- sample behavior of the proposed monitoring schemes and suggest that they are superior to existing competitors as long as changes do not occur at the very beginning of the monitoring. Extensions to statistics exhibiting an asymptotic mean-like behavior are briefly discussed. This is joint work with Mark Holmes from the University of Melbourne.

Prediction Bands for Functional Time Series

Session 1
Tue, 13:45
live

Efstathios Paparoditis

University of Cyprus

A bootstrap procedure for constructing prediction bands for a stationary functional time series is proposed. The procedure exploits a general vector autoregressive representation of the time-reversed series of Fourier coefficients appearing in the Karhunen-Loeve representation of the functional process. It generates backward-in-time, functional replicates that adequately mimic the dependence structure of the underlying process in a model-free way and have the same conditionally fixed curves at the end of each functional pseudo-time series. The bootstrap prediction error distribution is then calculated as the difference between the model-free, bootstrap-generated future functional observations and the functional forecasts obtained from the model used for prediction. This allows the estimated prediction error distribution to account for the innovation and estimation errors associated with prediction and the possible errors due to model misspecification. We establish the asymptotic validity of the bootstrap procedure in estimating the conditional prediction error distribution of interest, and we also show that the procedure enables the construction of prediction bands that achieve (asymptotically) the desired coverage. Prediction bands based on a consistent estimation of the conditional distribution of the studentized prediction error process also are introduced. Such bands allow for taking more appropriately into account the local uncertainty of prediction. Through a simulation study and the analysis of two data sets, we demonstrate the capabilities and the good finite-sample performance of the proposed method.

Joint work with Hanlin Shang, Macquarie University, Sidney, Australia

---

Graphical models for multivariate nonstationary time series

Session 2
Wed, 15:30
live

Suhasini Subba Rao
Texas A&M

Graphical modeling of multivariate time series is widely used for learning dynamic relationships among the components of a system. In contrast with Gaussian Graphical Models (GGM) of independent data, time series graphical models aim to capture conditional lead-lag as well as contemporaneous associations. However, to date, there is no general nonparametric graphical modeling framework for nonstationary time series. We propose NonStGGM, a nonparametric graphical modeling framework for nonstationary multivariate time series that includes sharp changes as well as smoothly varying dynamics. The NonStGGM graph captures the nuanced dynamics of a multivariate system through labelled nodes and edges. A salient feature of NonStGGM is the new notion of conditional stationarity and nonstationarity, which allows one to distinguish between direct and indirect nonstationary relationships; analogous to partial correlation which delineates direct and indirect associations in GGM. This can be used to search for a small subnetwork that serves as a "source" of nonstationarity in a large system, and can be potentially used as a dimension reduction tool for nonstationary multivariate time series.

Central to the NonStGGM framework is the introduction of several new technical tools. First, we connect conditional stationarity to an infinite dimensional inverse covariance matrix operator which contain Toeplitz submatrix operators. Second, we transform the inverse covariance matrix operator to the Fourier domain. We show that the corresponding integral kernel encodes different types of conditional relationships through various sparsity patterns. These sparsity patterns will allow us to deduce the NonStGGM network from the integral kernel of the covariance matrix operator. Third, assuming local stationarity, we show that this sparsity pattern can be learned from finite-length time series by nodewise regression of discrete Fourier Transforms (DFT). We demonstrate the feasibility of learning NonStGGM selection from finite samples on simulated data sets.

This is joint work with Sumanta Basu (Cornell University)

Contributed Talks

Novel Goodness-of-Fit Tests for Binomial Count Time Series

Session 1
Tue, 13:45

Boris Aleksandrov
Helmut-Schmidt-Universität Hamburg

For testing the null hypothesis of a marginal binomial distribution of bounded count data, we derive novel and flexible goodness-of-fit (GoF) tests. We propose two general approaches to construct moment-based test statistics. The first one relies on properties of higher-order factorial moments, while the second one uses a so-called Stein identity being satisfied under the null. For a broad class of stationary time series processes of bounded counts with joint bivariate binomial distributions of lagged time series values, we derive the limiting distributions of the proposed GoF-test statistics. Among others, our setup covers the binomial autoregressive model, but includes also other binomial time series obtained, e.g. by superpositioning independent binary time series. The test performance under the null and under different alternatives is investigated in simulations. A data example of price stability counts is used to illustrate the application of the novel GoF-tests.

A Test of Independence for Locally Stationary Processes Using a Weighted Characteristic Function-based Distance

Session 2
Wed, 15:30

Carina Beering
Helmut Schmidt University

We propose a testing procedure for independence of locally stationary processes resting on a weighted distance composed of characteristic functions (CF) and its empirical version. The basic idea of this concept is inspired by the distance covariance defined by Székely et al. (2007) and seized by Jentsch et al. (2020). In order to compile a testing procedure at the end, we provide the results needed for this purpose with the notion of the beneficial effects of a bootstrap analogue. Therefore, we establish the bootstrap versions of the previously presented findings. Prior to that, we transfer the concept of empirical weighted CF-distance to the bootstrap world. Finally, a simulation study is performed using our testing procedure to detect dependence.

References:

Jentsch, C., Leucht, A., Meyer, M. and Beering, C. (2020). Empirical characteristic functions-based estimation and distance correlation for locally stationary processes. Journal of Time Series Analysis 41, 110-133.

Székely, G.J., Rizzo, M.L. and Bakirov, N.K. (2007). Measuring and testing dependence by correlation of distances. The Annals of Statistics 35, 2769-2794.

Simultaneous Inference for Autocovariances based on Autoregressive Sieve Bootstrap

Session 2
Wed, 15:30

Alexander Braumann
TU Braunschweig

In this talk maximum deviations of sample autocovariances and autocorrelations from their theoretical counterparts over an increasing set of lags are considered. The asymptotic distribution of such statistics for physically dependent stationary time series, which is of Gumbel type, only depends on second order properties of the underlying time series. Since the autoregessive sieve bootstrap is able to mimic the second order structure asymptotically correctly it is an obvious problem whether the autoregressive sieve bootstrap, which has been shown to work for a number of relevant statistics in time series analysis, asymptotically works for maximum deviations of autocovariances and autocorrelations as well. We show that the question can be answered positively. Moreover potential applications including spectral density estimation and an investigation of finite sample properties of the autoregressive sieve bootstrap proposal by simulation are given.

Testing for isotropy with irregularly spaced spatial data

Session 2
Wed, 15:30

Theresa Eckle

Ruhr-Universität Bochum

Correctly specifying the covariance structure of a random field is essential for the analysis of spatial data. A common concept in this area is the isotropy assumption, which means that the covariance function of the random field only depends on the distance between two observations and not on their relative orientation. We propose a test for isotropy for irregularly sampled spatial data in the two-dimensional case. The test is based on the L^2-distance between the spectral density and its best approximation by a function only depending on the norm of the argument. Under the null hypothesis of isotropy, this minimal distance equals 0, while it is greater than 0 under anisotropy. Estimating the distance measure is facilitated by the fact that it has an explicit representation in terms of certain integrals of the spectral density and its square. These integrals can be estimated directly with the help of appropriate Riemann approximations over tapered spatial periodograms, where tapering techniques are used in order to avoid the occurrence of an edge effect bias. After standardization, the resulting test statistic is shown to be asymptotically standard normal distributed and gives rise to a consistent level α-test for isotropy.

Sequential change point detection in high-dimensional time series

Session 3
Fri, 13:45

Johannes Heiny

Ruhr-Universität Bochum

Change point detection in high-dimensional data has found considerable interest in recent years. Most of the literature either designs methodology for a retrospective analysis, where the whole sample is already available when the statistical inference begins, or considers online detection schemes controlling the average time until a false alarm. In this talk we take a different point of view and develop monitoring schemes for the online scenario, where high dimensional data arrives successively and the goal is to detect changes as fast as possible controlling at the same time the probability of a type I error of a false alarm. We develop a sequential procedure capable of detecting changes in the mean vector of a successively observed high dimensional time series with spatial and temporal dependence. The statistical properties of the method are analyzed in the case where both, the sample size and dimension tend to infinity.

Joint work with Josua Gösmann, Christina Stoehr and Holger Dette.

Moving sum data segmentation for stochastic processes based on invariance

Session 3
Fri, 13:45

Philipp Klein

Otto-von-Guericke-Universität Magdeburg

The segmentation of data into stationary stretches also known as multiple change point problem is important for many applications in time series analysis as well as signal processing and therefore plays an important role in a variety of fields, e.g. in finance, neuroscience and engineering. Based on strong invariance principles, we analyze data segmentation methodology using moving sum (MOSUM) statistics for a class of regime-switching multivariate processes where each switch results in a change in the drift. In particular, this framework includes the data segmentation of multivariate partial sum, integrated diffusion and renewal processes even if the distance between change points is sublinear. We study the asymptotic behavior of the corresponding change point estimators, show consistency and derive the corresponding localization rates. Furthermore, we derive the limit distribution of the change point estimators for local changes under weak conditions.

Adaptive spectral density estimation by model selection under local differential privacy

Session 2
Wed, 15:30

Martin Kroll

Ruhr-Universität Bochum

We study spectral density estimation under local differential privacy. Anonymization is achieved through truncation followed by Laplace perturbation. We select our estimator from a set of candidate estimators by a penalized contrast criterion. This estimator is shown to attain nearly the same rate of convergence as the best estimator from the candidate set. A key ingredient of the proof are recent results on concentration of quadratic forms in terms of sub-exponential random variables obtained by Götze et al. We illustrate our findings in a small simulation study.

Lagged Covariance and Cross-Covariance Operators of Processes in Cartesian Products of Abstract Hilbert Spaces

Session 1
Tue, 13:45

Sebastian Kühnert

WINGAS, Kassel (formerly at University of Rostock)

A major task in Functional Time Series Analysis is measuring the dependence within and between processes, for which lagged covariance and cross-covariance operators have proven to be a practical tool in well established spaces. This article deduces estimators and asymptotic upper bounds of the estimation errors for lagged covariance and cross-covariance operators of processes in Cartesian products of abstract Hilbert spaces for fixed and increasing lag and Cartesian powers. We allow the processes to be non-centered, and to have values in different spaces when investigating the dependence between processes. Also, we discuss features of estimators for the principle components of our covariance operators.

Sliding and disjoint blocks estimators for the extremal index

Session 3
Fri, 13:45

Sebastian Neblung

Universität Hamburg

Extreme value estimators based on the observations of a time series are often constructed from blockwise defined statistics. These blocks can be specified as disjoint blocks $(X_t)_{(i-1)s+1\le t\le is}$, $1 \le i \le \lfloor n/s_n \rfloor$, of length s, or alternatively as sliding blocks $(X_t)_{i\le t\le i+s-1}$, $1 \le i \le n-s+1$. Yet another approach are offered by runs estimators, which can be interpreted as a special type of sliding blocks estimators. All three types of estimators can be analyzed asymptotically in an unified framework. We use this framework to show that the sliding block statistic leads to a smaller asymptotic variance than that from disjoint blocks.

We will discuss this unified, peak-over-threshold framework by the example of the extremal index, which is the reciprocal of the mean cluster length of extremes. The asymptotics of all three type of estimators for the extremal index will be established under the same conditions. In particular we will see that all three estimators have the same asymptotic variance.

Ordinal Pattern Dependence in the Context of Long-Range Dependence

Session 1
Tue, 13:45

Ines Nüßgen

Universität Siegen

Ordinal pattern dependence is a multivariate dependence measure based on the co-movement of two time series. In strong connection to ordinal time series analysis, the ordinal information is taken into account to derive robust results on the dependence between the two processes. This talk deals with ordinal pattern dependence for a long-range dependent time series including mixed cases of short- and long-range dependence. We investigate the limit distributions for estimators of ordinal pattern dependence. In doing so, we point out the differences that arise for the underlying time series having different dependence structures. Depending on these assumptions, central and non-central limit theorems are presented. The limit distributions for the latter ones can be included in the class of multivariate Rosenblatt processes. Finally, a simulation study is discussed to illustrate our theoretical findings.

Dynamic Factor Model for Functional Time Series: Identification, Estimation, and Prediction

Session 1
Tue, 13:45

Sven Otto

University of Bonn

A fully functional factor model is proposed in which both the common component and the idiosyncratic component are random elements of the Hilbert space of square-integrable functions on a bounded domain. We discuss in detail the conditions under which the components of such model are exactly and asymptotically identified. This result allows us to obtain a two stage estimation framework for the factors and loading functions as well as separating the common functional component from the idiosyncratic functional component. In particular, we obtain an asymptotically valid criterion that estimates jointly a separation point between common and idiosyncratic components and a dynamic lag structure of the common component. Further, we discuss how to obtain prediction bands under additional distributional assumptions. Finally, the methodology is applied to the problem of yield curve modeling and forecasting. In an out-of-sample experiment, it is shown that predictions can be significantly improved when compared to the predictor from the dynamic Nelson-Siegel model, which is the most commonly used term structure model for yield curves.

11. Statistical learning and computational statistics

Chairs: Nicole Mücke, Michael Vogt

Live Sessions

Session 1 (Wednesday, 13:45)- zoom room 2

- **Gilles Blanchard** (live invited talk): Fast rates for prediction with limited expert advice
- **Joseph Meyer**: Random Planted Forests
- **Artur Bille**: Spectral clustering of combinatorial fullerene isomers based on their facet graph structure
- **Stephan Huckemann**: Clustering Manifold Data Based on Principal Nested (Stratified) Spheres

Session 2 (Wednesday, 15:30)- zoom room 2

- **Alexandra Carpentier** (live invited talk):
- **Benjamin Walter**: Analysis of convolutional neural network image classifiers in a hierarchical max-pooling model with additional local pooling
- **Youness Boutaib**: Path classification with continuous-time linear stochastic RNNs
- **Nathawut Phandoidaen**: Forecasting time series with neural networks

Session 3 (Friday, 12:00)- zoom room 4

- **Ingo Steinwart** (live invited talk):
- **Sophie Langer**: Estimation of a regression function on a manifold by fully connected deep neural networks
- **Anastasis Kratsios**: Universal Probability Measure-Valued Deep Neural Networks
- **Stefan Richter**: Statistical analysis of Wasserstein GANs with applications to time series forecasting

Session 4 (Friday, 13:45)- zoom room 4

- **Nicole Mücke** (live invited talk):
- **Bernhard Stankewitz**: From inexact optimization to learning via gradient concentration
- **Mahsa Taheri**: Statistical Guarantees for the Stationary Points of Shallow and Linear Neural Networks

Invited Talks

Fast rates for prediction with limited expert advice

Session 1
Wed, 13:45
live

Gilles Blanchard

Université Paris Saclay

We investigate the problem of minimizing the excess generalization error with respect to the best expert (predictor) in a finite family in the stochastic setting, under limited access to information. We assume that the learner only has access to a limited number of expert advices per training round, as well as for prediction. Assuming that the loss function is Lipschitz and strongly convex, we show that if we are allowed to see the advice of only one expert per round for T rounds in the training phase, or to use the advice of only one expert for prediction in the test phase, the worst-case excess risk in the prediction phase must have a "slow rate" $(1/sqrt(T))$ convergence at best. However, if we are allowed to observe at least two actively chosen experts per training round and use at least two experts for prediction, the "fast rate" of order $1/T$ can be achieved. We design novel algorithms achieving this rate in this setting, and in the setting where the learner has a budget constraint on the total number of observed experts, and give precise instance-dependent bounds on the number of training rounds and expert queries needed to achieve a given generalization error precision. [This is joint work with E. Saad]

Several structured thresholding bandit problem

Session 2
Wed, 15:30
live

Alexandra Carpentier

Otto-von-Guericke-Universität Magdeburg

This talk will be on the topic of sequential learning, and on some specific instances of the stochastic bandit problem. The thresholding bandit problem is a sequential learning setting where the learner samples sequentially K unknown distributions for T times, and aims at outputting at the end the set of distributions whose means μ_k are above a threshold τ. We will study this problem under four structural assumptions, i.e. shape constraints: that the sequence of means is monotone, unimodal, concave, or unstructured (vanilla case). We will provide in each case minimax results on the performance of any strategies, as well as matching algorithms. This will highlight the fact that even more than in batch learning, structural assumptions have a huge impact in sequential learning.
This work is based on three joint works with James Cheshire, Pierre Menard, Andrea Locatelli and Maurilio Gutzeit: `http://proceedings.mlr.press/v125/cheshire20a.html`, `http://proceedings.mlr.press/v139/cheshire21a.html` and `http://proceedings.mlr.press/v48/locatelli16.html`.

TBA

Session 4
Fri, 13:45
live

Nicole Mücke

Technische Universität Braunschweig

TBA

TBA

Session 3
Fri, 12:00
live

Ingo Steinwart

Universität Stuttgart

TBA

Contributed Talks

Spectral clustering of combinatorial fullerene isomers based on their facet graph structure

Session 1
Wed, 13:45

Artur Bille

Ulm University - Institute of Stochastics

A fullerene graph is a 3-connected 3-regular planar graph with only pentagonal and hexagonal faces. This graph can be seen as a mathematical model of the famous fullerene molecule. After Curl, Kroto and Smalley were awarded 1996 the Nobel Prize in chemistry, fullerenes have been the subject of much research in Physics, Chemistry, and Mathematics. However, fundamental questions like the exact number of all possible fullerenes and how to cluster them properly are still unanswered. The latter question might be answered using the spectrum of matrices corresponding to fullerene graphs. In my talk, I present a novel method for classifying combinatorial fullerene isomers using spectral graph theory. The main idea is to find clusters of isomers by analyzing their graph structure of hexagonal facets only. We also show that our cluster analysis can serve as a formal stability criterion, which became evident from comparing our results with recent quantum chemical calculations. The presented method is related to other classical clustering methods as k-means-classification or kernel clustering methods.

Path classification with continuous-time linear stochastic RNNs

Session 2
Wed, 15:30

Youness Boutaib

RWTH Aachen University

We give mathematical learning guarantees for path-classification tasks using linear stochastic recurrent neural networks with continuous-time rate dynamics. This architecture finds its origin in neuroscience and is simple as training only requires finding a pre-processing projection vector and the parameters of a read-out map. We give generalisation error bounds and argue that stochasticity provides learning with a robustness against adversarial attacks. We also explicitly show that these RNNs use a partial signature of the paths as the only vector-summary of the path upon which training is based.

Clustering Manifold Data Based on Principal Nested (Stratified) Spheres

Session 1
Wed, 13:45

Stephan Huckemann

Georg-August-Universität Göttingen

For Riemannian manifold data we propose a clustering method building on pre clustering with any favorite clustering method on metric spaces. If necessary, change the geometry of the data space to that of a (stratified) sphere. Then, reduce dimensions of clusters to one by principal nested (stratified) spheres. Decisively, this method is more suited to this end than classical PCA. Taking advantage of the 1D representations, post-cluster by circular mode hunting.

This is joint work with Benjamin Eltzner, Kanti Mardia and Henrik Wiechers.

Universal Probability Measure-Valued Deep Neural Networks

Session 3
Fri, 12:00

Anastasis Kratsios

ETH Zürich + University of Basel

We introduce deep neural architecture types with inputs from a separable and locally-compact metric space X and outputs in the Wasserstein- 1 space over a separable metric space Y. We establish the density of our architecture type in C(X; P1(Y)), quantitatively. NB that our results are new even in the case where X and Y are Euclidean, in which case, we find that many commonly used types such as MDNs and MGANs are universal special cases of our model type. We show that our models approximate functions in C(X; P1(Y)) by implementing e-metric projections in the Wasserstein- metric onto the hull of certain finite families of measures therein. If the target function can be represented as a mixture of finitely many functions, each taking values in a finite-dimensional topological submanifold of the Wasserstein space, we find that the approximating networks can be assumed to have bounded width. As applications of our results, we address the following problems. We show that, under mild conditions, our architecture can approximate any regular conditional distribution of an X-valued random element X depending on a Y -valued random element Y with arbitrarily high probability. Consequentially, we show that once our approximation of this regular conditional distribution is learned, any conditional expectation of the form E[f(X; Y)|Y = y] for Caratheodory f with uniformly-Lipschitz first component and a uniformly-bounded second component, is approximable by standard Monte-Carlo sampling against the learned measure. We illustrate our theory in the context of stochastic processes.

Estimation of a regression function on a manifold by fully connected deep neural networks

Session 3
Fri, 12:00

Sophie Langer

Technische Universität Darmstadt

In this talk we consider the estimation of a regression function from independent and identically distributed data. The L2 error with integration with respect to the distribution of the predictor variable is used as the error criterion. The rate of convergence of least squares estimates based on fully connected spaces of deep neural networks with ReLU activation function is analyzed for smooth regression functions. It is shown that in case that the distribution of the predictor variable is concentrated on a manifold, these estimates achieve a rate of convergence which depends on the dimension of the manifold and not on the number of components of the predictor variable.

Random Planted Forests

Session 1
Wed, 13:45

Joseph Meyer

University of Heidelberg

Random planted forests is a novel interpretable and tree-based algorithm for prediction in which each tree in a classical random forest is replaced by a family of planted trees that grow simultaneously. The motivation is to estimate the unknown regression function from a functional ANOVA decomposition perspective, where each tree corresponds to a function within that decomposition. Therefore, planted trees are limited in the number of interaction terms. The maximal order of approximation in the ANOVA decomposition can be specified or left unlimited. In a simulation study we find encouraging prediction and visualisation properties of the random planted forest method. The results are backed by theory developed for an idealised version of random planted forests in the case of an underlying additive model.

Forecasting time series with neural networks

Session 2
Wed, 15:30

Nathawut Phandoidaen
Heidelberg University

We consider high-dimensional stationary processes where a new observation is generated from a compressed version of past observations. The specific evolution is modeled by an encoder-decoder structure and will be estimated by an appropriate neural network. We state upper bounds for the expected forecast error under specific structural and sparsity assumptions introduced by Schmidt-Hieber in 2017. The results are shown for conditions either on the absolutely regular mixing coefficients or the functional dependence measure of the observed process.

Statistical analysis of Wasserstein GANs with applications to time series forecasting

Session 3
Fri, 12:00

Stefan Richter
Heidelberg University

We provide statistical theory for conditional and unconditional Wasserstein generative adversarial networks (WGANs) in the framework of dependent observations. We prove upper bounds for the excess Bayes risk of the WGAN estimators with respect to a modified Wasserstein-type distance. Furthermore, we formalize and derive statements on the weak convergence of the estimators and use them to develop confidence intervals for new observations. The theory is applied to the special case of high-dimensional time series forecasting.

From inexact optimization to learning via gradient concentration

Session 4
Fri, 13:45

Bernhard Stankewitz
Humboldt University of Berlin

Optimization was recently shown to control the inductive bias in a learning process, a property referred to as implicit, or iterative regularization. The estimator obtained iteratively minimizing the training error can generalise well with no need of further penalties or constraints. In this paper, we investigate this phenomenon in the context of linear models with smooth loss functions. In particular, we investigate and propose a proof technique combining ideas from inexact optimization and probability theory, specifically gradient concentration. The proof is easy to follow and allows to obtain sharp learning bounds. More generally, it highlights a way to develop optimization results into learning guarantees.

Statistical Guarantees for the Stationary Points of Shallow and Linear Neural Networks

Session 4
Fri, 13:45

Mahsa Taheri
Ruhr-University Bochum

Nonconvexity is a fundamental issue in deep learning in a sense that optimization algorithms just guarantee convergence to a stationary point. While statistical guarantees for uncomputable theoretical estimators (global optima) in deep learning are abundant, such guarantees for their practical counterparts (stationary points) are rare. In this paper, we prove statistical guarantees for the stationary points of regularized-linear neural networks with one hidden layer. We study the behavior of Hessian matrix (of population risk) and use empirical-process theory to prove that under some assumptions, the practical networks generalize essentially as well as the best network (which, of course, is unknown in practice). We note that even though linear neural networks are not used in practice, the theoretical understanding of them is important, because previous empirical studies show that their optimization may exhibit some properties of nonlinear models.

Analysis of convolutional neural network image classifiers in a hierarchical max-pooling model with additional local pooling

Session 2
Wed, 15:30

Benjamin Walter

Technische Universität Darmstadt

Image classification is considered, and a hierarchical max-pooling model with additional local pooling is introduced. Here the additional local pooling enables the hierachical model to combine parts of the image which have a variable relative distance towards each other. Various convolutional neural network image classifiers are introduced and compared in view of their rate of convergence.

12. Nonparametric and asymptotic statistics

Chairs: Ursula Müller, Tatyana Krivobokova

Live Sessions

Session 1 (Monday, 12:00)- zoom room 2

- **Alexander Meister** (live invited talk): Nonparametric estimation of the ability density in the Mixed-Effect Rasch Model
- **Dennis Müller**: Minimax Estimation of the Mode of Functional Data
- **Christoph Reihl**: Confidence bands for the covariance kernel of Banach space valued functional data
- **Felix Gnettner**: Depth-based two sample testing

Session 2 (Monday, 13:45)- zoom room 2

- **Angelika Rohde** (live invited talk): Sharp adaptive similarity testing with pathwise stability for ergodic diffusions
- **Christof Schötz**: A Law of Large Numbers for Fréchet Mean Sets
- **Shayan Hundrieser**: Limit Distributions for Empirical Circular Optimal Transport
- **Do Tran**: Fréchet means and geometry

Session 3 (Tuesday, 12:00)- zoom room 2

- **Hajo Holzmann** (live invited talk): Statistically optimal estimation of signals in modulation spaces using Gabor frames
- **Karolina Klockmann**: Fully data-driven non-parametric estimation of Toeplitz covariance matrices
- **Sergio Brenner Miguel**: Anistropic spectral cut-off estimation under multiplicative measurement errors

Session 4 (Thursday, 12:00)- zoom room 2

- **Enno Mammen** (live invited talk): Using methods from survival analysis for modeling dynamic interaction networks
- **Gerrit Grobler**: A New Goodness-of-Fit Test for the Rayleigh Distribution Based on Stein's Characterisation
- **Benjamin Eltzner**: Testing for Uniqueness of Estimators
- **Marilena Müller**: Testing for local alignment of locally stationary Hawkes processes

Session 5 (Thursday, 13:45)- zoom room 2

- **Jan Johannes** (live invited talk): Linear Functional Estimation under Multiplicative Measurement Errors
- **Alexander Kreiß**: Using Laguerre Polynomials for Semi-Parametric Estimation in Measurement Error Problems with an Application to Epidemics
- **Vitalii Makogin**: Change-point methods for anomaly detection in fibrous media
- **Maximilian Steffen**: PAC-Bayesian Estimation in High-Dimensional Multi-Index Models with Unknown Active Dimension

Invited Talks

Statistically optimal estimation of signals in modulation spaces using Gabor frames

Session 3
Tue, 12:00
live

Hajo Holzmann
Philipps-Universität Marburg

Time-frequency analysis deals with signals for which the underlying spectral characteristics change over time. The essential tool is the short-time Fourier transform, which localizes the Fourier transform in time by means of a window function. In a white noise model, we derive rate-optimal and adaptive estimators of signals in modulation spaces, which measure smoothness in terms of decay properties of the short-time Fourier transform. The estimators are based on series expansions by means of Gabor frames and on thresholding the coefficients. The minimax rates have interesting new features, and the derivation of the lower bounds requires the use of test functions which approximately localize both in time and in frequency. Simulations and applications to audio recordings illustrate the practical relevance of our methods.

Linear Functional Estimation under Multiplicative Measurement Errors

Session 5
Thu, 13:45
live

Jan Johannes
Ruprecht-Karls-Universität Heidelberg

We study the non-parametric estimation of the value of a linear functional evaluated at an unknown density function f with support on $\mathbb{R}_+$ based on an i.i.d. sample with multiplicative measurement errors. The theory covers in particular point-wise estimation of the density f, the survival function as well as the Laplace transform of f. The proposed fully-data driven plug-in procedure is based on the estimation of the Mellin transform of the density f, a regularisation of the inverse of the Mellin transform by a spectral cut-off (cf. [**?**]) and a data-driven model selection based on a Goldenshluger-Lepski method in order to deal with the upcoming bias-variance trade-off. We introduce further *Mellin-Sobolev spaces* which characterize the regularity of the unknown density f through the decay of its Mellin transform. Additionally, we show minimax-optimality over *Mellin-Sobolev spaces* of the plug-in estimator with optimal choice of the cut-off parameter and up to a deterioration by a logarithmic factor of the fully data-driven plug-in estimator.

Using methods from survival analysis for modeling dynamic interaction networks

Session 4
Tue, 12:00
live

Enno Mammen
Ruprecht-Karls-Universität Heidelberg

In statistical network analysis it is common to observe so called interaction data. Such data is characterized by the actors who form the vertices of a network. These are able to interact with each other along the edges of the network. One usually assumes that the edges in the network are randomly formed and dissolved over the observation horizon. In addition covariates are observed and the interest is to model the impact of the covariates on the interactions. In our analysis we use a flexible approach for modeling both dynamic event counting and dynamic link-based networks based on counting processes. The talk reports on joint work with Alexander Kreiss and Wolfgang Polonik.

Nonparametric estimation of the ability density in the Mixed-Effect Rasch Model

Session 1
Mon, 12:00
live

Alexander Meister
Universität Rostock

he Rasch model is widely used in the field of psychometrics when n persons under test answer m questions and the score, which describes the correctness of the answers, is given by a binary n×m-matrix. We consider the Mixed-Effect Rasch Model, in which the persons are chosen randomly from a huge population. The goal is to estimate the ability density of this population under nonparametric constraints, which turns out to be a statistical linear inverse problem with an unknown but estimable operator. Based on our previous result on asymptotic equivalence to a two-layer Gaussian model, we construct an estimation procedure and study its asymptotic optimality properties as n tends to infinity, as does m, but moderately with respect to n. Moreover numerical simulations are provided. This talk is based on a joint work with Johanna Kappus and Friedrich Liese.

Sharp adaptive similarity testing with pathwise stability for ergodic diffusions

Session 2
Mon, 13:45
live

Angelika Rohde
Albert-Ludwigs-Universität Freiburg

Suppose we observe an ergodic diffusion with unknown drift. We develop a fully data-driven nonparametric test for the null hypothesis that the drift is similar to a reference drift under supremum loss. Our procedure turns out to be asymptotically optimal in both rate and constant. Moreover, by means of the theory of rough paths, we investigate its behavior if the true process was driven by a fractional Brownian motion with Hurst index close to 1/2.

Contributed Talks

Anistropic spectral cut-off estimation under multiplicative measurement errors

Session 3
Tue, 12:00

Sergio Brenner Miguel
Heidelberg University

We study the non-parametric estimation of an unknown density f with support on $\mathbb{R}_+^d$ based on an i.i.d. sample with multiplicative measurement errors. The proposed fully data driven procedure is based on the estimation of the Mellin transform of the density f and a regularisation of the inverse of the Mellin transform by a spectral cut-off. The upcoming bias-variance trade-off is dealt with by a data-driven anisotropic choice of the cut-off parameter.

Testing for Uniqueness of Estimators

Session 4
Thu, 12:00

Benjamin Eltzner
Max-Planck-Institut für Biophysikalische Chemie

Uniqueness of the population descriptor is a standard assumption in asymptotic theory. However, so-called m-estimation problems, in which an estimator is determined by minimizing a cost function, often feature local minima of the sample cost function. These local minima may stem from multiple global minima of the underlying population cost function. We present a hypothesis test to systematically determine for a given sample whether the underlying population cost function may have multiple global minima. The test is widely applicable and we discuss applications to the mean on a non-euclidean data space and Gaussian mixture clustering.

Depth-based two sample testing

Session 1
Mon, 12:00

Felix Gnettner
Otto-von-Guericke-Universität Magdeburg

Depth functions provide measures of the deepness of a point with respect to a given set of observations. This non-parametric concept can be applied in spaces of any dimension and entails a center-outward ordering for the given data. Within the last years, depths with respect to functional data have been established. Liu and Singh (1993) presented a two sample test that is based on depth-ranks and offers opportunities for further investigations: Compared to the results of Zuo and He (2006) for this test, we make some different and new assumptions to fill a gap in their proof and prove their validity for additional depths – in particular for several integrated depths for functional data. Observing that the corresponding test statistic is not symmetric with respect to the two samples, some first numerical simulations indicate that the power can be greatly increased if Q(F, G) and Q(G, F) are jointly considered.

A New Goodness-of-Fit Test for the Rayleigh Distribution Based on Stein's Characterisation

Session 4
Thu, 12:00

Gerrit Grobler
North-West University

In this talk, a new goodness-of-fit test for the Rayleigh distribution is proposed. This test is developed by exploiting the Stein characterisation of the Rayleigh distribution. The newly suggested test is compared with the traditional tests as well as with some more modern tests by making use of a Monte Carlo simulation. The traditional tests include the Kolmogorov-Smirnov, Anderson-Darling and Cramer- von Mises tests. A test based on the empirical Laplace transform and a test based on the cumulative residual entropy are the two modern tests considered. When the powers of the respective tests are compared it can be seen that the newly proposed test is not only feasible but also very competitive. The results further indicate that the new test outperforms the other tests for most of the alternatives considered in the study. The asymptotic null distribution of the newly proposed test is derived and we also provide a proof of the consistency of the test.

Limit Distributions for Empirical Circular Optimal Transport

Session 2
Mon, 13:45

Shayan Hundrieser
Institute for Mathematical Stochastics, Georg-August-University of Göttingen

Empirical optimal transport (OT) based distances provide effective tools to compare and statistically match probability measures defined on a given ground space. Fundamental to this are distributional limit laws. In this work, we derive a central limit theorem for the empirical OT distance of circular data. Our limit results require only mild assumptions and include prominent examples such as the von Mises or wrapped Cauchy family. Most notably, no assumptions are required when data are sampled from the probability measure to be compared with, which is in strict contrast to the real line. This is joint work with Marcel Klatt and Axel Munk.

Fully data-driven non-parametric estimation of Toeplitz covariance matrices

Session 3
Tue, 12:00

Karolina Klockmann
Universität Wien

Estimation of the Toeplitz covariance matrix of a vector with a known mean is a central problem in many areas of multivariate analysis and is a complex task. In this context two main frameworks are considered: either there are N independent and identically distributed p-dimensional random vectors with a Toeplitz covariance matrix, or there is a single realization of a stationary stochastic process, given as one N-dimensional vector. In both frameworks the matrix of the sample covariances is known to be inconsistent in the spectral norm, so that regularized versions, such as the tapering or banding covariance estimators, have been proposed. The minimax optimality of the tapering estimator has been shown for the Toeplitz covariance matrices with a certain decay of their covariance sequence and for those with a sufficiently smooth spectral density function. However, such estimators are not guaranteed to be positive definite and data-driven choices of the regularization parameters are not available.

In this talk we present an estimator for the Toeplitz covariance matrix and its inverse which overcome these drawbacks. First, we derive an alternative version of the Whittle likelihood based on the Discrete Cosine Transform matrix, which is shown to asymptotically diagonalize Toeplitz matrices. This leads to the problem of spectral density estimation in a Gamma regression setting. Using variance stabilizing transforms of Brown, Cai and Zhou (2010) the transformed spectral density can be estimated with a periodic smoothing spline in a Gaussian regression setting. The resulting estimators for the Toeplitz covariance matrix and its inverse are positive definite and all regularization parameters are data-driven. As our main result, we show that our estimators attain the minimax optimal convergence rate. The performance of our estimators is compared to regularized versions of the sample covariance matrix in a simulation study.

Using Laguerre Polynomials for Semi-Parametric Estimation in Measurement Error Problems with an Application to Epidemics

Session 5
Thu, 13:45

Alexander Kreiß
KU Leuven

In epidemics interesting quantities like the reproduction number depend on the incubation period (time from infection to symptom onset) and/or the generation time (time until a new person is infected from another infected person). Therefore, estimation of the distribution of these two quantities is of distinct interest. However, this is a challenging problem since it is normally not possible to obtain precise observations of these two variables. Instead, in the beginning of a pandemic, it is possible to observe for infection pairs the time of symptom onset for both people as well as a window for infection of the first person (e.g. because of travel to a risk area). In this sense we have a measurement error problem. In the talk we suggest a simple semi-parametric sieve-estimation method based on Laguerre-Polynomials for density-estimation in such situations. We provide detailed theory for consistency and illustrate the finite sample performance for small datasets via a simulation study in the example above. This is joint work with Ingrid Van Keilegom.

Change-point methods for anomaly detection in fibrous media

Session 5
Thu, 13:45

Vitalii Makogin
Ulm University

We consider the problem of detecting anomalies in the directional distribution of fibre materials observed in 3D images. We divide the image into a set of scanning windows and classify them into two clusters: homogeneous material and anomaly. Based on a sample of estimated local fibre directions, for each scanning window we compute several classification attributes, namely the coordinate wise means of local fibre directions, the entropy of the directional distribution, and a combination of them. We also propose a new spatial modification of the Stochastic Approximation Expectation-Maximization (SAEM) algorithm. Besides the clustering, we also consider testing the significance of anomalies. To this end, we apply a change point technique for random fields and derive the exact inequalities for tail probabilities of a test statistics. The proposed methodology is first validated on simulated images. Finally, it is applied to a 3D image of a fibre reinforced polymer.

Minimax Estimation of the Mode of Functional Data

Session 1
Mon, 12:00

Dennis Müller
Universität Rostock

We want to estimate the mode of a probability distribution that is defined on an infinite-dimensional function space, e.g. the space of monotonic functions or the space of smooth functions. We will use the small ball probabilities of the distribution to define the mode. Thus, it will not be necessary to assume that there exists a probability density function. Upper rates of convergence will be given under an entropy constraint, e.g. we demand that there exist finite covers for the space. We will then proceed to derive the lower rate in a setting where the distribution is supported on a Sobolev ellipsoid.

Testing for local alignment of locally stationary Hawkes processes

Session 4
Thu, 12:00

Marilena Müller
Heidelberg University

A model for locally stationary Hawkes processes is considered. In particular, their immigration and reproductionfunction are not restricted to be constant over the observed time. In previous work a consistent nonparametric estimator was developed in an asymptotic framework, making it possible to now formulate testing results. We observe two Hawkes processes and test whether they are realizations of the same underlying model at a fixed point in time. Alternatively one could compare the behaviour of one Hawkes process at two distinct time points. Resampling via wild bootstrap is enabled, such that confidence bands can be conducted.

Confidence bands for the covariance kernel of Banach space valued functional data.

Session 1
Mon, 12:00

Christoph Reihl
University of Bayreuth

The use and study of functional data is a common practice in modern statistics by now. Many classical problems have been extended from real valued to functional data, such as inference for the mean and the covariance structure. Naturally, most of the proofs cannot directly be transferred from real valued spaces to function spaces. The presentation deals with one of the most common questions: Estimating the trend and the covariance function, and constructing confidence bands for banach space valued functional data.

Throughout the presentation, each function is observed at discrete points, including measurement errors. For the estimation of the trend and covariance kernel, two estimators are discussed, which use the concept of smoothing via weight functions. It will be shown, that, for large sample size and observation points, the estimators smooth out the unintended departures and are also asymptotically gaussian, regarding the supremum norm. For that result, a special version of the functional central limit theorem, based on metric entropies, is used. The asymptotic normality is then used for constructing uniform confidence bands, both for the trend and the covariance. Furthermore, a naive bootstrap method is introduced, and its consistency for the confidence bands is proven. Finally, the validity of the confidence bands, both constructed asymptotically and via bootstrap, is checked by a simulation study, considering four different data settings.

A Law of Large Numbers for Fréchet Mean Sets

Session 2
Mon, 13:45

Christof Schötz
Heidelberg University

A Fréchet mean of a random variable with values in a metric space is an element of the metric space that minimizes the expected squared distance to that random variable. This minimizer may be non-unique. We study strong laws of large numbers for sets of Fréchet means as well as of generalizations where the square is replaced by an arbitrary positive power. We show almost sure convergence of empirical versions of these sets in one-sided Hausdorff distance. The derived results require only minimal assumptions. In particular, only a first moment condition is assumed.

PAC-Bayesian Estimation in High-Dimensional Multi-Index Models with Unknown Active Dimension

Session 5
Thu, 13:45

Maximilian Steffen

Universität Hamburg

The multi-index model with sparse dimension reduction matrix is a popular approach to circumvent the curse of dimensionality in a high-dimensional regression setting. Building on the single-index analysis by Alquier and Biau (2013), we develop a PAC-Bayesian estimation method for a possibly miss-specified multi-index model with unknown active dimension and an orthogonal dimension reduction matrix. Our main result is a non-asymptotic oracle inequality, which shows that the estimation method adapts to the active dimension of the model, the sparsity of the dimension reduction matrix and the regularity of the link function. Under a Sobolev regularity assumption on the link function the estimator achieves the usual minimax rate of convergence and no additional price is paid for the unknown active dimension.

This talk is based on joint work with Mathias Trabs from Universität Hamburg.

Reference

[1] Alquier, P. and Biau, G. (2013). Sparse single-index model. *Journal of Machine Learning Research*, 14.(1), 243–280.

Fréchet means and geometry

Session 2
Mon, 13:45

Do Tran

Goettingen University

Fréchet means are indispensable for nonparametric statistics on non-Euclidean spaces. Different behaviors of the CLT of Fréchet means on non-Euclidean spaces hint that geometry plays a crucial role in the deviation of the central limit theorem (CLT) from being classical. In some sense, the Fréchet mean "senses" topological and geometric structure. Conversely, stickiness and smeariness of Fréchet mean show that intrinsic geometric properties (e.g. curvatures, singularities) can greatly influence the outcome of a sampling process on a non-Euclidean space even when the variance of the population measure is finite. Therefore, to have a firm mathematical foundation for statistical theory on non-Euclidean spaces, or stratified spaces in particular, it is imperative to understand how geometry can affect behaviors of CLTs of Fréchet means on stratified spaces. In this talk, to achieve a better understanding of the interaction, we review different behaviors of the CLT of Fréchet means on non-Euclidean settings to have better understanding on interaction between geometry and statistics. Our goal is to give a guidance to answer an important question: What information should one expect to get by sampling from a stratified space?

13. Statistical methodology

Chairs: Alexander Meister, Mathias Trabs

Live Sessions

Session 1 (Tuesday, 12:00)- zoom room 4

- **Aurore Delaigle** (live invited talk): Covariance estimation for fragments of functional data
- **Johannes Krebs**: On approximation theorems for the Euler characteristic with applications to the bootstrap
- **Shayan Hundrieser**: Testing under Finite Sample Smeariness of Fréchet Means on the Circle
- **Raoul Müller**: Non-Euclidean distance based Levene's test

Session 2 (Tuesday, 13:45)- zoom room 4

- **Sasha Goldenshluger** (live invited talk): Density deconvolution under general assumptions
- **Fatima Jammoul**: Consistently recovering the signal from noisy functional data
- **Thomas Kuenzer**: Estimating the conditional distribution in functional regression problems
- **Thomas Staudt**: Measuring statistical dependency with optimal transport
- **Jonas Brehmer**: Using scoring functions to evaluate point process forecasts

Session 3 (Wednesday, 12:00)- zoom room 4

- **Cristina Butucea** (live invited talk): Local differential privacy and support recovery for sparse Gaussian vectors
- **Marius Smuts**: Distribution-free goodness-of-fit tests for the Pareto distribution based on a characterization
- **Christian Weiß**: Some goodness-of-fit tests for the Poisson distribution with applications in Biodosimetry
- **Elzanie Bothma**: A new class of tests for the Weibull distribution using Stein's method in the presence of random right censoring
- **Dmitry Otryakhin**: Fast automatic deforestation detection

Invited Talks

Local differential privacy and support recovery for sparse Gaussian vectors

Session 3
Wed, 12:00
live

Cristina Butucea

Université Paris-Est Marne-la-Vallée

Local differential privacy has prevailed as the most convenient formalism to randomize sensitive data via privacy mechanisms (that are Markov kernels) submitted to some constraints. We address the problem of support recovery of the sparse mean of a $d-$dimensional Gaussian vector, observed independently n times, under the additional constraints that we have to produce and use only $\alpha-$locally differentially private data for inference. We provide lower and upper bounds on the rate of convergence for the expected Hamming loss over classes of sparse vectors whose non-zero coordinates are separated from 0 by a constant $a > 0$. We derive necessary and sufficient conditions (up to log factors) for support recovery. When we restrict our attention to non- interactive mechanisms that act independently on each coordinate our lower bound shows that, contrary to the non-private setting, both exact and almost full recovery are impossible whatever the value of a in the high-dimensional regime such that $n\alpha^2/d^2 \lesssim 1$. However, in the regime $n\alpha^2/d^2 \gg \log(n\alpha^2/d^2)\log(d)$ we can exhibit a critical value a^* (up to a logarithmic factor) where a phase transition occurs. These results can be improved when allowing for all non- interactive mechanisms that act globally on all coordinates, in the sense that phase transitions occur at lower levels. This is joint work with A. Dubois and A. Saumard.

Estimating a Covariance Function from Fragments of Functional Data

Session 1
Tue, 12:00
live

Aurore Delaigle

University of Melbourne

Functional data are often observed only partially, in the form of fragments. In that case, the standard approaches for estimating the covariance function do not work because entire parts of the domain are completely unobserved. In previous work, Delaigle and Hall (2013, 2016) have suggested ways of estimating the covariance function, based for example on Markov assumptions. In this work we take a completely different approach which does not rely on such assumptions. We show that, using a tensor product approach, it is possible to reconstruct the covariance function using observations located only on the diagonal of its domain.

Density deconvolution under general assumptions

Session 2
Tue, 13:45
live

Sasha Goldenshluger

University of Haifa

We discuss the problem of density deconvolution under general assumptions on the measurement error distribution. Typically deconvolution estimators are constructed using Fourier transform techniques, and it is assumed that the characteristic function of the measurement errors does not have zeros on the real line. This assumption is rather strong and is not fulfilled in many cases of interest. We develop a methodology for constructing optimal density deconvolution estimators in the general setting that covers vanishing and non–vanishing characteristic functions of the measurement errors. We derive upper bounds on the risk of the proposed estimators and provide sufficient conditions under which zeros of the corresponding characteristic function have no effect on estimation accuracy. Moreover, we show that the derived conditions are also necessary in some specific problem instances.

Contributed Talks

A new class of tests for the Weibull distribution using Stein's method in the presence of random right censoring

Session 3
Wed, 12:00

Elzanie Bothma

North-West University, South Africa

In this talk, we discuss a new class of tests for the Weibull distribution based on Stein's method. The proposed tests are applied in the framework of random right censoring. We investigate the finite sample performance of the new tests using a Monte Carlo study. It is found that the newly proposed class of tests outperform competing tests against the majority of the distributions and censoring proportions considered.

Using scoring functions to evaluate point process forecasts

Session 2
Tue, 13:45

Jonas Brehmer

Heidelberg Institute for Theoretical Studies

Many decision makers in industry or public institutions rely on forecasts of certain random quantities when choosing among alternative actions and assessing the associated risks. If relevant events cannot be measured at fixed points, but occur randomly in space and/or time, point processes arise as natural models in many applications, e.g. epidemiology, seismology, or quantitative criminology. Such models are often used to create point process-based forecasts, for instance (conditional) intensities, or higher order summary statistics such as pair correlations. Usually, decision makers will face a number of different predictions concerning these quantities, making a comparison of their accuracy crucial for well-founded decisions. A principled approach to comparative forecast evaluation relies on scoring or loss functions, which assign a real number to each pair of forecast and realized observation of a random variable. We establish some general results which transfer the idea of scoring functions to the point process setting. This leads to a novel comparative evaluation method for point process-based forecasts and provides a new perspective on several existing ones. Since our approach focuses on relative performance, it can be used as a model selection technique which complements existing goodness-of-fit tests.

Testing under Finite Sample Smeariness of Fréchet Means on the Circle

Session 1
Tue, 12:00

Shayan Hundrieser

Institute for Mathematical Stochastics, Georg-August-University of Göttingen

Fréchet Means of circular data may exhibit nonstandard asymptotic rates, a phenomenon known as smeariness, rendering quantile-based asymptotic inference inapplicable. Although smeary probability distributions are rather uncommon, in this work we bring attention to a new phenomenon which we refer to as finite sample smeariness (FSS), where samples of a distribution appear as if they stem from a smeary distribution. In particular, all circular distributions supported by more than a half circle are affected by FSS and empirical levels of quantile-based tests may deviate strongly under FSS from their nominal level. Suitably designed bootstrap tests however are shown to remain valid under FSS and keep their level fairly well. This is joint work with Benjamin Eltzner and Stephan Huckemann.

Consistently recovering the signal from noisy functional data

Session 2
Tue, 13:45

Fatima Jammoul

Graz University of Technology, Institute of Statistics

We consider noisy functional data $Y_t(s_i) = X_t(s_i) + u_{ti}$ that has been recorded at a discrete set of observation points. Naturally, the goal is to recover the underlying signal X_t. Commonly, this is done by non-parametric smoothing approaches, e.g. kernel smoothing or spline fitting. These methods act function by function and do not take the overall presented information into consideration. We argue that it is often more accurate to take the entire data set into account, which can help recover systematic properties of the underlying signal. Other approaches using functional principal components do just that, but require strong assumptions on the smoothness of the underlying signal. We show that under very mild assumptions, the signal may be viewed as the common components of a factor model. Using this discovery, we develop a PCA driven approach to recover the signal and show consistency. Our theoretical results hold under rather mild conditions, in particular we do not require specific smoothness assumptions for the underlying curves and allow for a certain degree of autocorrelation in the noise. We demonstrate the applicability of our approach with simulation experiments and real life data analysis. Our considerations show that even in settings that are advantageous for competing methods, the factor model approach provides competitive results. In particular we observe that for growing sample size, the factor model approach shows an improving fit, which is not the case for classic spline smoothers. The proposed method performs particularly well in cases of rough data and provides insight into the nature of underlying functional structure in real life data cases.

On approximation theorems for the Euler characteristic with applications to the bootstrap

Session 1
Tue, 12:00

Johannes Krebs

Heidelberg University

In this talk we study approximation results and central limit theorems for the Euler characteristic of the Vietoris-Rips and Čech filtration in the critical regime. The Euler characteristic is a simple yet major functional in topological data analysis. We apply our results to the smooth bootstrap of the Euler characteristic and determine its rate of convergence in the Kantorovich-Wasserstein and Kolmogorov distance.

This contribution is joint work with B. Roycraft and W. Polonik (UC Davis).

Estimating the conditional distribution in functional regression problems

Session 2
Tue, 13:45

Thomas Kuenzer

Graz University of Technology

We consider the problem of consistently estimating the conditional distribution $P(Y \in A|X)$ of a functional data object $Y = (Y(t) : t \in [0,1])$ given covariates X in a general space, assuming that Y and X are related by a functional linear regression model. Two natural estimation methods for this problem are proposed, based on either bootstrapping the estimated model residuals, or fitting functional parametric models to the model residuals and estimating $P(Y \in A|X)$ via simulation. We show that under general consistency conditions on the regression operator estimator, which hold for certain functional principal component based estimators, consistent estimation of the conditional distribution can be achieved, both when Y is an element of a separable Hilbert space, and when Y is an element of the Banach space of continuous functions on the unit interval. The latter results imply that sets A that specify path properties of Y that are of interest in applications can be considered, such as the maximum of the curve. Our methods have numerous applications in the context of constructing prediction sets, quantile regression and VaR estimation. Compared to direct modelling these curve properties using scalar-on-function regression, modelling the whole response distribution and extracting the curve properties in a second step allows us

to harness the full information contained in the functional data to fit the regression model and achieve better results. We study the proposed methods in several simulation experiments and real data analysis of electricity price curves and show that they outperform both the non-parametric kernel estimator and functional binary regression.

Non-Euclidean distance based Levene's test

Session 1
Tue, 12:00

Raoul Müller

Institut für Mathematische Stochastik (IMS), Göttingen

We present a new statistic for testing for equality of scatter ("variances") in two or more groups of observations. Our statistic works for observations in any metric space and does not need central objects of the observed data. The statistic is based on Levene's test. We developed and tested the statistic for point pattern data, for which the calculation of a central object, i.e. a barycenter or Fréchet mean, is infeasible for moderate and large instances. For the calculation of our statistic we only need pairwise distances between the observations. We compare our statistic with existing methods for analysis of variance for non-Euclidean data and provide asymptotics.

Fast automatic deforestation detection

Session 3
Wed, 12:00

Dmitry Otryakhin

Stockholm University

In this talk, two algorithms for automatic forest classification are described. In their foundation, there lie hypothesis testing procedures using high altitude images. One of them assumes independent stable distributions for colour intensities of pixels of the images. It uses the Cramér-von Mises test statistic and obtained 96.7

Distribution-free goodness-of-fit tests for the Pareto distribution based on a characterization

Session 3
Wed, 12:00

Marius Smuts

North-West University

We propose three new classes of goodness-of-fit tests for the Pareto type I distribution based on a characterization. The asymptotic null distribution for the tests are derived and their Bahadur efficiencies are compared to the efficiencies of some of the existing tests. It is found that the new integral type test has superior local efficiencies amongst the new tests, and in general, has higher efficiencies than the competing tests considered. The finite-sample performance of the newly proposed tests is evaluated and compared to that of other existing tests by means of a Monte Carlo study. It is found that the new tests (especially the integral type tests) perform favourably compared to the other tests.

Measuring statistical dependency with optimal transport

Session 2
Tue, 13:45

Thomas Staudt

University of Göttingen

What is statistical dependency and how can it be quantified in a meaningful and general way? This talk tries to contribute to this question by presenting recent developments that use optimal transport to measure the association between random variables. The focus lies on the transport dependency, a general and flexible approach with several intriguing properties. In particular, it takes metrical properties of the base spaces into account and captures the idea that a high degree of dependency should not only imply a (nearly) functional relation between random variables, but that it should also mean that one variable can be predicted by the other in the presence of statistical uncertainties.

Some goodness-of-fit tests for the Poisson distribution with applications in Biodosimetry

Session 3
Wed, 12:00

Christian Weiß

Helmut-Schmidt-Universität Hamburg

New characterizations of the Poisson distribution based on an identity involving the Binomial thinning operator are presented. These characterizations allow the construction of statistics for testing the Poisson distribution against alternatives belonging to a large family called the LC-class, and against general alternatives. The usefulness and the power of the tests are illustrated with several examples of applications in Biodosimetry.

14. S(P)DEs: Theory and Numerics

Chairs: Arnulf Jentzen, Thomas Kruse

Live Sessions

Session 1 (Tuesday, 15:30)- zoom room 4

- **Michaela Szölgyenyi** (live invited talk): Numerics for SDEs with Sobolev drift via reduction to quadrature problems
- **Lukas Gonon**: Random feature neural networks learn Black-Scholes type PDEs without curse of dimensionality
- **Stefan Perko**: Approximating stochastic gradient descent with diffusions: error expansions and impact of learning rate schedules
- **Avi Mayorcas**: A Stochastic Model of Chemorepulsion with Additive Noise and Nonlinear Sensitivity

Session 2 (Wednesday, 12:00)- zoom room 3

- **Martin Hutzenthaler** (live invited talk): On a stochastic Gronwall inequality
- **Annalena Mickel**: Optimal L^1-Approximation of the log-Heston SDE by Euler-Type Methods
- **Sam Baguley**: General path integrals and stable SDEs
- **Lucio Galeati**: Singular DDSDEs driven by additive fBm

Session 3 (Wednesday, 15:30)- zoom room 3

- **Larisa Yaroslavtseva** (live invited talk): An adaptive strong order 1 method for SDEs with discontinuous drift coefficient
- **Petru A. Cioica-Licht**: Weighted L_p-Sobolev regularity for SPDEs on domains with corner singularities
- **Tommaso Rosati**: Longtime behaviour of the Allen-Cahn equation with generic initial datum
- **Simon Weissmann**: Analysis of the ensemble Kalman inversion: from discrete to continuous time

Session 4 (Thursday, 13:45)- zoom room 4

- **Patrick Cheridito** (live invited talk): Deep splitting method for (S)PDEs
- **Willem van Zuijlen**: Total mass asymptotics of the parabolic Anderson model
- **Lukas Wessels**: Peng's Maximum Principle for Stochastic Partial Differential Equations
- **Markus Tempelmayr**: A tree-free approach to regularity structures – the structure group

Session 5 (Friday, 12:00)- zoom room 2

- **Andreas Eberle** (live invited talk): Convergence bounds for Hamiltonian Monte Carlo in high dimension
- **Alexis Anagnostakis**: Rate of convergence to the local time of sticky diffusions
- **Katharina Schuh**: Convergence of unadjusted Hamiltonian Monte Carlo for mean-field models
- **Tom Klose**: Precise Laplace asmptotics for the generalized parabolic Anderson model

Invited Talks

Deep splitting method for (S)PDEs

Session 4
Thu, 13:45
live

Patrick Cheridito
ETH Zurich

A numerical method for high-dimensional (S)PDEs is introduced which combines operator splitting with deep learning. It divides the (S)PDE approximation problem into a sequence of separate learning problems. Since the computational graph for each of the subproblems is comparatively small, the approach can handle extremely high-dimensional problems. Different examples from physics, stochastic control and mathematical finance will be discussed.

Convergence bounds for Hamiltonian Monte Carlo in high dimension

Session 5
Fri, 12:00
live

Andreas Eberle
Rheinische Friedrich-Wilhelms-Universität Bonn

Hamiltonian Monte Carlo (HMC) is a class of MCMC methods that combines the Hamiltonian flow with velocity randomizations. Despite their empirical success, until a few years ago there have been almost no convergence bounds for Hamiltonian Monte Carlo methods. This has changed in the last years where approaches to quantify convergence to equilibrium based on coupling, conductance and hypocoercivity have been developed. In this talk, I will compare upper and lower bounds on convergence rates and mixing times that follow by these different approaches. I will then focus on the coupling approach and explain how it can be used to obtain a relatively good understanding of the dimension dependence for unadjusted HMC in several high dimensional model classes. Current limitations of the approach will be pointed out as well. In particular, the correct order of the mixing time for Metropolis-adjusted HMC is still widely open even in simple scenarios.

On a stochastic Gronwall inequality

Session 2
Wed, 12:00
live

Martin Hutzenthaler
Universität Duisburg-Essen

The Gronwall inequality is frequently used to estimate quantities of solutions of (stochastic) differential equations. In this talk we explain a new stochastic Gronwall inequality which provides upper bounds for p-th moments of suprema of Itô processes which satisfy a suitable one-sided affine-linear growth condition. Example applications demonstrate the power of this stochastic Gronwall inequality.

Numerics for SDEs with Sobolev drift via reduction to quadrature problems

Session 1
Tue, 15:30
live

Michaela Szölgyenyi
Universität Klagenfurt

We study the strong convergence rate of the Euler-Maruyama scheme for scalar SDEs with additive noise and irregular drift. We provide a novel framework for the error analysis by reducing it to a weighted quadrature problem for irregular functions of Brownian motion. By analyzing the quadrature problem we obtain for abitrarily small $\epsilon > 0$ a strong convergence order of $(1+\kappa)/2-\epsilon$ for a non-equidistant Euler-Maruyama scheme, if the drift has Sobolev-Slobodeckij-type regularity of order κ. Joint work with A. Neuenkirch (University of Mannheim).

An adaptive strong order 1 method for SDEs with discontinuous drift coefficient

Session 3
Wed, 15:30
live

Larisa Yaroslavtseva
Universität Passau

In recent years, a number of results have been proven in the literature for strong approximation of stochastic differential equations (SDEs) with a drift coefficient that may have discontinuities in space. In many of these results it is assumed that the drift coefficient satisfies piecewise regularity conditions and the diffusion coefficient is Lipschitz continuous and non-degenerate at the discontinuity points of the drift coefficient. For scalar SDEs of that type the best L_p-error rate known so far for approximation of the solution at the final time point is $3/4$ in terms of the number of evaluations of the driving Brownian motion and it is achieved by the transformed equidistant quasi-Milstein scheme. Recently in [1] it has been shown that for such SDEs the L_p-error rate $3/4$ can not be improved in general by no numerical method based on evaluations of the driving Brownian motion at fixed time points. In this talk we present a numerical method based on sequential evaluations of the driving Brownian motion, which achieves an L_p-error rate of at least 1 in terms of the average number of evaluations of the driving Brownian motion for such SDEs.

Contributed Talks

Rate of convergence to the local time of sticky diffusions

Session 5
Fri, 12:00

Alexis Anagnostakis

Université de Lorraine

We study the convergence of a class of approximation functionnals to the local time of a sticky process. First, we prove the asymptotic behavior of the functionals for the sticky Brownian motion for different convergence rates. Then, via an adapted version of Girsanov's theorem, we extend the result to solutions of SDEs that admit a sticky point. Finally we present two potential applications: estimation of the stickiness parameter and sticky point detection. Both applications use as statistic the occupation time vs local time ratio, hence the necessity to have a good estimation of the latter.

General path integrals and stable SDEs

Session 2
Wed, 12:00

Sam Baguley

Hasso-Plattner-Institut

We study existence and uniqueness of weak SDE solutions driven by stable processes, in the spirit of the classical Engelbert-Schmidt time-change approach. Our approach is not based on classical stochastic calculus arguments but on the general theory of Markov processes.

Weighted L_p-Sobolev regularity for SPDEs on domains with corner singularities

Session 3
Wed, 15:30

Petru A. Cioica-Licht

Universität Duisburg-Essen

Although there exists an almost fully-fledged L_p-theory for semi-linear second order stochastic partial differential equations on smooth domains, very little is known about the regularity of these equations on non-smooth domains that have corners and/or edges. As it is already known from the deterministic theory, boundary singularities may have a negative impact on the regularity of the solution. For stochastic equations, this effect comes on top of the already known incompatibility of noise and boundary condition. In this talk I will show how a system of mixed weights consisting of appropriate powers of the distance to the vertexes and of the distance to the boundary can be used in order to deal with both sources of singularity and their interplay.

Singular DDSDEs driven by additive fBm

Session 2
Wed, 12:00

Lucio Galeati

Universität Bonn

In this talk I will consider distribution dependent (or McKean-Vlasov) SDEs driven by additive fractional Brownian motion of Hurst parameter $H \in (0,1)$, with particular focus on convolutional (or true McKean-Vlasov) drifts. Strong existence and pathwise uniqueness are established for drifts of Holder regularity C^α with $\alpha > 1 - 1/(2H)$, thus extending the results by Catellier and Gubinelli to the distribution-dependent setting. Based on a joint work with F. Harang and A. Mayorcas

---

Random feature neural networks learn Black-Scholes type PDEs without curse of dimensionality

Session 1
Tue, 15:30

Lukas Gonon
University of Munich

This work investigates the use of random feature neural networks for learning Kolmogorov partial (integro-)differential equations associated to Black-Scholes and more general exponential Lévy models. Random feature neural networks are single-hidden-layer feedforward neural networks in which only the output weights are trainable. This makes training particularly simple, but (a priori) reduces expressivity. Interestingly, this is not the case for Black-Scholes type PDEs, as we show here. We derive bounds for the prediction error of random neural networks for learning sufficiently non-degenerate Black-Scholes type models. A full error analysis is provided and it is shown that the derived bounds do not suffer from the curse of dimensionality. We also investigate an application of these results to basket options and validate the bounds numerically.

Precise Laplace Asymptotics for the Generalised Parabolic Anderson Model

Session 5
Fri, 12:00

Tom Klose
Technische Universität Berlin

We present a Laplace method for the renormalised solution to the generalised 2D Parabolic

---

A Stochastic Model of Chemorepulsion with Additive Noise and Nonlinear Sensitivity

Session 1
Tue, 15:30

Avi Mayorcas
University of Cambridge

We establish global well-posedness and exponential ergodicity for a parabolic SPDE model of chemotaxis in the repulsive regime with additive space-time white noise. In addition we obtain tail bounds on the invariant measure on any L^p space. It is interesting that the tail bounds we obtain are strictly sub-Gaussian, in contrast to those obtained for comparable stochastic reaction-diffusion equations by Moinat & Weber '20 which were shown to possess super-Gaussian tails. In this talk I will briefly introduce the modelling of chemotaxis and stochastic models thereof as well as natural ways one may wish to extend our current work - arxiv.org/abs/2106.11165.

Optimal L^1-Approximation of the log-Heston SDE by Euler-Type Methods

Session 2
Wed, 12:00

Annalena Mickel
Universität Mannheim

We study the L^1-approximation of the log-Heston SDE at discrete time points by equidistant Euler-type methods. We establish the convergence order $1/2-\epsilon$ for $\epsilon > 0$ arbitrarily small if the Feller index ν of the underlying CIR process satisfies $\nu > 1$. For the L^1-approximation at the final time point this convergence order is optimal, since we also show that arbitrary methods which use an equidistant discretization of the driving Brownian motion can achieve at most order $1/2$ in this case. Moreover, we discuss the case $\nu \leq 1$ and illustrate our findings by several numerical examples.

Approximating stochastic gradient descent with diffusions: error expansions and impact of learning rate schedules

Session 1
Tue, 15:30

Stefan Perko

Friedrich-Schiller University Jena

Applying a stochastic gradient descent method for minimizing an objective gives rise to a discrete-time process of estimated parameter values. In order to better understand the dynamics of the estimated values it can make sense to approximate the discrete-time process with a continuous-time diffusion. We refine some results on the weak error of diffusion approximations. In particular, we explicitly compute the leading term in the error expansion of an ODE approximation with respect to a parameter h discretizing the learning rate schedule. The leading term changes if one extends the ODE with a Brownian diffusion component. Finally, we show that if the learning rate is time varying, then its rate of change needs to enter the drift coefficient in order to obtain an approximation of order 2.

Longtime behaviour of the Allen-Cahn equation with generic initial datum

Session 3
Wed, 15:30

Tommaso Rosati

Imperial College London

We consider the longtime behaviour of the Allen-Cahn equation with a random, small initial datum. We prove that after a time depending on the "smallness" of the initial condition, the solution develops an interface given by nodal sets of a Gaussian field with a Gaussian correlation function. The interface then evolves under mean curvature flow. The proof follows the dynamic of the equation over different time scales and builds on a Wild expansion of the solution and on the level set approach to mean curvature flow. This is a joint work with Martin Hairer and Khoa Le.

Convergence of unadjusted Hamiltonian Monte Carlo for mean-field models

Session 5
Fri, 12:00

Katharina Schuh

Universität Bonn

In this talk we study the unadjusted Hamiltonian Monte Carlo algorithm applied to high-dimensional probability distributions of mean-field type. We evolve dimension-free convergence and discretization error bounds in Wasserstein distance. These bounds require the discretization step to be sufficiently small, but do not require strong convexity of either the unary or pairwise potential terms present in the mean-field model. To handle high dimensionality, we use a particlewise coupling that is contractive in a complementary particlewise metric. This talk is based on joint work with Nawaf Bou-Rabee.

,

A tree-free approach to regularity structures – the structure group

Session 4
Thu, 13:45

Markus Tempelmayr
MPI MiS Leipzig

We consider the approach of replacing trees by (fewer) multi-indices as an index set of the abstract model space, which was introduced by Otto, Sauer, Smith and Weber to tackle quasi-linear singular SPDE. We show that this approach is consistent with the postulates of regularity structures when it comes to the structure group. In particular, the structure group arises from a Hopf algebra structure.

In fact, this approach allows to interpret the dual of the structure group as a Lie group arising from a Lie algebra consisting of derivations. These derivations are the infinitesimal generators arising from actions on the space of pairs (nonlinearities, functions of space-time).

We also argue that our structure is compatible with the tree-based one in case of branched rough paths and of the generalized parabolic Anderson model.

This is joint work with Pablo Linares and Felix Otto.

Total mass asymptotics of the parabolic Anderson model

Session 4
Thu, 13:45

Willem van Zuijlen
WIAS Berlin

We consider the parabolic Anderson model with a white noise potential in two dimensions. This model is also called the stochastic heat equation with a multiplicative noise. We study the large time asymptotics of the total mass of the solution. Due to the irregularity of the white noise, in two dimensions the equation is a priori not well-posed. Using paracontrolled calculus or regularity structures one can make sense of the equation by a renormalisation, which can be thought of as "subtracting infinity of the potential". To obtain the asymptotics of the total mass we use the spectral decomposition, an alternative Feynman-Kac type representation and heat-kernel estimates which come from joint works with Khalil Chouk, Wolfgang König and Nicolas Perkowski.

Strong convergence of the ensemble Kalman inversion: from discrete to continuous time

Session 3
Wed, 15:30

Simon Weissmann
Universität Heidelberg

The ensemble Kalman filter (EnKF) is a widely used methodology for data assimilation problems and has been recently generalized to inverse problems, known as ensemble Kalman inversion (EKI). We view the method as a derivative free optimization method for a least-squares misfit functional and discuss various variants of the scheme such as variance inflation and regularization. This opens up the perspective to use the method for a wide range of applications, e.g. imaging, groundwater flow problems, biological problems as well as in the context of the training of neural networks. We formulate the scheme in a discrete time setting and verify the convergence to its continuous time limit, which is given by a system of coupled stochastic differential equations.

Peng's Maximum Principle for Stochastic Partial Differential Equations

Session 4
Thu, 13:45

Lukas Wessels
Technische Universität Berlin

We extend Peng's maximum principle for semilinear stochastic partial differential equations (SPDEs) in one space-dimension with non-convex control domains and control-dependent diffusion coefficients to the case of general cost functionals with Nemytskii-type coefficients. Our analysis is based on a new approach to the characterization of the second order adjoint state as the solution of a function-valued backward SPDE.

Speakers