GPSD 2018

February 27–March 2, 2018

Organisation

Philipp Harms
Eva Lütkebohmert-Holtz
Peter Pfaffelhuber
Angelika Rohde
Thorsten Schmidt

Plenary speakers

Christina Goldschmidt, University of Oxford (UK)
Marcel Nutz, Columbia University, New York (USA)
Kavita Ramanan, Brown University, Providence (USA)
Wendelin Werner, ETH Zurich (Switzerland)
Bin Yu, University of California, Berkeley (USA)

Universität Freiburg
Mathematisches Institut
Abteilung für Mathematische Stochastik

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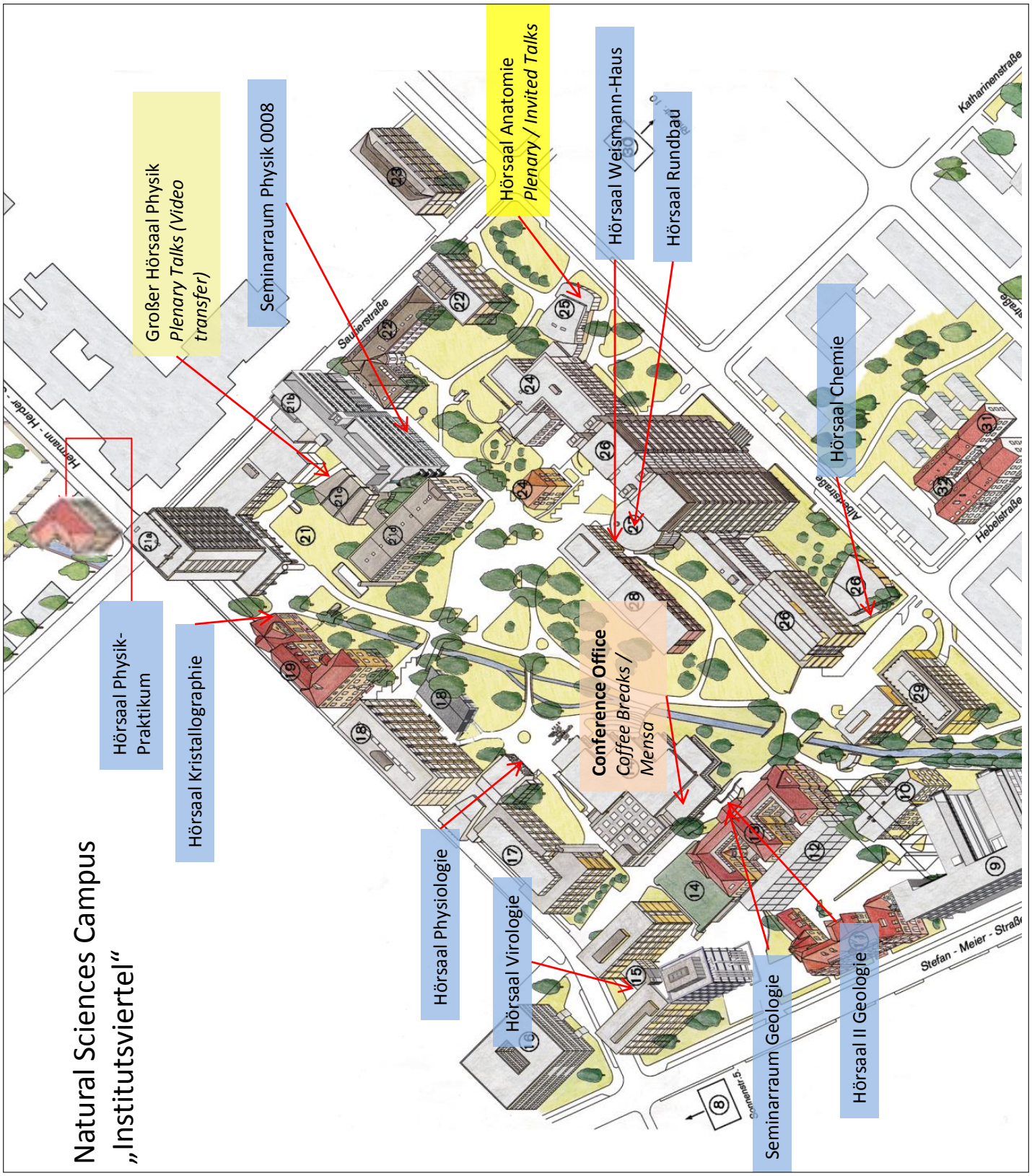
13th German Probability and Statistics Days

Freiburger Stochastik-Tage, February 27–March 2, 2018

Map of the area



13th German Probability and Statistics Days

Freiburger Stochastik-Tage, February 27–March 2, 2018

Keys for the book of abstract

For all boxes in the sidebar, Tue, 16:30 HS Anatomie is used for a plenary talk, Thu, 17:20 HS Anatomie is used for an invited section talk, and Tue, 17:55 HS Kristall is used for a contributed talk or poster presentation.

Within the boxes:
First line shows the abbreviated weekday and the time of the talk/the presentation.
Second line lists the place, where the talk/the presentation will take place.

Addresses for the lecture halls:

in the sidebar	address
Get Together	Historisches Kaufhaus, Kaisersaal, Münsterplatz 24
HS II Geolog.	Hörsaal II (room 02.033), Albertstr. 23b; in the building from Geology/Mineralogy
HS Anatomie	Hörsaal Anatomie, Albertstr. 17
HS Chemie	Großer Hörsaal Chemie, Albertstr. 21 (Ecke Hebelstr.)
HS Kristall	Hörsaal Kristallographie, Hermann-Herder-Str. 5
HS Physik	Großer Hörsaal Physik, Hermann-Herder-Str. 3 (behind Gustav-Mie-Haus)
HS Phys.-Prak.	Hörsaal Physik-Praktikum, Hermann-Herder-Str. 6; (corner Sautierstr./Hermann-Herder-Str., vis-a-vis to hospital)
HS Physiologie	Hörsaal Physiologie, Hermann-Herder-Str. 7; entrance vis-a-vis to Mensa
HS Virologie	Hörsaal Virologie, Hermann-Herder-Str. 11; entrance vis-a-vis to data processing center (Rechenzentrum)
HS Rundbau	Hörsaal Rundbau, Albertstr. 21 (vis-a-vis to HS Weismann-Haus)
HS Weismann	Hörsaal Weismann-Haus, Albertstr. 21a
SR Geologie	Seminarraum Geologie (room 03.037), Albertstr. 23b; in the building from Geology/Mineralogy
SR Phys. 0008	Seminarraum Physik 00.008, Hermann-Herster-Str. 3b (Gustav-Mie-Haus)

Abstracts

Plenary talks

Christina Goldschmidt

Tue, 16:30
HS Anatomie

Department of Statistics, University of Oxford

Voronoi cells in the Brownian continuum random tree

Take a uniform random tree with n vertices and select k of those vertices independently and uniformly at random; call these distinguished vertices sites. (We assume that n is large and k is fixed, so that with high probability the sites are distinct.) Find the associated Voronoi cells: for each vertex in the tree, assign it to the cell of the site (or sites) which is closest in the graph distance. Now consider the vector of the proportions of the vertices lying in each of the k cells. We prove that this vector converges in distribution to the Dirichlet$(1, 1, \dots, 1)$ distribution (that is, it is asymptotically uniform on the $(k-1)$-dimensional simplex). In fact, this is most neatly formulated as a result about the scaling limit of the uniform random tree, namely the Brownian continuum random tree: if we pick k independent sites from the mass measure of the tree, their Voronoi cells have masses which are jointly Dirichlet$(1, 1, \dots, 1)$-distributed. An analogue of this result also holds for (the scaling limit of) uniform unicellular random maps on surfaces of arbitrary genus.

Joint work with: Louigi Addario-Berry • Omer Angel • Guillaume Chapuy • Éric Fusy

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Marcel Nutz

Fri, 11:30
HS Anatomie

Columbia University

Supply and Shorting in Speculative Markets

History offers various episodes of exuberance in asset pricing, from the recent valuations of crypto currencies and the dot-com bubble of the 1990s to the South Sea bubble of the early 1700's. In this talk, we discuss how speculation and heterogeneity among market participants can lead to asset price bubbles in an equilibrium model with rational agents, and how supply and short-selling affect equilibrium prices.

Joint work with: Johannes Muhle-Karbe • Jose Scheinkman

Kavita Ramanan

Wed, 09:00
HS Anatomie

Brown University

Beyond Mean-Field Limits: Local Dynamics of Interacting Stochastic Processes on Sparse Graphs

Many applications can be modeled as a large system of interacting particles on a locally finite graph in which the infinitesimal evolution of each particle depends on its own state and the empirical measure of the states of neighboring particles. Given a sequence of regular graphs G_n whose size goes to infinity, and dynamics that are suitably symmetric, a key question is to understand the limiting dynamics of a typical particle in the system. The case when each G_n is a clique falls under the purview of classical mean-field limits, and it is well known that (under suitable assumptions) the dynamics of a typical particle is governed by a nonlinear Markov process. In this talk, we consider the complementary sparse case when G_n converges in a suitable sense to a countably infinite locally finite graph G, and describe various limit results, both in the setting of diffusions and Markov chains. In particular, when G is a d-regular tree, we obtain an autonomous characterization of the local dynamics of a typical node and its neighborhood in terms of a stochastic equation whose infinitesimal evolution depends on not only

the states of the particles but also certain conditional laws given the history of the process. We also obtain a local characterization for the annealed dynamics on a class of Galton–Watson trees. The proofs rely on a certain Gibbs structure of the dynamics on the countably infinite graph G, which may be of independent interest.

Joint work with: Anjan Ganguly • Dan Lacker • Mitchell Wortsman • Ruoyu Wu

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Wendelin Werner
ETH Zürich

Tue, 09:30
HS Anatomie

The (quantum) disk as patchwork of (quantum) disks

We will describe in heuristic and non-technical terms how to decompose a simply connected planar domain equipped with an independent Gaussian Free Field (and therefore corresponding Liouville Quantum gravity structure) into a (fractal) patchwork of i.i.d. similar structures welded along their boundaries.
Among the concepts entering that game are Conformal loop ensembles (and their explorations via SLE-type curves), asymmetric stable Lévy processes and branching structures. This result sheds some new light on the nature of these quantum surfaces and their relations to the corresponding discrete structures such as planar maps.
This is based on (partly ongoing) joint work with Jason Miller and Scott Sheffield.

Bin Yu
University of California, Berkely

Thu, 09:00
HS Anatomie

Three principles of data science: predictability, stability, and computability

In this talk, I'd like to discuss the intertwining importance and connections of three principles of data science in the title. They will be demonstrated in the context of two collaborative projects
in neuroscience and genomics, respectively. The first project in neuroscience uses transfer learning to integrate fitted convolutional neural networks (CNNs) on ImageNet with regression methods to provide predictive and stable characterizations of neurons from the challenging primary visual cortex V4.
The second project proposes iterative random forests (iRF) as a stablized RF to seek predictable and interpretable high-order interactions between biomolecules.

Invited talks

Louis-Pierre Arguin
City University of New York

Section 3
Fri, 10:30
HS Anatomie

The maxima of the Riemann zeta function in a short interval of the critical line

A conjecture of Fyodorov, Hiary & Keating states that the maxima of the modulus of the Riemann zeta function on an interval of the critical line behave similarly to the maxima of a log-correlated process. In this talk, we will discuss a proof of this conjecture to leading order, unconditionally on the Riemann Hypothesis. We will highlight the connections between the number theory problem and the probabilistic models including the branching random walk. We will also discuss the relations with the freezing transition for this problem. This is joint work with D. Belius (Zurich), P. Bourgade (NYU), M. Radizwill (McGill), and K. Soundararajan (Stanford).

Fabienne Comte
Université Paris Descartes

Section 10
Tue, 11:15
HS Anatomie

Nonparametric regression function estimation with non compactly supported bases

In this talk, I will describe the specific properties of Laguerre and Hermite bases, and analyze how they have been used for density estimation, with direct and noisy observation.
Then I will focus on nonparametric regression model and explain how most results about adaptive nonparametric least squares estimation, usually restricted to compact supports, can be generalized to non compactly supported bases. The proofs of the risk bounds of the estimators rely on a matrix Bernstein inequality by Tropp. The results also apply to dependent models such as autoregressive models or discretely observed diffusion processes. They can be extended to other (implicit) regression problems, such as survival function estimation in presence of interval censoring.
The presentation borrows from a series of papers in collaboration with D. Belomestny (Duisburg-Essen University), V. Genon-Catalot (Université Paris Descartes) and G. Mabon.

David Dereudre
University Lille

Section 2
Fri, 09:00
HS Anatomie

Percolation for Poisson outdegree-one graphs

A Poisson outdegree-one graph is an oriented graph based on a Poisson point process such that each vertex has only one outgoing edge. In this talk we will discuss the percolation property of such graphs. Our main result ensures absence of percolation for a large class of non oriented graphs. In particular, we solve a conjecture by Daley et al. on the absence of percolation for the line-segment model. In this planar model, a segment is growing from any point of the Poisson process and stops its growth whenever it hits another segment. The random directions are picked independently and uniformly on the unit disk. Other models will be discussed as well.

Joint work with: David Coupier • Simon Le Stum

Margherita Disertori
Universität Bonn

Section 5a
Thu, 17:20
HS Anatomie

Random operators in quantum diffusion and history dependent stochastic processes.

Random operators play an important role in the study of physical properties of disordered materials. The prominent examples are random Schroedinger operators and random band matrices. In recent years they also proved to have unexpected connections to certain history dependent stochastic processes. I will give an overview and some results.

Paul Embrechts
ETH Zürich

Section 4a
Thu, 14:00
HS Anatomie

Quantile-based Risk Sharing

We address the problem of risk sharing among agents using a two-parameter class of quantile-based risk measures, the so-called Range-Value-at-Risk (RVaR), as their preferences. The family of RVaR includes the Value-at-Risk (VaR) and the Expected Shortfall (ES), the two popular and competing regulatory risk measures, as special cases. We first establish an inequality for RVaR-based risk aggregation, showing that RVaR satisfies a special form of subadditivity. Then, the Pareto-optimal risk sharing problem is solved through explicit construction. To study risk sharing in a competitive market, an Arrow-Debreu equilibrium is established for some simple, yet natural settings. Further, we investigate the problem of model uncertainty in risk sharing, and show that, generally, a robust optimal allocation exists if and only if none of the underlying risk measures is a VaR. Practical implications of our main results for risk management and policy makers are discussed, and several novel advantages of ES over VaR from the perspective of a regulator are thereby revealed.

Joint work with: Hailyan Liu • Ruodu Wang

Alison Etheridge
University of Oxford

Section 5b
Thu, 16:30
HS Anatomie

Modelling populations under fluctuating selection

It has been recognised for a very long time that natural selection is not necessarily a constant force acting on a population; for example the genetic types favoured in a wet year may be different from those favoured in a dry year. As a result, fluctuating environmental conditions can maintain a balance between the different genotypes over extended periods. If, for example, we suppose that selection is acting on a single gene, then it is straightforward to write down a stochastic (ordinary) differential equation that captures the evolution of the frequencies of the different types of that gene (alleles) in the population. Crucially, such models can also capture genetic drift – the randomness due to reproduction in a finite population. What is much less studied is the evolution of allele frequencies in a population that is spatially structured.
Here we discuss one such model, based on the so-called spatial Lambda-Fleming–Viot process, that can capture something of the interplay between fluctuating selection and genetic drift. We shall see that when viewed over sufficiently large spatial and temporal scales, in at least two spatial dimensions, allele frequencies are dominated by the fluctuations due to the environment and can be captured by an spde. Ideally, one would be able to capture family struture in the population. As time permits we shall explain some partial results in this direction.

Franco Flandoli

Scuola Normale Superiore di Pisa

Section 1
Thu, 10:45
HS Anatomie

Randomness in 2D Euler equations

2D Euler equations are an interesting intermediate model between over simplified dynamics and 3D more elaborate fluid dynamic models, where it is possible to investigate a number of difficult questions about well posedness and turbulence, some of the main open questions in PDE theory and classical Physics. Randomness, introduced in the initial conditions and possibly as a noise, add a tool with several potentialities, described in the talk.

Valentine Genon-Catalot

Université Paris Descartes

Section 4b
Wed, 16:30
HS Anatomie

Inference for stochastic differential equations with random effects

Random effects models are of wide use in longitudinal data collected in clinical trials, epidemiology, pharmacokinetic pharmacodynamic experiments and agriculture. Random effects are incorporated to accomodate variability among subjects while the same structural model rules the dynamics of each subject.
In a series of papers, written jointly with Fabienne Comte (Université Paris Descartes, France), Maud Delattre (AgroParistech, France), Charlotte Dion (Université Pierre et Marie Curie, France), Catherine Larédo (I.N.R.A. and Université Paris Diderot, France), Adeline Samson (Université Grenoble Alpes, France), we have studied various aspects of statistical inference for stochastic differential equations with random effects. Assume that N *i.i.d.* real valued processes given by

$$dX_i(t) = b(\Phi_i, X_i(t))dt + \sigma(\Psi_i, X_i(t)dW_i(t), X_i(0) = x, \quad i = 1, \dots, N,$$

are observed on a time interval $[0, T]$, where observations may be either continuous or discrete and T may be fixed or large. The Wiener processes $W_1, \dots, W_N$ are independent, the random variables (Φ_i, Ψ_i), $i = 1, \dots, N$ are *i.i.d.* and independent of the Wiener processes. The random variables (Φ_i, Ψ_i) are the random efffects and are unobserved. It required to estimate the joint distribution of the random effects from the observed values of the processes $(X_i(t))$. We have investigated both parametric and non parametric inference for this distribution with asymptotic results as N tends to infinity while T is fixed or tends also to infinity. In the case where n discrete observations are available for each sample path, asymptotic results are obtained while both the number N of trajectories and the number n of observations per trajectory tend to infinity.

Leonid Mytnik

Israel Institute of Technology

Section 7
Wed, 10:45
HS Anatomie

Dimension of the boundary of the super-Brownian motion

We study the boundary of the super-Brownian motion in dimensions less or equal to 3. The Hausdorff dimension of the boundary is established.

Joint work with: E. Perkins

Victor Panaretos

EPFL

Section 11
Wed, 17:20
HS Anatomie

Nearly Blind Deconvolution of Gaussian Processes

Functional data analyses typically proceed by smoothing, followed by functional PCA. This paradigm implicitly assumes that rough variation is due to nuisance noise. Nevertheless, relevant functional

features such as time-localised or short scale fluctuations may indeed be rough relative to the global scale, but still smooth at shorter scales. These may be confounded with the global smooth components of variation by the smoothing and PCA, potentially distorting the parsimony and interpretability of the analysis. We investigate how both smooth and rough variations can be recovered on the basis of discretely observed functional data. ssuming that a functional datum arises as the sum of two uncorrelated components, one smooth and one rough, we develop identifiability conditions for the recovery of the two corresponding covariance operators. In the Gaussian case, this would correspond to a sort of blind deconvolution problem. The key requirement is that the the superposed covariances possess complementary forms of parsimony: one smooth and low rank (large scale), and the other banded and potentially high rank (small scale). Under these conditions, we show that the recovery problem is reducible to a low rank matrix completion problem, and exploit this to construct consistent estimators of the two covariances. (Based on joint work with Marie-Hélène Descary.)

Andrzej Ruszczynski
Rutgers University New Brunswick

Section 6
Tue, 17:30
HS Anatomie

Risk-Averse Control of Partially Observable Markov Systems

We consider risk measurement in controlled partially observable Markov systems in discrete time. In such systems, part of the state vector is not observed, but affects the transition kernel and the costs. We introduce new concepts of risk filters and study their properties. We also introduce the concept of conditional stochastic time consistency. We derive the structure of risk filters enjoying this property and prove that they can be represented by a collection of law invariant risk measures on the space of function of the observable part of the state. We also derive the corresponding dynamic programming equations. Then we illustrate the results on a clinical trial problem and a machine deterioration problem. In the final part of the talk, we shall discuss risk filtering and risk-averse control of partially observable Markov jump processes in continuous time.

Suhasini Subba Rao
Texas A&M University, College Station, Texas 77845

Section 8
Thu, 11:35
HS Anatomie

Linear Regression with Time Series Regressors

In several diverse applications, from the neurosciences to econometrics, it is of interest to model the influence observed regressors have on a response of interest.
In many of these applications, the regressors have a meaningful ordering and are usually a long time series. The problem of linear regression, where the number of regressors n is of the same order or magnitudes larger than the number of responses p has received considerable attention.
However, most of these approaches place a sparsity assumption on regressor coefficients. When the regressors are a time series, the sparse assumption can be unrealistic with no intuitive interpretation. In this talk we consider the problem of linear regression with time series regressors, but work under the assumption that the regressor coefficients are absolutely summable.
We propose a computationally efficient method for estimating the regression parameters, that avoids matrix inversion. We show that the parameter estimators are consistent and derive a central limit theorem The proposed estimation scheme, leads to a simple method for estimating the variance of the parameter estimators. Though consistent the parameter estimators are noisy, thus we describe a post-processing step to reduce the noise in the estimators.

Joint work with: Raanju Sundararajan

Thordis L. Thorarinsdottir
Norwegian Computing Center

Section 9
Wed, 11:35
HS Anatomie

On developing general and efficient inference algorithms for complicated hierarchical models

A common problem in spatial statistics consists of estimating the marginal distribution of a phenomena at any location within a region. The (usually two or three) parameters of the marginal distribution are then assumed to depend on a set of covariates and, potentially, a spatially structured random effect. In addition, it is often of interest to incorporate a model averaging component to assess model uncertainty in the effect of the proposed covariates. We discuss how inference for such models can be performed in a Bayesian setting in a general and an efficient manner without the need for user-specified tuning parameters in the Bayesian inference algorithm. This is demonstrated in two applications where the three-parameter generalized extreme value (GEV) distribution with latent Gaussian fields is used for spatial modelling of extreme hourly precipitation and for regional flood frequency analysis in Norway.

Aad van der Vaart
Leiden University

Section 12
Tue, 14:00
HS Anatomie

On Bayesian uncertainty quantification

We give an overview of theoretical results that justify or not the use of a posterior distribution of an high- or infinite-dimensional parameter as a method for uncertainty quantification. The posterior distribution is the conditional distribution of the parameter given the data when the parameter is thought of as having been generated by a prior. For the non-Bayesian it is just a random distribution over the parameter space, whose spread could be used to form the equivalent of a confidence set. We shall see that in the nonparametric situation this is only justified if the prior does not oversmooth the true parameter. Furthermore, if the smoothness of the prior is chosen dependent on the data (adaptation), then uncertainty quantification is correct for a large set of, but not all true parameters.

Section 1: Stochastic analysis

Franco Flandoli
Scuola Normale Superiore di Pisa

Thu, 10:45
HS Anatomie

Randomness in 2D Euler equations

2D Euler equations are an interesting intermediate model between over simplified dynamics and 3D more elaborate fluid dynamic models, where it is possible to investigate a number of difficult questions about well posedness and turbulence, some of the main open questions in PDE theory and classical Physics. Randomness, introduced in the initial conditions and possibly as a noise, add a tool with several potentialities, described in the talk.

Randolf Altmeyer

Wed, 12:00
HS Kristall

Generalized Itô formulas for Itô semimartingales

Consider a d-dimensional Itô semimartingale X with jumps. We prove generalized Itô formulas for L^2-Sobolev functions f. Similar to [1], who consider only Brownian motion, the usual second order terms are replaced by the quadratic covariations $[\partial_k f(X), X^{(k)}]$. An important novelty, as opposed to existing results in the literature, is that we do not require X to be reversible for obtaining the quadratic covariations as limits in probability. The proof is based on semimartingale approximations in the Fourier domain, which were introduced in [2]. This allows us to derive Itô formulas also for processes X with non-smooth coefficients. For sufficiently regular f the quadratic covariations can be identified explicitly as functionals with respect to the occupation measure of X.

References:

[1] H. Föllmer, P. Protter, A. Shiryaev (1995). Quadratic covariation and an extension of Itô's formula. *Bernoulli* 1, 149–169
[2] R. Altmeyer (2017). Estimating Occupation Time Functionals. *arXiv preprint*

Mahdi Azimi
Martin Luther University Halle-Wittenberg

Tue, 11:40
HS Kristall

A maximum principle for a stochastic optimal control problem in $\mathbf{L^q}$ *spaces*

We consider an optimal control problem in Banach space E, where $E = L^q(S, \mathcal{S}, \mu)$, μ is a finite measure. The state process will be defined as Ito Volterra stochastic integral equation and the stochastic integral is defined with respect to a cylindrical Wiener process and a control process is defined as F valued process where F is another Banach space. By using appropriate assumptions and L^p-stochastically integrability in Banach spaces, corresponding backward stochastic Ito Volterra integral equations will be formulated and a duality principle between forward and backward stochastic Ito Volterra integral equations will be derived. Then we solve the stochastic optimal control problem by using of maximum principle.

Joint work with: Wilfried Grecksch

Julio Backhoff Veraguas
TU Wien

Tue, 17:55
HS Kristall

Martingale Benamou-Brenier: a probabilistic perspective

In classical optimal transport, the contributions by Benamou, Brenier and McCann (among others) regarding the time-dependent version of the problem, have had a lasting impact in the field and led to many applications. It is remarkable that this is achieved even if in continuous time classical optimal transport, mass/particles only travel in straight lines. Of course this fails to happen when we consider (continuous-time) martingale optimal transport; namely when we only allow for martingale couplings in the transport problem.
In this talk we discuss the existence of a martingale analogue to McCann's interpolation and the Benamou–Brenier formula from a probabilistic – as opposed to analytic – point of view. This remarkable martingale is characterized by very natural optimality and geometric properties: in a precise way, it provides a canonical martingale way to connect two measures in convex order.

Joint work with: Mathias Beiglböck • Martin Huesmann • Sigrid Källblad

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Daniel Bartl

Tue, 11:15
HS Kristall

Characterization of pointwise conditional nonlinear expectations

In this talk we focus on pointwise conditional nonlinear expectations, defined on the spaces of measurable (upper semianalytic) functions. Under the assumption that $\Omega = U \times V$ is the product of two Polish spaces, we prove that a conditional nonlinear expectation $\mathcal{E}(\cdot|U) : \mathcal{L}^\infty(\Omega) \to \mathcal{L}^\infty(U)$ satisfies a monotone-convergence type continuity if and only if there exists a set-valued mapping $\mathcal{P}_V$ from U to the probabilities on V with weakly compact values and analytic graph such that $\mathcal{E}(X|U)(u) = \sup_{P \in \mathcal{P}_V(u)} \int_V X(u,v)\, P(dv)$. Further, given more than one conditional nonlinear expectation, the tower-property is characterized via a pasting property of the representing measures.

Denis Belomestny
Duisburg–Essen University

Fri, 10:55
HS Kristall

Projective simulation and regression methods for Mckean–Vlasov SDEs

In the first section a projection-based simulation method for solving McKean–Vlasov stochastic differential equations is proposed. This approach is based on a projection-type estimation of the marginal density of the solution in each time step. The projection-based method leads in many situation to a significant complexity reduction compared to the widely used kernel density estimation algorithms.
In the next section we propose a regression method based on an approximating particle system for solving conditional expected functionals related to the MVSDE globally in space. Unlike usual Monte Carlo regression that is based on independent sample trajectories, the trajectories of the particle system are generally dependent. As a consequence, the classical convergence analysis for Monte Carlo based regression needs to be reconsidered.
As a main application, this approach allows for a regression based backward simulation algorithm for optimal stopping of McKean–Vlasov SDEs, in the spirit of the well-known Longstaf & Schwartz and Tsitsiklis & van Roy methods.

References:

[1] D. Belomestny, J. Schoenmakers (2017). *Projected particle methods for solving McKean–Vlasov stochastic differential equations*, https://arxiv.org/abs/1708.08087

Joint work with: John Schoenmakers

Wolfgang Bock
TU Kaiserslautern

Thu, 16:30
HS Kristall

Recent results on grey Brownian motion

Fractional differential equations are a very intensively studied object in many fields of applications. The fractionality introduces a long-range coupling along the trajectories which gives the possibility to model memory effects. On the other side, the well known connecion of partial differential equations and stochastic processes, which is in the heat equation case given via the famous Feynman–Kac formaula usually breaks down in the fractional case. For a certain class of space-time fractional heat equations however, it is shown by Schneider, that a Feynman–Kac like formula exists for a process which he names grey Brownian motion. In fact the characteristic function of the process is in a similar fashion given as that of a standard Wiener process, where the exponential function is replaced by a Mittag-Leffler function. In this talk we derive solutions of the Ornstein–Uhlenbeck driven by Grey Brownian motion and of a linear Wick-type SDE driven by Grey Brownian motion. The solutions are characterized to be in a suitable distribution space of Mittag-Leffler Analysis introduced by Grothaus, Jahnert, Riemann and Silva. Moreover we give an overview of process properties related to Physics. And discuss recent results of grey Brownian motion.

Joint work with: José Luís Silva • Ludwig Streit

Oleg Butkovsky
Technische Universitat Berlin

Wed, 10:45
HS Kristall

Strong existence and uniqueness for stable SDEs with distributional drift

We study a one dimensional stochastic differential equation with a distributional drift driven by α-stable noise:

$$dX_t = b(X_t)dt + dL_t.$$

Note that the equation is not well-posed in the classical sense: here b is not a function but just a generalized function from the negative Holder space $\mathcal{C}^{-\beta}$. Thus, a priori it is not even clear what one should call a solution to this equation.
We define the notion of a solution, and show that this SDE has a unique strong solution whenever $\beta < \alpha/2 - 1/2$. Our main tool is a new version of Zvonkin-type transformation of drift suggested by F. Flandoli, M. Gubinelli, E. Priola (2009). This generalizes the corresponding results of E. Priola (2012) and extends to the context of stable processes the classical results of A. Zvonkin (1974) as well as the more recent results of R. Bass and Z.-Q. Chen (2001).

Joint work with: Siva Athreya • Leonid Mytnik

Carsten Chong
École Polytechnique Fédérale de Lausanne

Fri, 09:25
HS Kristall

Intermittency for the stochastic heat equation with Lévy noise

We investigate the moment asymptotics of the solution to the stochastic heat equation driven by a $(d+1)$-dimensional Lévy space-time white noise. Unlike the case of Gaussian noise, the solution typically has no finite moments of order $1 + 2/d$ or higher. Intermittency of order p, that is, the exponential growth of the pth moment as time tends to infinity, is established in dimension $d = 1$ for all values $p \in (1, 3)$, and in higher dimensions for some $p \in (1, 1 + 2/d)$. The proof relies on a new moment lower bound for stochastic integrals against compensated Poisson measures. The behavior of the intermittency exponents when $p \to 1 + 2/d$ further indicates that intermittency in the presence of jumps is much stronger than in equations with Gaussian noise. The effect of other parameters like the diffusion constant or the noise intensity on intermittency will also be analyzed in detail.

Joint work with: Péter Kevei

Sören Christensen
University of Hamburg

Tue, 17:30
HS Kristall

Monotone stopping problems revisited

Most optimal stopping problems are not straightforwardly solved. One of the few exceptions is the class of monotone stopping problems as already introduced and studied in in the 1960s. This approach allows for explicit solutions even if the underlying process has no Markovian structure. On the other hand, the field of application seems to be limited on a first view, so that the use of this method has declined in recent research.
The aim of this talk is, however, to show the power of this approach. It, for example, allows us to solve certain classes of multidimensional stopping problems explicit, e.g., variants of the Poisson disorder problem and an optimal investment problem. It furthermore leads to a full classification of all one-sided stopping problems for underlying random walks and Lévy process: the reward functions with optimal strategies of threshold-type are exactly the monotone and log-concave ones. This generalizes many existing results in the literature using only elementary arguments.

Nils Detering
University of California Santa Barbara

Wed, 11:35
HS Kristall

Large linear systems of coupled diffusions

We consider large linear systems of coupled diffusions and their convergence as the number of diffusions goes to infinity. Our results cover two complementing scenarios, a homogeneous coupling where propagation of chaos can be observed and a heterogeneous coupling, which looks like a chain and where neighboring components are highly dependent. Further we develop a test to detect whether a single observed diffusion process is of chain or of mean field type.

Joint work with: Jean-Pierre Fouque • Tomoyuki Ichiba

Christian Döbler
University of Luxembourg

Thu, 14:25
HS Kristall

Error bounds on the normal approximation in non-diffusive situations

Starting from the pioneering work of Nourdin and Peccati (2009) there has recently been much progress in providing error bounds on the normal (and non-normal) approximation of functionals of random fields, whose law is the stationary distribution of some diffusive Markov generator, in particular for Gaussian processes. Although also in non-diffusive situations like the Poisson space framework or for functionals of a Rademacher sequence, many remarkable achievements have been made, here, the developed techniques have not been strong enough to provide analogs of fundamental result on Gaussian spaces like e.g. the so-called fourth moment theorem.
In this talk we will emphasize how, by taking on a spectral viewpoint and by focussing on carré du champ operators, also in non-diffusive situations such problems can be effectively addressed. More precisely, we show that on the Poisson space there is an exact fourth moment theorem comparable to the one in a Gaussian framework, whereas for functionals of independent Rademacher variables this does not hold.
Finally we would like to discuss the main differences between the Poisson and the Rademacher situation from an abstract point of view and also to point out some potential applications of our newly derived bounds.

Joint work with: Giovanni Peccati • Anna Vidotto • Guangqu Zheng • Kai Krokowski

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Julian Fischer
IST Austria

Thu, 18:10
HS Kristall

An analysis of variance reduction methods in stochastic homogenization

The theory of stochastic homogenization predicts that an elliptic PDE with a random coefficient field may be approximated on large scales by an elliptic PDE with a (deterministic) constant effective coefficient. The most widespread approach for the computation of such effective coefficients in stochastic homogenization is the so-called representative volume element (RVE) method: A sample volume of the random coefficient field is chosen, say, a cube with side length L; by solving the equation of the homogenization corrector on this sample volume, one may obtain an approximation for the effective coefficient. However, the resulting approximation for the effective coefficient is a random variable, as it depends on the sample of the random coefficient field. It turns out that the leading-order contribution to the error of this approximation is actually caused by the random fluctuations of the approximation around its expected value. To increase the efficiency of numerical methods, it is therefore desirable to reduce the variance of the approximation.
We provide an improved rigorous analysis of the variance reduction approaches in stochastic homogenization introduced by Blanc, Le Bris, Legoll, and Minvielle. Our approach relies on a quantitative multivariate normal approximation result for sums of random variables with a "multilevel local dependence structure".

Peter Frentrup
Humboldt-Universität zu Berlin

Tue, 14:00
HS Kristall

Stability for gains from large investors' strategies in M1/J1 topologies

When investigating market impact models one crucial aspect is the definition of gains from (large) block trades. Here being important that the large investor should not be able to circumvent her liquidity cost by e.g. fast trading in small blocks or in rates. Such approximations of a trading strategy cannot be covered by the uniform or Skorokhod's J_1 topology; an adequate choice is Skorokhod's M_1 topology. Starting from a general price impact model where the observed price $S_t = g(\bar{S}_t, Y_t^\Theta)$ is a function of an unperturbed price process $\bar{S}$ and a controlled transient impact process Y^Θ, we extend the trading gains functional $L_\cdot(\Theta) = -\int_0^\cdot S_t \, \mathrm{d}\Theta_t$ from continuous finite-variation strategies Θ to general adapted càdlàg processes Θ, such that $\Theta \mapsto L_\cdot(\Theta)$ is continuous in M_1 (and J_1 and uniformly) in probability. As a consequence, we uniquely identify the gains from a block trade $\Delta\Theta_t$ as $-\int_0^{\Delta\Theta_t} g(\bar{S}_{t-}, Y_{t-}^\Theta + x)\,\mathrm{d}x$. The gains functional L for trading with price impact in a large class of strategies allows to tackle different optimal liquidation problems, and is a prerequisite for further tasks such as hedging.

Joint work with: Todor Bilarev • Dirk Becherer

Wilfried Grecksch

Tue, 14:50
HS Kristall

Parameter estimate for a linear parabolic fractional SPDE

A drift parameter estimation problem is studied for a linear parabolic stochastic partial differential equation driven by a multiplicative cylindrical fractional Brownian motion with Hurst index $h \in]1/2, 1[$ and a multiplicative APoisson process with values in a Hilbert space. Equations are introduced for the Galerkin approximations of the mild solution process. A mean square estimation criterion is used for these equations. It is proved that the estimate is unbiased and weakly consistent for the original problem.

Miryana Grigorova
Centre for Risk and Insurance, Hannover

Tue, 12:05
HS Kristall

Doubly Reflected BSDEs and non-linear $\mathcal{E}^f$-Dynkin games: beyond right-continuity

We formulate a notion of doubly reflected BSDE in the case where the barriers ξ and ζ do not satisfy any regularity assumption. Under a technical assumption (a Mokobodzki-type condition), we show existence and uniqueness of the solution.
In the case where ξ is right upper-semicontinuous and ζ is right lower-semicontinuous, the solution is characterized in terms of the value of a corresponding $\mathcal{E}^f$-Dynkin game, i.e. a game problem over stopping times with (non-linear) f-expectation, where f is the driver of the doubly reflected BSDE. In the general case where the barriers do not satisfy any regularity assumptions, the solution of the doubly reflected BSDE is related to the value of "an extension" of the previous non-linear game problem over a larger set of "stopping strategies" than the set of stopping times. This characterization is then used to establish a comparison result and *a priori* estimates with universal constants.

References:

[1] M. Grigorova, P. Imkeller, Y. Ouknine, M.-C. Quenez (2017). *Doubly Reflected BSDEs and $\mathcal{E}^f$-Dynkin games: beyond the right-continuous case*, available at https://arxiv.org/abs/1704.00625.

Joint work with: Peter Imkeller • Youssef Ouknine • Marie-Claire Quenez

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Lena-Susanne Hartmann
Friedrich-Schiller-Universität

Wed, 11:10
HS Kristall

Parabolic SPDE with multiplicative Lévy noise

We are looking at the stochastic advection-diffusion equation driven by Lévy noise acting on the gradient. We investigate how solutions to these equations can be understood if the driving noise has jumps, and establish basic existence and uniqueness results. Furthermore, we seek to give meaning to our results by showing that our solution can be interpreted as limit process of a sequence of classical solutions that we gain by replacing the driving Lévy process with a continuous pathwise approximation.

Simon Holbach

Tue, 15:15
HS Kristall

Periodic ergodicity for degenerate diffusions with time-dependent drift

We consider a deterministic dynamical system

$$\begin{aligned} \dot{x}_t &= F(x_t, y_t) + S(t), \\ \dot{y}_t &= G(x_t, y_t). \end{aligned} \tag{DS}$$

with multidimensional variables $x = (x_1, \dots, x_N)$, $y = (y_1, \dots, y_L)$. We introduce a stochastic version of (DS) by replacing the T-periodic input signal S with a random perturbation of it, i.e.

$$\begin{aligned} dX_t &= F(X_t, Y_t)dt + dZ_t, \\ dY_t &= G(X_t, Y_t)dt, \\ dZ_t &= [S(t) + b(Z_t)]dt + \sigma(Z_t)dW_t \end{aligned} \tag{SDS}$$

with some N-dimensional Brownian Motion W. This system is degenerate in the sense that the number of its components $N + L + N$ is much bigger than the dimension N of the driving Brownian Motion. Our goal is to find conditions on (DS) and b and σ that are sufficient for (SDS) to be ergodic in the sense of positive Harris recurrence of the corresponding T-grid chain. The general strategy is provided

by methods that were introduced by Höpfner, Löcherbach and Thieullen in a series of articles on a stochastic version of the Hodgkin-Huxley model. The main tools are the Support Theorem, Malliavin Calculus and classical Lyapunov functions. Interesting examples include the aforementioned Hodgkin–Huxley model as well as a chain of coupled oscillators.

References:

[1] R. Höpfner, E. Löcherbach, M. Thieullen (2016) Strongly degenerate time inhomogeneous SDEs: densities and support properties. Application to a Hodgkin–Huxley system with periodic input. ESAIM P&S 20, 527–554

Anselm Hudde
Universität Duisburg-Essen

Wed, 18:10
HS Kristall

Malliavin Calculus for enlarged σ-fields and Applications to the Approximation of SDEs and SPDEs

In this talk I will present Malliavin Calculus for enlarged σ-fields which can be applied to a perturbation theory which allows us to estimate the distance of the solution of an SDE and an Itô process. The perturbation theory can then be applied to the numerical approximation of SDEs and SPDEs.

Joint work with: Martin Hutzenthaler • Arnulf Jentzen

Alexander Kalinin
Imperial College London

Fri, 09:00
HS Kristall

Mild solutions to path-dependent PDEs

Recently, Dupire, Cont, and Fournié introduced horizontal and vertical derivatives of non-anticipative functionals on path spaces and established the functional Itô formula, the path-dependent generalization of the widely applied Itô formula. These concepts led to the new exciting class of path-dependent partial differential equations (PPDEs). In relevant publications, the most common approach to construct classical or viscosity solutions to PPDEs is to utilize backward stochastic differential equations (BSDEs). In this talk, we instead rely on Markovian integral equations and present path-dependent diffusion processes, which may fail to be Markov, but whose path processes can be turned into diffusions, to derive a general existence and uniqueness result for mild solutions to semilinear parabolic PPDEs. Motivated by the fact that this solution concept can provide optimal strategies and value functions for problems of stochastic optimal control, we show that continuous mild solutions may also be viewed as viscosity solutions.

References:

[1] B. Dupire. Functional Itô calculus. *Bloomberg Portfolio Research Paper*, 2009.
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Joint work with: Alexander Schied

Thomas Kruse
Universität Duisburg-Essen

Wed, 16:55
HS Kristall

Multi-level Picard approximations for high-dimensional nonlinear parabolic partial differential equations

In this talk we present a family of new approximation methods for high-dimensional PDEs and BSDEs. A key idea of our methods is to combine multi-level approximations with Picard fixed-point approximations. Thereby we obtain a class of multi-level Picard approximations. Our error analysis proves that for semi-linear heat equations, the computational complexity of one of the proposed methods is bounded by $O(d\,\varepsilon^{-(4+\delta)})$ for any $\delta > 0$, where d is the dimensionality of the problem and $\varepsilon \in (0, \infty)$ is the prescribed accuracy. We illustrate the efficiency of one of the proposed approximation methods by means of numerical simulations presenting approximation accuracy against runtime for several nonlinear PDEs from physics (such as the Allen-Cahn equation) and financial engineering (such as derivative pricing incorporating default risks) in the case of $d = 100$ space dimensions.

Joint work with: Weinan E • Martin Hutzenthaler • Arnulf Jentzen

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Claudine Leonhard

Thu, 17:20
HS Kristall

On the Simulation of Iterated Stochastic Integrals in Infinite Dimensions

Higher order numerical methods for the approximation of stochastic partial differential equations that do not possess commutative noise require the simulation of iterated stochastic integrals. We present two schemes to approximate stochastic double integrals with respect to an infinite dimensional Q-Wiener process in case of a trace class operator Q. These are derived from the methods introduced for finite dimensional stochastic double integrals by [1] and [2]. Particularly, we highlight the differences in the derivation and the peculiarities in the error estimates compared to the finite dimensional setting. Moreover, we comment on the computational cost of these methods.

References:

[1] P. E. Kloeden, E. Platen, I. W. Wright (1992). The approximation of multiple stochastic integrals. *Stoch. Anal. Appl.* 10(4), 431–441
[2] M. Wiktorsson (2001). Joint characteristic function and simultaneous simulation of iterated Itô integrals for multiple independent Brownian motions. *Ann. Appl. Probab.* 11(2), 470–487

Joint work with: Andreas Rößler

Sara Mazzonetto

Wed, 17:45
HS Kristall

About existence, uniqueness, and numerical approximation for some stochastic partial differential equations

We present an all-in-one result about existence, uniqueness, and numerical approximation of the mild solution of some stochastic partial differential equations with additive white noise and non-globally Lipschitz continuous nonlinearities.
The numerical approximation is based on a recently introduced explicit full-discrete scheme (see Hutzenthaler, Jentzen, and Salimova (2016)).
And for example, in the case of stochastic Burgers equation with additive white noise, we recover simultaneously existence, uniqueness, and strong convergence of the numerical scheme to the exact solution (for the strong convergence result see Jentzen, Salimova, and Welti (2017)).

Joint work with: Arnulf Jentzen • Diyora Salimova

Christian Mönch
Universität Mannheim

Tue, 14:25
HS Kristall

Decorrelation and Persistence of the Rosenblatt process

We consider the 'one sided exit problem' for a real valued stochastic process, i.e. the determination of the first exit time distribution of the process from a half line. For non-Markovian processes it is highly challenging to even calculate the tail asymptotics of this distribution.
It is conjectured that the distribution decays polynomially for any continuous self-similar process with stationary increments. In this case the decay exponent should be a simple function of the index of self-similarity. We resolve the conjecture in the special case of the Rosenblatt process using a non-Gaussian version of Slepian's Lemma and discuss some open problems related to the general setting.

Joint work with: Frank Aurzada

Marvin S. Mueller
ETH Zurich

Wed, 17:20
HS Kristall

Weak convergence rates for noise discretizations of stochastic evolution equations

We prove essentially sharp weak convergence rates for noise discretizations of a wide class of stochastic evolution equations with non-regularizing semigroups and additive or multiplicative noise. This class covers the nonlinear stochastic wave equation with space-time white noise, but also the HJMM, stochastic Schroedinger and linearized stochastic Korteweg–de Vries equation. We find that the weak rate equals twice the strong rate and depends in an explicit way on the regularity of the noise coefficient.

Joint work with: Philipp Harms

David Johannes Prömel
University of Oxford

Thu, 15:15
HS Kristall

Rough convolution equations and related SDEs

In stochastic analysis and its applications various types of stochastic differential and integral equations, such as stochastic differential equations with possible delay, stochastic Volterra equations or moving average equations driven by Lévy processes, play a central role. In order to treat the aforementioned stochastic equations in a unifying pathwise framework, we study the convolution equation

$$u(t) = u_0(t) + \int_{\mathbb{R}} \phi(t-s)\sigma(u(s))\xi(s)\,ds, \quad t \in \mathbb{R},$$

where u_0 is an initial condition, ϕ is a real-valued kernel function, σ is a vector field and ξ is a "rough" driving signal. As an example one might think of ξ as the weak derivative of a Brownian motion and of ϕ as an indicator function of the interval $[0, T]$, which would turn the convolution equation into a classical stochastic differential equation driven by a Brownian motion.
We prove pathwise existence and uniqueness results for this type of convolution equations. For this purpose we generalize and adapted the paracontrolled distribution approach, which was recently introduced by Gubinelli, Imkeller and Perkowski to deal with singular stochastic PDEs. Furthermore, we show the continuity of the solution map $\xi \mapsto u$ on a suitable enhanced path space. In the case of classical rough differential equations this corresponds to one of the central results in rough path theory, namely, the continuity of the Itô-Lyons map defined on the space of rough paths. This offers access to prove classical and new results (e.g. well-posedness, regularity of the solution, large deviations, support theorem) regarding stochastic differential and integral equations.

Joint work with: Mathias Trabs

Martin Redmann
Weierstrass Institute

Thu, 16:55
HS Kristall

Solving linear parabolic rough partial differential equations

In this talk, we discuss the numerical approximation of parabolic PDEs driven by a rough path which, e.g., can be the lift of a path of a fractional Brownian motion. By using the Feynman–Kac formula, the solution can be represented as the expected value of a functional of the corresponding hybrid Stratonovich-rough differential equation. A time-discretisation of this equation and a Monte Carlo regression in the spatial variable lead to an approximation of the solution to the rough PDE. We analyse the regression error and provide several numerical experiments to illustrate the performance of our method.

Joint work with: Christian Bayer • John Schoenmakers • Denis Belomestny • Sebastian Riedel

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Sebastian Riedel
TU Berlin

Thu, 14:50
HS Kristall

Random dynamical systems and rough paths

Rough paths theory (in the sense of Lyons) is a pathwise calculus which can be used to solve stochastic differential equations. We prove that rough differential equations naturally induce random dynamical systems provided the driving path satisfies a version of the cocycle property. This gives rise to the study of new random dynamical systems which are not necessarily Markovian. In particular, we can study convergence to equilibrium, the existence of attractors and stable manifolds for SDEs driven by a fractional Brownian motion.

Joint work with: Ismaël Bailleul • Michael Scheutzow

Martin Saal
TU Darmstadt

Thu, 17:45
HS Kristall

The primitive equations driven by space-time white noise

The primitive equations are a version of the Navier–Stokes equations and they form the basic model to study the large scale dynamics of oceanic and atmospheric flows.
In these systems the horizontal direction is large compared to the vertical one, and so also the dynamics are assumed to be governed by the movement in the horizontal directions.
The mathematical formulation is due to Lions, Teman and Wang, they consider a domain of the form $\Omega = [0,1]^2 \times (-h, h)$ (h small). The velocity u of the fluid is described by $u = (v, w)$, where $v = (v_1, v_2)$ denotes the horizontal components and w the vertical one, and the surface pressure is p. The primitive equations read

$$\begin{aligned} \partial_t v + v_1 \partial_x v + v_2 \partial_y + w \partial_z v - \Delta v + \begin{pmatrix} \partial_x \\ \partial_y \end{pmatrix} p = 0, \ \text{in } \Omega \times (0,T), \\ \partial_z p = 0, \ \text{in } \Omega \times (0,T), \\ \partial_x v_1 + \partial_y v_2 + \partial_z w = 0, \ \text{in } \Omega \times (0,T), \end{aligned}$$

complemented with boundary and initial conditions.
In contrast to the standard Navier–Stokes equations these equations have an anisotropic structure, the vertical velocity w only appears in the divergence equation and in the nonlinearity.
To take into account physical uncertainties Debussche, Glatt-Holtz, Temam and Ziane considered the primitive equations with a multiplicative white (in time) noise and established the global existence and uniqueness of strong, pathwise solutions. Our aim is to prove the well-posedness of the primitive equations with additive space-time white noise by using Hairer's theory of regularity structures. The

result of Zhu and Zhu for the classical Navier–Stokes system cannot be carried over because of structural differences of the systems.
In our presentation we briefly introduce the primitive equations and we show how to handle the vertical component w in the framework of regularity structures. This function does not fulfill an evolution equation, it has to be recovered from the divergence free condition $\partial_x v_1 + \partial_y v_2 + \partial_z w = 0$ by an integration in the z-variable. Therefore, we have to construct a good map on the level of regularity structures which represents this integration. Having such a map at hand, one can start to study the well-posedness of the primitive equations with space-time white noise.

References:

[1] A. Debussche, N. Glatt-Holtz, R. Temam, M. Ziane (2012). Global existence and regularity for the 3D stochastic primitive equations of the ocean and atmosphere with multiplicative white noise. *Nonlinearity* 25(7), 2093–2118.
[2] J. L. Lions, R. Temam, Sh. H. Wang (1992). New formulations of the primitive equations of atmosphere and applications. *Nonlinearity* 5(2), 237–288.
[3] R. Zhu, X. Zhu (2015). Three-dimensional Navier–Stokes equations driven by space-time white noise. *Journal of Differential Equations* 259(9), 4443–4508

Joint work with: Sebastian Zaigler • Volker Betz

Alexander Schnurr
Siegen University

Thu, 14:00
HS Kristall

The Fourth Characteristic of a Semimartingale

We extend the class of semimartingales in a natural way. This allows us to incorporate processes having paths that leave the state space. By carefully distinguishing between two killing states, we are able to introduce a fourth semimartingale characteristic which generalizes the fourth part of the Levy quadruple.
Since three characteristics have become canonical over the years, we motivate the fourth characteristic also by considering Feller processes. Analyzing their generator, we find a natural fourth component which does not have an analogue in the theory of semimartingales yet. Our fourth characterstic completes a classical picture and allows to incorporate affine process (with killing) and non-conservative solutions to martingale problems in the semimartingale framework.
Using the probabilistic symbol, we analyze the close relationship between the generators of certain Markov processes with killing and their (now four) semimartingale characteristics.

Stefan Tappe
Albert-Ludwigs-Universität Freiburg

Fri, 10:30
HS Kristall

Invariant manifolds in the space of tempered distributions

In this presentation we deal with the existence of solutions to stochastic partial differential equations in scales of Hilbert spaces, and show how this is related to the existence of invariant manifolds. As a particular example, we will treat an equation in the space of tempered distributions; here the Hilbert scales are given by Hermite–Sobolev spaces.

Joint work with: Bhaskaran Rajeev

Willem van Zuijlen
Weierstrass Institute

Wed, 16:30
HS Kristall

The principal eigenvalue of the Anderson Hamiltonian in continuous space

In this talk I will discuss almost sure asymptotics of the principal eigenvalue of the Anderson Hamiltonian with space white noise potential with Dirichlet boundary conditions on large boxes in $\mathbb{R}^2$.

Joint work with: Khalil Chouk

Section 2: Spatial statistics and random structures

David Dereudre
University Lille

Fri, 09:00
HS Anatomie

Percolation for Poisson outdegree-one graphs

A Poisson outdegree-one graph is an oriented graph based on a Poisson point process such that each vertex has only one outgoing edge. In this talk we will discuss the percolation property of such graphs. Our main result ensures absence of percolation for a large class of non oriented graphs. In particular, we solve a conjecture by Daley et al. on the absence of percolation for the line-segment model. In this planar model, a segment is growing from any point of the Poisson process and stops its growth whenever it hits another segment. The random directions are picked independently and uniformly on the unit disk. Other models will be discussed as well.

Joint work with: David Coupier • Simon Le Stum

Gilles Bonnet
University of Bochum

Wed, 16:30
HS Virologie

Monotonicity of facet numbers of random convex hulls

Let $X_1, \dots, X_n$ be independent random points that are distributed according to a probability measure on $\mathbb{R}^d$ and let P_n be the random convex hull generated by $X_1, \dots, X_n$ $(n \geq d+1)$. For natural classes of probability distributions and by means of Blaschke-Petkantschin formulae from integral geometry it is shown that the mean facet number of P_n is strictly monotonically increasing in n.

Joint work with: Julian Grote • Daniel Temesvari • Christoph Thäle • Nicola Turchi • Florian Wespi

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Julian Grote

Wed, 11:35
HS Virologie

Isotropic random polytopes

Fix a space dimension $d \geq 2$, the parameter $\alpha > -1$ and $\beta \geq 1$ and let $\gamma_{d,\alpha,\beta}$ be the measure of an isotropic random variable in $\mathbb{R}^d$ with density

$$c^d_{\alpha,\beta} \, ||x||^\alpha \, \exp\left(-\frac{\|x\|^\beta}{\beta}\right).$$

By K_λ we denote the random convex hull of a Poisson point process in $\mathbb{R}^d$ with intensity measure $\lambda\gamma_{d,\alpha,\beta}$, $\lambda > 0$. In the Gaussian case, i.e., $\alpha = 0$ and $\beta = 2$, Calka and Yukich (2016) obtained precise expectation and variance asymptotics for the intrinsic volumes and face numbers of K_λ. Moreover, they proved that the scaling limit of its boundary converges to a festoon of parabolic surfaces.
The present talk has two main purposes. First, we generalize the expectation and variance asymptotics from the Gaussian setting to our huge class of underlying densities. Secondly, we show that the scaling limit of ∂K_λ coincides with the above mentioned festoon for all parameter α and β in the underlying density. Thus, this festoon turns out to be a unique scaling limit for the boundary of our class of isotropic random polytopes.

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 2: Spatial statistics and random structures

Rudolf Grübel
Leibniz Universität Hannover

Tue, 14:00
HS Virologie

Binary trees and their limits

Combinatorial Markov chains are objects at the interface of Discrete Mathematics, Probability, and Theoretical Computer Science. Such processes $X = (X_n)_{n\in\mathbb{N}_0}$ are adapted to a combinatorial family $\mathbb{F}$ in the sense that X_n takes its values in the set of structures of size n. Discrete Potential theory, as initiated by Doob about 60 years ago, has been extremely useful as a tool for the asymptotic analysis of combinatorial Markov chains: It provides a natural compactification $\overline{\mathbb{F}}$ of $\mathbb{F}$ with the properties that X_n converges almost surely in $\overline{\mathbb{F}}$ as $n \to \infty$ and that the limit X_∞ generates the tail σ-field associated with X.
We will walk through the general ideas and then discuss specific results for two classical chains where $\mathbb{F}$ is the set of binary trees.

References:

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Partially joint work with: Steve Evans • Anton Wakolbinger

Felix Hermann
Albert-Ludwigs-Universität Freiburg

Tue, 14:50
HS Virologie

Branching processes with disasters and applications for duplication-based random graphs

We investigate a continuous-time branching process $(X_t)_{t\geq 0}$ underlying binomial disasters, which occur at times $\tau_1, \tau_2, \ldots$ of an independent unit-rate Poisson process. The disasters are such that $X_{\tau_k} \sim \mathcal{B}(X_{\tau_k-}, p)$ for some $p \in [0,1]$, $k = 1, 2, \ldots$ As a first result, we show a strong duality relation to a piecewise deterministic Markov processes. This enables us to apply limit theorems for Poisson processes (such as large deviations) to compute asymptotics of extinction probabilities for $(X_t)_{t\geq 0}$. As an application, we give a connection to the degree distributions of a class of duplication-based graph-valued processes with edge-deletion and the asymptotic size of its connected component.

Joint work with: Peter Pfaffelhuber

Christian Hirsch
LMU Munich

Tue, 15:15
HS Virologie

Graph-based Pólya urns on countable networks

We examine the behavior of a class of reinforcement models on countably infinite graphs. The strengths of the edges evolve according to a stochastic process subject to the following dynamics. First, vertices fire at times given by a Poisson point process. Second, if a vertex fires at a point in time, then one of the adjacent edges is selected with a probability that is proportional to the current strength to a power $\alpha > 1$. Third, the weight of the selected edge is then increased by 1. In particular, this model is an extension of the recently introduced graph-based Pólya urns from finite to countable graphs.
We analyze the connectivity structure of the family of edges used a positive proportion of time. For very large α this family decomposes into trees of diameter at most 3 if the underlying graph is a lattice,

a random geometric graph or a suitable Galton–Watson tree. On the other hand, on the integers, there can be connected components of arbitrarily large size if α is close to 1.

Joint work with: Mark Holmes • Victor Kleptsyn

Stephan Huckemann
Universtät Göttingen

Tue, 17:55
HS Virologie

Backward nested subspace inference and applications to stem cell differentiaton

More than half a century ago, Anderson (1963) derived asymptotics for principal component analysis (PCA), which have been extended by Watson (1983) and Ruymgaart and Yang (1997).
For data on manifold or stratified spaces (in computer vision and pattern recognition, say), various generalizations of PCA have been developed, and since Pythagoras Theorem is no longer true, they often come in form of nested subspaces.
For such, we derive asymptotics, and this involves controlling nested randomness. Under rather general conditions, asymptotic strong consistency holds. Under additional, still rather general hypotheses, among them existence of a.s. local twice differentiable charts, asymptotic joint normality can be shown. If charts factor suitably, this leads to individual asymptotic normality for the last element, a principal nested mean or a principal nested geodesic, say.
It turns out that all these results pertain to principal nested spheres (PNS) and principal nested great subspheres (PNGS) analysis by Jung et al. (2012). For illustration, a nested bootstrap two-sample test derived is applied to PNGS to track early human mesenchymal stem cell differentiation over a coarse time grid and, among others, to locate a change point with direct consequences for the design of further studies.

References:

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Joint work with: Benjamin Eltzner

Benedikt Jahnel
Weierstrass Institute Berlin

Wed, 17:20
HS Virologie

Continuum percolation for Cox point processes

We investigate continuum percolation for Cox point processes, that is, Poisson point processes driven by random intensity measures. First, we derive sufficient conditions for the existence of non-trivial sub- and super-critical percolation regimes based on the notion of stabilization. Second, we give asymptotic expressions for the percolation probability in large connection radius, large density and coupled regimes. In some regimes, we find universality, whereas in others, a sensitive dependence on the underlying random intensity measure survives.

Joint work with: Christian Hirsch • Elie Calie

Zakhar Kabluchko
WWU Münster

Wed, 11:10
HS Virologie

Absorption probabilities for Gaussian polytopes and angles of regular simplices

The Gaussian polytope is defined as the convex hull of n independent standard Gaussian random points in the d-dimensional Euclidean space. We compute explicitly the probability that the Gaussian polytope contains a fixed point at distance R from the origin. This and many other quantities related to Gaussian to polytopes are connected to volumes of regular spherical simplices. We review results on such volumes and formulae for inner and outer angles of regular simplices.

Joint work with: Dmitry Zaporozhets

Jürgen Kampf
Ulm university

Wed, 18:10
HS Virologie

Variances of estimators based on pixel configuration counts

In this talk we discuss the (approximate) computation of the surface area of a set $K \subseteq \mathbb{R}^d$ which is only observed through a pixel image. A popular approach is to count the number of occurrences of certain patterns, so-called pixel configurations, in the pixel image and then to approximate the surface area by a weighted sum of these counts.
Ziegel and Kiderlen (2010) investigate the estimation of the surface area in $\mathbb{R}^3$ in the design-based setting, i.e. when the set K is shifted at random. They determine weights such that for no set K the asymptotic bias is more than 4% of the correct surface area, where they study the asymptotics as the grid size t of the pixel lattice tends to zero. However, the bias is only one component of the estimation error. The other component, the variance, has not been considered so far.
In this talk we will show that under the model assumptions of (Ziegel and Kiderlen, 2010) the variance tends to zero of order t^2. So it is asymptotically neglectable compared to the bias.
The method of our proof is to derive upper and lower bounds for the pixel configuration counts. These upper and lower bounds will be invariant under shifts of the set K and they will be close to each other. Therefore we can conclude that the variance of the pixel configuration counts and thus the variance of estimators based on them must be small.
A simulation study shows that the theoretical derived order is optimal in general, but that it can be improved e.g. when K is a ball.

References:

[1] J. Ziegel, M. Kiderlen (2010). Estimation of surface area and surface area measure of three-dimensional sets from digitizations. Image Vision and Computing 28, 64–77.

Claudia Klüppelberg
Technical University of Munich

Tue, 17:30
HS Virologie

Bayesian networks based on max-linear structural equations

We study Bayesian networks based on max-linear structural equations as introduced in [1] and provide a summary of their independence properties. In particular we emphasize that distributions for such networks are never faithful to the independence model determined by their associated directed acyclic graph unless the latter is a polytree, in which case they are always faithful. In addition, we consider some of the basic issues of estimation and discuss generalised maximum likelihood estimation of the coefficients. Finally we argue that the structure of a minimal network asymptotically can be identified completely from observational data.

References:

[1] Gissibl, N. and Klüppelberg, C. (2015) Max-linear models on directed acyclic graphs. Bernoulli, forthcoming.

[2] Lauritzen, S. and Klüppelberg, C. (2017) Bayesian networks for max-linear models. Submitted.

Joint work with: Nadine Gissibl • Steffen Lauritzen

Günter Last
Karlsruher Institut für Technologie, Institut für Stochastik

Wed, 14:00
HS Virologie

Concentration inequalities for measures of a Boolean model

We consider a Boolean model Z driven by a Poisson particle process on a metric space equipped with a measure ϱ. We assume that ϱ satisfies a certain integrability assumption with respect to the intensity measure of the Poisson process. Due to the interaction of overlapping particles, the distribution of $\varrho(Z)$ cannot be described explicitly.
In this talk we derive concentration inequalities for $\varrho(Z)$. To this end we first prove two concentration inequalities for functions of a Poisson process on a general phase space.

Joint work with: Fabian Gieringer

Wolfgang Löhr
TU Chemnitz

Tue, 14:25
HS Virologie

Diffusion limit of the Aldous chain on cladograms in a new state space of algebraic measure trees

The Aldous chain on N-cladograms is a simple, mixing Markov chain on the set of binary trees with N labelled leaves. It has the uniform distribution as reversible measure, and its mathematical analysis was initiated by Aldous. He and Schweinsberg showed in [1] and [2] that its relaxation time is of order N^2. Aldous conjectured in a Fields Institute talk 1999, and does so on his open problems page, that there is an $N \to \infty$ limit diffusion "on some space of continuum trees". Despite several attempts, however, constructing this limit diffusion in a space of metric (measure) trees ($\mathbb{R}$-trees) has failed since then. Therefore, we propose to change the state space and instead of considering the graph distance, to focus on the *tree-structure* alone.
We present a new framework for a space of such (continuum) trees possessing no metric structure. We call them *algebraic trees*, because we formalize the tree-structure by a tertiary operation, namely the branch point map. We construct a natural topology on a space of (sufficiently nice) algebraic measure trees, which is closely related to convergence of triangulations of the circle. In this state space, we are able to prove convergence of the Aldous chain on N-cladograms to a limit with continuous paths.

References:

[1] D. Aldous (2000). Mixing time for a Markov chain on cladograms. *Combin. Probab. Comput.* 9, 191–204

[2] J. Schweinsberg (2002). An $O(n^2)$ bound for the relaxation time of a Markov chain on cladograms, *Random Struct. Algorithms* 20(1), 59–70

Joint work with: Anita Winter • Leonid Mytnik

Dominic Schuhmacher

Tue, 12:05
HS Virologie

Convergence rates for geostatistical thinning of point processes based on Gaussian random fields

In a random thinning of a point process Ξ on $\mathbb{R}^d$, survival or extinction is decided by tossing (possibly asymmetric and dependent) coins for each point. It is often convenient to model a thinning by a $[0,1]$-valued random field π of survival probabilities on $\mathbb{R}^d$ and to assume that, given Ξ and π, a point at x survives with probability $\pi(x)$ independently of any other survivals.
It is well known that, under an abstract stability condition, an increasingly dense process thinned by an asymptotically vanishing random field converges in distribution towards a Cox or even Poisson process. In this talk we consider the stationary situation and assume that π can be expressed as a [0,1]-valued function of a Gaussian random field that is independent of Ξ. We present rates in Wasserstein distance for approximation of the thinning by a Poisson process, which depend in an explicit way on the decay of the correlation function of the Gaussian random field, its regularity at 0, and the orderliness and the β-mixing behaviour of the point process Ξ. We use various tools from Stein's method for the proof.

Joint work with: Oskar Hallmann

Matthias Schulte
University of Bern

Wed, 14:25
HS Virologie

Multivariate normal approximation of Poisson functionals

The aim of this talk is to compare a vector F of random variables depending on a Poisson process with a Gaussian random vector N. Quantitative bounds for the distance between F and N in several probability metrics are presented. These so-called second order Poincare inequalities involve only the first two difference operators of the components of F. Two of the considered probability metrics are defined in terms of non-smooth test functions and are multivariate generalizations of the univariate Kolmogorov distance. The proofs of the second order Poincare inequalities rely on Malliavin calculus and Stein's method. As applications, multivariate quantitative central limit theorems for problems from stochastic geometry are considered.

Joint work with: Joseph E. Yukich

Hauke Seidel
Universitaet Muenster

Wed, 10:45
HS Virologie

Convex Cones Spanned by Regular Polytopes, and Probabilistic Applications

Let P be an n-dimensional regular crosspolytope, simplex, or cube centred at the origin of $\mathbb{R}^n$.
We consider convex cones of the form

$$C = \{\lambda x + \lambda e_{n+1} : \lambda \geq 0, x \in P\} \subset \mathbb{R}^{n+1},$$

where $e_1, \dots, e_{n+1}$ is the standard basis of $\mathbb{R}^{n+1}$.
We shall derive explicit probabilistic expressions for the inner and outer solid angles of these cones.
As a corollary, we shall derive a formula for the inner and outer solid angles of a regular crosspolytope.
Also, we shall compute the probability that a random linear subspace intersects a fixed face of a regular crosspolytope, cube or simplex.
If time permits, we shall explain how these cones are an important tool in determining the absorption probability of the symmetric Gaussian polytope $\mathcal{P}_{n,d}$, that is the probability that a deterministic point $x \in \mathbb{R}^d$ is contained in the convex hull of n independent standard normally distributed points $X_1, \dots, X_n$ in $\mathbb{R}^d$ together with their negatives $-X_1, \dots, -X_n$.

Joint work with: Zakhar Kabluchko • Dmitry Zaporozhets

Evgenii Sovetkin
RWTH Aachen

Tue, 11:15
HS Virologie

Local averages tests for random fields

This work is motivated by an application in the electroluminescence (EL) image analysis of photovoltaics (PV) modules. The EL image technique is a useful tool for investigating the state of a PV module and allows a researcher to look inside a module and analyse the crystalline structure at high resolution. However, there is a lack of statistical methods to employ the information provided by EL images in the analysis of large PV systems.
In our work we aim to construct detectors of defects that might be present in PV modules. To do so we consider a greyscale EL image as a random field with a 2-dimensional domain and construct several statistical tests based on the supremum of the spatial linear statistic evaluated on a random field. Functional limit theorems under the null and alternative hypotheses are showed. Asymptotic distributions for the spatial test statistics are obtained under several weak assumptions on the random field.
Lastly, we present simulation studies under the null and alternative hypotheses and compare power of the considered tests.

Joint work with: Ansgar Matthias Steland

Ansgar Matthias Steland
RWTH Aachen

Tue, 11:40
HS Virologie

Extreme Value Asymptotics for Moving Local Means in Random Fields

We study Gumbel type extreme value asymptotics for moving local averages of random fields which may be non-Gaussian and weakly dependent. The local averages are parameterized by a bandwidth parameter, which may depend on n. It turns out that a proof can be based on a generalization of classical results due to Bermann and Deo, which provide extreme value asymptotics for a large class of stationary and non-stationary Gaussian sequences, and strong approximations for i.i.d. and weakly dependent random fields. The results are of particular importance for the statistical analysis of imaging data.

Daniel Temesvari
Ruhr-Universität Bochum

Wed, 16:55
HS Virologie

Convex Hulls of Poission Point Processes, Random Cones and Random Points on Half-Spheres

Let $U_1, U_2, \ldots$ be random points sampled uniformly and independently from the d-dimensional upper half-sphere. We show that, as $n \to \infty$, the f-vector of the spherical convex hull of $U_1, \ldots, U_n$ weakly converges to a certain limiting random vector, without any normalization. We also show convergence of the expected f-vector and identify the limiting constants. More generally, the $(d+1)$-dimensional convex cone generated by $U_1, \ldots, U_n$ weakly converges, after a suitable rescaling, to a certain random convex cone. The intersection of this cone with the tangent hyperplane of the half-sphere at its north pole is the convex hull of the Poisson point process whose intensity measure has a power-law density function proportional to $\|x\|^{-(d+\gamma)}$ with $\gamma = 1$. We compute the expected number of facets, the expected intrinsic volumes and the expected T-functional of this random convex hull for arbitrary $\gamma > 0$.

Joint work with: Christoph Thäle • Zakhar Kabluchko • Alexander Marynych

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Nicola Turchi
Ruhr-Universität Bochum

Wed, 12:00
HS Virologie

Limit theorems for random polytopes with vertices on convex surfaces

The random polytope K_n, defined as the convex hull of n points chosen uniformly at random on the boundary of a smooth convex body, is considered. Proofs for lower and upper variance bounds, strong laws of large numbers and central limit theorems for the intrinsic volumes of K_n are presented. A normal approximation bound from Stein's method and estimates for surface bodies are among the tools involved.

References:

[1] I. Bárány, F. Fodor, V. Vígh (2010). Intrinsic volumes of inscribed random polytopes in smooth convex bodies. *Adv. in Appl. Probab.*, 42(3), 605–619.
[2] K.J. Bőrőczky, F. Fodor, D. Hug, (2013). Intrinsic volumes of random polytopes with vertices on the boundary of a convex body. *Trans. Am. Math. Soc.*, 365(2), 785–809.
[3] R. Lachièze-Rey, G. Peccati (2017). New Berry-Esseen bounds for functionals of binomial point processes. *Ann. Appl. Probab.*, 27(4), 1992–2031.
[4] R. Lachièze-Rey, M. Schulte, J. Yukich (2017). Normal approximation for sums of stabilizing functionals. arXiv:1702.00726
[5] M. Reitzner (2002). Random points on the boundary of smooth convex bodies. *Trans. Amer. Math. Soc.*, 354(6), 2243–2278.
[6] M. Reitzner (2003). Random polytopes and the Efron-Stein jackknife inequality. *Ann. Probab.*, 31(4), 2136–2166.
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[8] R. M. Richardson, V. H. Vu, L. Wu (2008). An inscribing model for random polytopes. *Discrete Comput. Geom.*, 39(1-3), 469–499.
[9] C. Schutt, E. Werner (2003). Polytopes with vertices chosen randomly from the boundary of a convex body. *Geometric aspects of functional analysis. Lecture Notes in Math.*, 1807, 241–422. Springer, Berlin.
[10] C. Thäle (2017+). Central limit theorem for the volume of random polytopes with vertices on the boundary. to appear in *Discrete Comput. Geom.*, 1–11, https://doi.org/10.1007/s00454-017-9862-2.
[11] C. Thäle, N. Turchi, F. Wespi (2017+). Random polytopes: central limit theorems for intrinsic volumes. to appear in *Proceedings of the American Mathematical Society.*, arXiv:1702.01069
[12] V. H. Vu (2005). Sharp concentration of random polytopes. *Geom. Funct. Anal.*, 15(6), 284–1318.

Joint work with: Florian Wespi

Johannes Wieditz
Georg-August-Universität Göttingen

Wed, 17:45
HS Virologie

An algorithm for computing Fréchet means on the sphere

For most optimisation methods an essential assumption is the vector space structure of the feasible set. This condition is not fulfilled if we consider optimisation problems over the sphere. We present an algorithm for solving a special global problem over the sphere, namely the determination of Fréchet-p-means, which are points minimising the mean distance to the p-th power to a given sample of points. The derived method needs no further assumptions on the input data or the objective function. It finds every global minimiser within a predefined accuracy, in particular in cases where classical methods fail.

Joint work with: Thomas Hotz • Gabriele Eichfelder

13th German Probability and Statistics Days
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Section 3: Limit theorems, large deviations and extremes

Section 3: Limit theorems, large deviations and extremes

Louis-Pierre Arguin
City University of New York

Fri, 10:30
HS Anatomie

The maxima of the Riemann zeta function in a short interval of the critical line

A conjecture of Fyodorov, Hiary & Keating states that the maxima of the modulus of the Riemann zeta function on an interval of the critical line behave similarly to the maxima of a log-correlated process. In this talk, we will discuss a proof of this conjecture to leading order, unconditionally on the Riemann Hypothesis. We will highlight the connections between the number theory problem and the probabilistic models including the branching random walk. We will also discuss the relations with the freezing transition for this problem. This is joint work with D. Belius (Zurich), P. Bourgade (NYU), M. Radizwill (McGill), and K. Soundararajan (Stanford).

Merdan Artykov
TU Dortmund

Wed, 17:45
HS Physiologie

Limit theorems for random walks on noncompact Grassmannians with growing dimensions

We study some central limit theorems for invariant random walks on non-compact Grassmannian $SU(p,q)/S(U(p)\times U(q))$ over the fileds $\mathbb{R},\mathbb{C}$, and the quaternions $\mathbb{H}$ with rank q and dimension parameter p. For $p > q$ these random walks can be identified can be identified with some Markov processes $(S_n^p)_{n\geq 0}$ on the Weyl chambers

$$C_q := \{x = (x_1, \dots, x_q) \in \mathbb{R}^q : x_1 \geq \cdots \geq x_q \geq 0\}.$$

These Markov processes appear also in the context of certain Calogero–Moser–Sutherland particle models systems living on C_q. These models also have interpretations in the theory of random matrices and associated diffusions are projections of Brownian motions on the symmetric spaces G/K with rank q where K is compact subgroup of Lie group G.
We present CLT's for fixed parameter p for $n \to \infty$ as well as CLT's for $n, p \to \infty$ coupled in a certain way. The proofs are based on spherical Fourier analysis and associated spherical characteristic functions are given by the Hekman–Opdam hypergeometric functions.

References:

[1] O. Chybiryakov, N. Demni, L. Gallardo, M. Rösler, M. Voit, M. Yor (2008), textitHarmonic and Stochastic Analysis of Dunkl Processes. Travaux en Cours Mathematiques, 226 pp., Eds. P. Graczyk et al., Hermann.
[2] Grundmann W (2013). Limit Theorems on Hypergroups. Dissertation, TU Dortmund.
[3] Voit M (2013). Central limit theorems for hyperbolic spaces and Jacobi processes on $[0,\infty[$. *Monatsh. Math.* 169, 441–468.
[4] Voit M (2016) . Dispersion and Limit Theorems for Random Walks Associated with Hypergeometric Functions of Type BC. *J. Theoret. Probab.* 1–40.

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 3: Limit theorems, large deviations and extremes

Carina Betken

Fri, 09:00
HS Physiologie

Fluctuations in the preferential attachment model

We look at the indegree of a uniformly chosen vertex in a preferential attachment random graph, where the probability that a newly arriving vertex n connects to an older vertex i is proportional to a sublinear function f of the indegree of vertex i at that time. We provide rates of convergence for the total variation distance between this degree distribution and an asymptotic power-law distribution, which is derived in [1], as the number of vertices tends to ∞. For f such that $k < f(k) \leq k + 1$ we develop Stein's method for the given asymptotic degree distribution, whereas for $f(k) \sim k^{\alpha}$, with $\alpha \in (0, 1)$, we use a coupling of a discrete- and a continuous-time Markov process.

References:

[1] S.Dereich, P.Mörters (2009). Random networks with sublinear preferential attachment: Degree evolutions. *Electron. J. Probab.*, 43, 1222–1267

Joint work with: Hanna Döring • Marcel Ortgiese

Dirk-Philip Brandes
University Ulm

Tue, 11:15
HS Physiologie

On the sample autocovariance of a Lévy driven continuous time moving average process sampled at a renewal sequence

We consider a Lévy driven continuous time moving average process X sampled at random times which follow a renewal structure independent of X. Asymptotic normality of the sample mean, the sample autocovariance, and the sample autocorrelation is established under certain conditions on the kernel and the random times. We compare our results to a classic non-random equidistant sampling method as done in [1] and give an application to parameter estimation of the generalized Ornstein–Uhlenbeck process.

References:

[1] S. Cohen, A. Lindner (2013). A central limit theorem for the sample autocorrelations of a Lévy driven continuous time moving average process. *J. Stat. Plan. Inference* **143**, 1295–1306.

Joint work with: Imma Valentina Curato

Gauthier Bruno Dierickx
University of Luxembourg

Tue, 14:25
HS Physiologie

On a generalized Darling–Erdős theorem

Let X_i, $i \geq 1$ be centered i.i.d. random vectors with a finite $2+\delta$, $\delta > 0$ moment and covariance matrix the identity matrix. Denote the partial sums by $S_k := \sum_{i=1}^{k} X_i$, $k \geq 1$. It was proven by Horváth that there exists two sequences a_n, b_n, $n \geq 1$ such that

$$a_n \max_{k=1}^{n} \frac{|S_k|}{\sqrt{k}} - b_n \to Y, \quad \text{as } n \to \infty$$

where Y has the extreme value distribution $F_Y(x) := \exp(-e^{-x})$, $x \in \mathbb{R}$.
The above theorem was first established for random variables, with a uniformly bounded absolute third moment by Darling and Erdős in [1].
Using a new strong approximation we provide an improved version of the Darling–Erdős for centered i.i.d. random variables having only a finite second moment. We then extend the generalized Darling–Erdoős theorem to the multivariate case. Furthermore, following Einmahl, we show that under an additional assumption one obtains the usual Darling–Erdős theorem back.

References:

[1] Darling, D. A. and Erdős, P. (1956). A limit theorem for the maximum of normalized sums of independent random variables. *Duke Math. J.* **23** 143–155.
[2] Einmahl, U. (1989). The Darling–Erdős theorem for sums of i.i.d. random variables. *Probab. Th. Rel. Fields.* **82**, 241–257.
[3] Horváth, L. (1994). Likelihood method for testing changes in the parameters of normal observations. *Ann. Stat.* **21**, 671–680.

Joint work with: Uwe Einmahl

Marie-Christine Düker
Ruhr-Universität Bochum

Wed, 16:55
HS Physiologie

Limit theorems for multivariate long-range dependent processes

Over the last thirty years, long-range dependent stochastic processes become an important instrument for modeling phenomena in econometrics, engineering and hydrology to mention some examples. Moreover, the analysis of high-dimensional time series gets more attention.
This talk deals with the study of different types of limit theorems under the assumption of multivariate long-range dependence. It includes the behavior of partial sums of multivariate linear processes, subordinated Gaussian processes and the sample autocovariances.
A suitable matrix-valued normalization sequence under the assumption of multivariate LRD, which could be of particular interest for further results in this context, is investigated.

References:

[1] Dueker, M.: Limit theorems for multivariate long-range dependent processes. arxiv:1704.08609

Hendrik Flasche
WWU Münster

Wed, 15:15
HS Physiologie

Expected number of real zeroes of random Taylor series

Let $\xi_0, \xi_1, \ldots$ be i.i.d. random variables with zero mean and unit variance. Consider a random Taylor series of the form

$$f(z) = \sum_{k=0}^{\infty} \xi_k c_k z^k,$$

where $c_0, c_1, \ldots$ is a real sequence such that c_n^2 is regularly varying with index $\gamma - 1$, where $\gamma > 0$. We prove that

$$\mathbb{E}N[0, 1-\varepsilon] \sim \frac{\sqrt{\gamma}}{2\pi} |\log \varepsilon|,$$

as $\varepsilon \downarrow 0$, where $N[0, r]$ denotes the number of real zeroes of f in the interval $[0, r]$. If time permits, we also present a limit theorem on the expected number of real zeroes of random trigonometric polynomials.

References:

[1] H. Flasche (2017). Expected number of real roots of random trigonometric polynomials. Stoch. Proc. Appl., 127(12), pp. 3928–3942.
[2] H. Flasche and Z. Kabluchko (2017). Expected number of real zeros of random Taylor series. Preprint at arXiv:1709.02937.

Joint work with: Zakhar Kabluchko

13th German Probability and Statistics Days
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Section 3: Limit theorems, large deviations and extremes

Davide Giraudo

Tue, 15:15
HS Physiologie

A deviation inequality for martingales and some applications

Let $(S_n, \mathcal{F}_n)_{n\geqslant 1}$ be a real valued martingale and let $X_i := S_i - S_{i-1}$, $X_1 = S_1$ denote its increments. We are interested in the control of the function

$$P_n \colon x \mapsto \mathbb{P}\left(\left\{\max_{1\leqslant i\leqslant n} |S_i|\right\} > x\right).$$

Nagaev (2003) showed that it is possible to bound P_n by using the functions $I_n \colon x \mapsto \mathbb{P}\big(\{\max_{1\leqslant i\leqslant n}|X_i|\} > x\big)$ and $C_n \colon x \mapsto \mathbb{P}\left(\left\{\sum_{i=1}^n \mathbb{E}\left[X_i^2 \mid \mathcal{F}_{i-1}\right]\right\} > x\right)$ (with $\mathcal{F}_0 = \{\emptyset, \Omega\}$). This requires square integrability of each X_i.
We shall present an extension in two directions of his work. We shall treat the case where $X_i \in \mathbb{L}^p$ for $1 < p < 2$ as well as the Banach space valued case.
This inequality can be applied for in linear regression models. Moreover, when the vector $(X_i)_{i\geqslant 1}$ is identically distributed as well as $\left(\mathbb{E}\left[X_i^2 \mid \mathcal{F}_{i-1}\right]\right)_{i\geqslant 1}$, we can formulate estimates of large and moderated deviations for the maximum of partial sums and gives rates in the law of large numbers.
The presented results come from the paper https://arxiv.org/abs/1603.00432.

Matthias Glock
TU Ilmenau

Wed, 16:30
HS Physiologie

A new proof of Pinelis and Sakhanenko's Bennett-type inequality for vectors

We consider the following Bennett-type inequality for random vectors based on [1] by I. Pinelis and A. I. Sakhanenko: given independent random variables $X_1, \dots, X_n$ taking values in $\mathbb{R}^d$ with $\mathrm{E}\, X_i = 0$ and $\|X_i\| \leq b$ a.s., we have with $S_n = X_1 + \cdots + X_n$ and $s^2 = \sum_{i=1}^n \mathrm{E}\,\|X_i\|^2$ for $t > 0$

$$\mathrm{P}(\|S_n\| \geq t) \leq 2\,\exp\Big(-\tfrac{s^2}{b^2}\phi\big(\tfrac{tb}{s^2}\big)\Big), \tag{1}$$

with $\phi(x) = (1+x)\ln(1+x) - x$ for $x \geq 0$. The proof uses an elaborate estimation of the term $2\,\mathrm{E}\cosh(h\|S_n\|)$ in order to control the moment generating function of $\|S_n\|$.
Here we present a new proof for this useful inequality based on the matrix concentration inequalities by J. Tropp, as developed in [2, 3]. These can be employed here by using a suitable linear embedding of a vector $X \in \mathbb{R}^d$ into a symmetric matrix, e.g. a result in [2] leads to

$$\mathrm{P}(\|S_n\| \geq t) \leq (d+1)\,\exp\Big(-\tfrac{s^2}{b^2}\phi\big(\tfrac{tb}{s^2}\big)\Big).$$

Using ideas from [3] this can be further enhanced by using more sophisticated techniques relying on the so called intrinsic dimension of a (p.s.d.) matrix, which eventually leads to a new interesting proof of (1), demonstrating the versatility of the matrix approach by J. Tropp.

References:

[1] I. Pinelis, A. I. Sakhanenko (1986). Remarks on Inequalities for Large Deviation Probabilities. *Theory of Probability & Its Applications* 30(1), 143–148
[2] J. A. Tropp (2012). User-Friendly Tail Bounds for Sums of Random Matrices. *Foundations of Computational Mathematics* 12(4), 389–434
[3] J. A. Tropp (2015). An Introduction to Matrix Concentration Inequalities. *Found. Trends Mach. Learn.* 8(1–2), 1–230

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Section 3: Limit theorems, large deviations and extremes

Katharina Hees

Tue, 14:50
HS Physiologie

Extremes of observations with heavy-tailed inter-arrival times

Classical Extreme Value theory deals with the extreme values of observations of idd random variables $X_1, X_2, \ldots$ and admits that these events occur at intervals of fixed time length or with exponentially distributed inter-arrival times. Recently a new model called Continuous Time Random Maxima, also called max-renewal process or shock process, has been introduced. This model generalizes the temporal dynamics of extreme value theory by assuming random waiting times between observations. If the waiting times are heavy-tailed, this theory provides a model for bursty events.
In this talk we consider such a model in the case where the jumps and waiting times are independent, as well as the case where a jumps depend on the preceding or subsequent waiting time. It is a well-known result in extreme value theory that the partial maxima process converges in the Skorokhod J_1 topology to an extremal process. In the case of infinite mean waiting times, the process which tracks the maximum converges to an extremal process as well, but time-changed with an inverse stable subordinator. We will also have a look at the exceedance time, which is the time until one observes for the first time an event whose magnitude is larger than a threshold l. In the classical case these exceedance times are asymptotically Generalized Pareto distributed. We will see, that in the case of heavy-tailed waiting times the asymptotic distribution has a Mittag–Leffler distribution.

References:

[1] K. Hees, H. P. Scheffler (2017). On Joint SUM/MAX Stability and SUM/MAX Domains of Attraction. *Probability and Mathematical Statistics* To appear
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[3] M. Meerschaert, A. S. Stoev. (2007). Extremal limit theorems for observations separated by random waiting times .*Journal of Statistical Planning and Inference* 139(7), 2175–2188

Joint work with: Peter Scheffler • Peter Straka

Lothar Heinrich

Thu, 15:15
HS Physiologie

On Bernstein's blocking method for strongly mixing spatial processes

We consider a stationary spatial process $X(\cdot)$ defined on the bounded Borel sets of $\mathbb{R}^d$ and satisfying $X(A \cup B) = X(A) + X(B)$ for $A \cap B = \emptyset$. Examples of such processes are point processes, Hausdorff measures supported by random closed sets etc. In order to prove asymptotic normality of $X(W_n)$, where $\{W_n\}$ is an unboundedly increasing sequence of convex sets in $\mathbb{R}^d$, we impose a condition of weak dependence on $X(\cdot)$ formulated in terms of the α-mixing coefficient $\alpha(\mathcal{F}_1, \mathcal{F}_2) := \sup\{\big|\,\mathbf{P}(U \cap V) - \mathbf{P}(U)\,\mathbf{P}(V)\,\big| : U \in \mathcal{F}_1, V \in \mathcal{F}_2\}$.
To quantify the dependence between $X(C_a)$ and $X(\mathbb{R}^d \setminus C_{a+r})$, where $C_b = [-b, b]^d$, we assume that there exist non-increasing functions
$\alpha_X^*,\ \alpha_X^{**} : [\frac{1}{2}, \infty) \to [0, \infty)$ such that

$$\alpha\big(\mathcal{F}_X(C_a), \mathcal{F}_X(\mathbb{R}^d \setminus C_{a+r})\big) \le \begin{cases} \alpha_X^*(r) & \text{for} \quad \frac{1}{2} = a \le r\,, \\ a^{d-1}\,\alpha_X^{**}(r) & \text{for} \quad \frac{1}{2} \le r \le a\,, \end{cases}$$

where $\mathcal{F}_X(B)$ denotes the σ-algebra generated by $X(A)$ for bounded subsets $A \subseteq B$.
We prove a CLT for $X(W_n)$ (after centering with $\mathbf{E}X(W_n)$ and suitable scaling) if
$\exists\ \delta > 0$ such that $\mathbf{E}\big|X((0,1]^d)\big|^{2+\delta} < \infty$, $\sum_{n=1}^{\infty} n^{d-1}\big(\alpha_X^*(n)\big)^{\delta/(2+\delta)} < \infty$ and $n^{2d-1}\,\alpha_X^{**}(n) \underset{n\to\infty}{\longrightarrow} 0$.
The proof relies on Bernstein's blocking method which has to be adapted (in a non-trivial way) to the sequence $\{W_n\}$.

Jana Jureckova
Charles University, Prague

Tue, 14:00
HS Physiologie

Average Extreme Regression Quantile and its One-Step Version

In the linear regression model, we describe the averaged extreme regression quantile and its one-step version. The former is a solution of a specific linear programming problem, the latter one estimates separately the slope components of the model, using a specific (rank) R-estimator. Though seemingly quite different, we show that both versions coincide, what facilitates the analysis and applications of these characteristics. For a special class of light-tailed parent distributions, the R-estimator estimates the slope parameters consistently and the averaged extreme regression quantile is asymptotically equivalent to the extreme quantile of model errors, up to the standardization.

References:

[1] J. Jureckova (2007): Remark on extreme regression quantile. Sankhya 69, Part 1, 87–100.
[2] J. Jureckova (2016). Averaged extreme regression quantile. Extremes 19, 41–49.
[3] J. Jureckova (2017). Regression Quantiles and Averaged Regression Quantile Processes. In: Analytical Methods in Statistics (J. Antoch et al., Eds.). Springer Proceedings in Mathematics and Statistics, 193, 53–62.
[4] J. Jureckova, J. Picek (2014). Averaged regression quantiles. In: Contemporary Developments in Statistical Theory (S. Lahiri et al., Eds.). Springer Proceedings in Mathematics and Statistics, 68, 203–216.

Kevin Leckey
Technische Universität Dortmund

Fri, 09:25
HS Physiologie

A limit theorem for the ϱ-length of random functional graphs with fixed degree sequences

Pollard's ϱ-algorithm is a factorization method inspired by probabilistic ideas. Its running time is proportional to the ϱ-length of the functional graph of a polynomial mod p, where $N = pq$ is the number to factorize. The functional graph of $f : V \to V$ is a directed graph with vertex set V and edge set $\{(x, f(x)) : x \in V\}$, whereas the ϱ-length of a vertex v is the length of the shortest self-intersecting path starting at v.
In order to study the running time of his algorithm, Pollard made the (rather unrealistic) assumption that a polynomial mod p behaves like a permutation chosen uniformly at random. In this talk we discuss a different probabilistic model for functional graphs based on fixing the indegree sequence in advance. Such a model was already suggested by Martins and Panario, who studied the asymptotic behaviour of degree sequences in polynomials mod p.
We show that the rescaled ϱ-length in this model converges weakly to a Rayleigh distribution, provided some regularity conditions for the degree sequence hold. The scaling supports the conjecture that the 'typical' running time of Pollard's ϱ-algorithm is $O(N^{1/4})$.

Joint work with: Nicholas Wormald

David Lipshutz
Technion

Wed, 14:50
HS Physiologie

Exit time asymptotics for small noise stochastic delay differential equations

In this talk we consider a small noise stochastic delay differential equation (SDDE). We obtain asymptotic estimates, as the noise vanishes, on the time it takes a solution of the SDDE to exit a bounded domain that is attracted to a stable equilibrium point or periodic orbit of the corresponding deterministic delay differential equation. To obtain these asymptotics, we prove a sample path large deviation

principle (LDP) for the SDDE that is uniform over initial conditions in bounded sets. The proof of the uniform sample path LDP uses a variational representation for exponential functionals of strong solutions of the SDDE. We anticipate that the overall approach may be useful in proving uniform sample path LDPs for other in finite-dimensional small noise stochastic equations.

Mathias Mørck Ljungdahl
Aarhus University

Tue, 12:05
HS Physiologie

A Limit theorems for a class of moving average processes under multiple degeneracies

In a recently published article O'Connor et al., they proved a series of limit theorems for power variations of Lévy driven moving averages. The explosive behaviour at the degenaricy at 0 for the underlying kernel function plays a central role in the limit.
In this talk I will present an extension of one of the limit theorems in O'Connor et al. to case where the underlying kernel function may have degeneracies not at 0 but finitely many.

References:

[1] O'Connor, Andreas Basse, Lachieze-Rey, Raphael and Podolskij, Mark (2016). *Power variation for a class of stationary increments Levy driven moving averages*, *Annals of Probability*

Vitalii Makogin
Universität Ulm

Wed, 17:20
HS Physiologie

Limit theorems for volumes of excursion sets of anisotropic Gaussian random fields

Very often we need to investigate the behavior of area (or space) where extremes occur. In stochastic terms we model such objects by excursions sets. Let $\{X(t), t \in \mathbb{R}^d\}$ be a measurable random field and T be a Borel set of $\mathbb{R}^d$. Then for each level $u \in \mathbb{R}$, $A_u(X, T) = \mathbb{I}\{t \in T : X(t) \geq u\}$ is called the excursion set of X in T over the level u. In this talk we consider the volumes of the excursion sets, given by $\nu_d(A_u(X, T)) = \int_T \mathbb{I}\{X(t) \geq u\} d\nu_d(t) = \int_T \mathbb{I}\{X(t) \in [u, \infty)\} d\nu_d(t)$.
We consider asymptotic distribution of normalized volumes $\nu_d(A_u(X, W_n))$ as $n \to \infty$ in case when X is a subordinated Gaussian random field and $\{W_n, n \geq 0\}$ is some growing sequence of observation windows.
In the first part, we present the central limit theorems, i.e., when the limiting distribution is normal. More precisely, the main result of this part is formulated as follows.
Let $\{Y(t), t \in \mathbb{R}^d\}$ be a real valued centered Gaussian random field with $\mathbf{E}[Y(t)]^2 = 1$ and covariance function $\varrho(t, s) = \mathbf{Cov}(Y(t), Y(s))$, $t, s \in \mathbb{R}^d$. Let $\{X(t) = f(Y(t)), t \in \mathbb{R}^d\}$ be the corresponding subordinated field, where $f : \mathbb{R}^d \to \mathbb{R}$ is a Borel function with $\mathbf{E}Y(0)\mathbb{I}\{f(Y(0)) \geq u\} \neq 0$. Let $(W_n)_{n\in\mathbb{N}}$ be a sequence of Borel sets s.t. $\nu_d(W_n) \to \infty$, $n \to \infty$. If

$$\lim_{n\to\infty} \frac{\int_{W_n}\int_{W_n} \varrho^2(t, s) dtds}{\int_{W_n}\int_{W_n} \varrho(t, s) dtds} = 0$$

then for any $u \in \mathbb{R}$

$$\frac{\int_{W_n} \mathbb{I}\{X(t) \geq u\} dt - \nu_d(W_n)\mathbf{P}(X(0) \geq u)}{\mathbf{E}[Y(0)\mathbb{I}\{X(0) \geq u\}]\sqrt{\int_{W_n}\int_{W_n} \varrho(t, s) dtds}} \xrightarrow{d} N(0, 1), n \to \infty.$$

This result allows dealing with anisotropic fields and observation windows. In case of stationary positively associated random fields, we present simpler conditions when central limit theorem holds true. Particularly, we consider anisotropic fractional Gaussian noise $\{G^H(t), t \in \mathbb{R}^d\}$, $H = (H_1, \dots, H_d) \in (0, 1)^d$, which is centered Gaussian random field with covariance function

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$\mathbf{E}G^H(t)G^H(s) = C(t-s), t, s \in \mathbb{R}^d_+$, where

$$C(u) = \frac{1}{2^d}\prod_{i=1}^{d}\left(|u_i|^{2H_i} + |u_i+1|^{2H_i} - 2|u_i|^{2H_i}\right), t, u \in \mathbb{R}^d.$$

Fractional Gaussian noise has long memory, if $\max_{i=\overline{1,d}} H_i > 1/2$ and the main result works in this case. Some other examples are also considered.
In fact, the normal distribution is not unique for volumes of excursion sets. The second part of the talk is devoted to non-central limit theorems and the limiting random variables are written as multiple Wiener–Itô integrals. Their distributions are determined by Hermite expansions and limiting properties of spectral densities and we show that there are a variety of the cases. In particular, we have the special interest in the anisotropic case which was not considered before. Namely, let $\{X(t) = f(Y(t)), t \in \mathbb{R}^d\}$ be the corresponding subordinated Gaussian random field, where f is a Borel function on $\mathbb{R}^d$. Denote by m the Hermite rank of $G_u(x) := f(x)\mathbb{I}\{x \geq u\}$ for $u \in \mathbb{R}$. Suppose that Y has spectral density

$$g_A(z_1, \dots, z_d) = \prod_{l=1}^{d}\frac{L_l(z_l)}{|z_l|^{1-\gamma_l}}, z = (z_1, \dots, z_d) \in \mathbb{R}^d,$$

where $\gamma_l \in (0, 1/m), l = \overline{1,d}$ and $L_l, l = \overline{1,d}$ are slowly varying functions at 0. Let $W_n = \prod_{l=1}^{d}[0, r_{n,l}]$, $r_{n,l} \to \infty, l = \overline{1,d}$.
Then

$$\frac{1}{\sqrt{c_m}}\prod_{l=1}^{d}\frac{r_{n,l}^{\gamma_l m/2-1}}{L_l(r_{n,l}^{-1})}\left(\int_{W_n}\mathbb{I}\{X(t) \geq u\}\nu_d(dt) - \nu_d(W_n)\mathbf{P}(X(0) \geq u)\right)$$

$$\xrightarrow[n\to\infty]{d}\int_{\mathbb{R}^{dm}}{}'\prod_{l=1}^{d}\frac{1}{|y_{1,l}\cdots y_{m,l}|^{(1-\gamma_l)/2}}\frac{e^{i(y_{1,l}+\cdots+y_{m,l})}-1}{i(y_{1,l}+\cdots+y_{m,l})}\widetilde{W}(dy_1)\dots\widetilde{W}(dy_m).$$

References:

[1] Bulinski A., Spodarev E., Timmermann F. (2012). Central limit theorems for the excursion set volumes of weakly dependent random fields. Bernoulli 18.1, 100–118.
[2] Ivanov A. V., Leonenko N. N. (1989). Statistical analysis of random fields, Mathematics and its Applications (Soviet Series), vol. 28, Kluwer Academic Publishers Group, Dordrecht.
[3] Samorodnitsky G. (2016). Stochastic processes and long range dependence. Springer Series in Operations Research and Financial Engineering, Springer.

Noela Müller

Wed, 11:10
HS Physiologie

Central limit theorem analogues for multicolor urn models

A central limit theorem for the fine fluctuations of urn models under general assumptions on their replacement matrices and initial configurations is derived. The result is an extension of known central limit theorems for urn processes with irreducible, balanced replacement matrices whose second largest eigenvalue does not surpass a certain threshold to a reasonably greater class of urn models. Applications include the cyclic urn, the *m*ary search tree or the *B*-urn for large parameter values.

Ralph Neininger

Wed, 10:45
HS Physiologie

Bounds on the rates of convergence in Pólya urns

Based on a recent recursive description of the evolution of Pólya urn processes by M. Knape and the speaker new results on bounds for the rates of convergence for the composition of Pólya urns are presented. The urns under consideration are with two colors, balanced and irreducible. The rates of

convergence are bounded with respect to the Kolmogorov–Smirnov metric and the Wasserstein metrics for regimes with a non-normal limit distributions and with respect to a Zolotarev metric for regimes with a normal limit. Also the critical regimes at the change from normal to non-normal are covered. The bounds confirm a conjecture of Svante Janson from 2004.

Partially joint work with: M. Knape

Joint work with: Andrea Kuntschik

Tuan Anh Nguyen
AG Stochastic Analysis, Universität Duisburg-Essen

Tue, 17:30
HS Physiologie

A Liouville property for the random conductance model

The classical Liouville theorem states that if a (discrete, continuum) harmonic function (in the sense that it maps a simple random walk on $\mathbf{Z}^d$ or a standard Brownian motion on $\mathbf{R}^d$ to a martingale) has certain growth (for instance, sublinear, subquadratic etc.), it must be of a certain form (for instance, constant, linear function etc.). This is a beautiful result, not only in complex analysis and PDEs, but also in probability theory: see Lippner and Mangoubi (2014) for a very elegant probabilistic proof which has been found recently.
We are interested in investigating Liouville properties when the standard motions (simple random walks, standard Brownian motions) are replaced by random motions in random media.
Such questions on Liouville properties first appeared in the *probability community*. The zero-order Liouville property, which ensures the uniqueness of the sublinear corrector appearing in the proof of the quenched invariance principle was proved by
Benjamini, Duminil-Copin, Kozma, and Yadin (2015). In fact, they also prove the first order Liouville property: On a supercritical percolation cluster the space of harmonic functions (i.e. functions which map the simple random walk on supercritical percolation clusters to a martingale), which grow at most linearly $O(|x|)$, has dimension $d+1$, the same dimension as that in the euclidean case.
In contrast to their paper focussing on simple random walks on percolation clusters, I would like to study *random walks among random conductances* (jump rates proportional to conductances) on $\mathbf{Z}^d$ meaning all positive conductances live on $\mathbf{Z}^d$.
However, the model remains a challenge when the conductances are assumed to be *degenerate* in the sense that they are not assumed to be bounded from above and below by deterministic constants. Indeed, they are only assumed to be stationary and ergodic and satisfy a moment and inverse moment condition.
The main result is the following: the space of harmonic functions (those which map random walks among random conductances to martingales) with growth $O(|x|^{1+\alpha}), \alpha \in (0,1)$ has dimension $d+1$.
The strategy of the proof is to use the ideas given by Bella, Fehrman, and Otto who prove similar results on stochastic homogenization in the continuum setting.
To implement their idea in the discrete case we need to apply several analytic and numerical methods.

References:

[1] Lippner and Mangoubi (2014). *Harmonic functions on the lattice: Absolute monotonicity and propagation of smallness*. Duke Mathematical Journal. 164(13) 2577–2595
[2] Bella, Fehrman, and Otto (2016). *A Liouville theorem for elliptic systems with degenerate ergodic coefficients*. arXiv:1605.00687
[3] Benjamini, Duminil-Copin, Kozma, and Yadin (2015). *Disorder, entropy and harmonic functions*. Annals of Probability. 43(5), 2332–2373

Marco Oesting
Universität Siegen

Thu, 14:50
HS Physiologie

Efficient simulation of Brown-Resnick processes based on variance reduction of Gaussian processes

Brown–Resnick processes are max-stable processes that are associated to Gaussian processes. Their simulation is often based on the corresponding spectral representation which is not unique. We show that simulation accuracy and efficiency can be substantially improved by minimizing the maximal variance of the underlying Gaussian process. Such a minimization is a difficult mathematical problem that also depends on the geometry of the simulation domain. We extend Matheron's (1974) seminal contribution in two aspects: (i) making his description of a minimal maximal variance explicit for convex variograms on symmetric domains and (ii) proving that the same strategy reduces the maximal variance also for a huge class of non-convex variograms representable through a Bernstein function. A simulation study confirms that our non-costly modification can lead to substantial improvements and compete with state-of-the-art algorithms.

Joint work with: Kirstin Strokorb

Andre Pessik

Tue, 11:40
HS Physiologie

Limit Theorems for Bipower / Multipower Variations of stationary increments Lévy Driven Moving Averages

Lévy driven moving averages provide a unifying framework to some well-known processes such as the fractional Brownian motion and the Ornstein–Uhlenbeck process. They have infinitely divisible marginals, which results from the driving Lévy process, and depending on the chosen kernel function an arbitrary correlation structure.
This properties make the Lévy driven moving averages of relevance for stochastic volatility models, which often use limit theorems for power, bipower and multipower variations. Especially bipower and multipower variations provide tools to separate continuous components and jump components in the underlying models.
Based on the first order asymptotic results for power variations proven in [1] and [2] we derive limit theorems for bipower/multipower variations of Lévy driven moving averages, which heavily depends on the interplay between the given orders of the increments, the considered powers, the Blumenthal–Getoor index of the driving pure jump Lévy process and the behaviour of the kernel functions at 0. Furthermore in some of our results we are able to get hold of the convergence rates.

References:

[1] A. Basse-O'Connor, R. Lachièze-Rey and M. Podolskij (2016). Power variation for a class of stationary increments Lévy driven moving averages. *Annals of Probability*.
[2] A. Basse-O'Connor and M. Podolskij (2017). On critical cases in limit theory for stationary increments Lévy driven moving averages. *Stochastics* 89, 360–383.

Bero Roos
University of Trier

Wed, 12:00
HS Physiologie

On Bobkov's approximate de Finetti representation via new permanent approximation inequalities

We present new upper bounds for the distance between a properly normalized permanent of a rectangular complex matrix and the product of the arithmetic means of the entries of its columns. It turns out that the bounds improve on those from earlier work. Our proofs are based on some new identities for the above-mentioned differences and also for related expressions for matrices over a rational associative

commutative unital algebra. Some of our identities are generalizations of results in Dougall (1905). As an application, we discuss an improvement of results of Bobkov (2005) and Roos (2015) on an approximate de Finetti representation for probability measures, on product measurable spaces, which are symmetric under permutations of coordinates.

References:

[1] Bobkov, S. G. (2005). Generalized symmetric polynomials and an approximate de Finetti representation. Journal of Theoretical Probability, 18(2), 399–412.
[2] Dougall, J. (1905). Quantitative proofs of certain algebraic inequalities. Proceedings of the Edinburgh Mathematical Society, 24, 61–77.
[3] Roos, B. (2015). On Bobkov's approximate de Finetti representation via approximation of permanents of complex rectangular matrices. Proceedings of the American Mathematical Society, 143(4), 1785–1796.
[4] Roos, B. (2017). New permanent approximation inequalities via identities.Preprint, revised version, 28 pages, 2017 (arxiv.org/abs/1612.03702).

Holger Sambale
Bielefeld University

Wed, 14:25
HS Physiologie

Higher Order Concentration of Measure

We investigate the higher order concentration of measure phenomenon for functions typically centered at stochastic expansions of order $d-1$ with bounded d-th order derivatives or differences, where d is any natural number. The results yield uniform exponential bounds for $|f|^{2/d}$. In particular, we consider deviations of functions of independent random variables, differentiable functions on Euclidean spaces with LSI type measures, and functions on the unit sphere. We also discuss some applications of these bounds.

Joint work with: S. Bobkov • Friedrich Götze

Helge Schäfer
Technische Universität Darmstadt

Wed, 11:35
HS Physiologie

The cycle structure of random permutations without macroscopic cycles

We consider uniform random permutations conditioned to have no macroscopic cycles and study the asymptotic behaviour of the cycle structure. We show that the small cycles exhibit classical behaviour, whereas long cycles are strongly influenced by the concrete choice of constraint. We also show that the process of cumulative cycle numbers not exceeding a given length has a limit shape on a suitable scale and that the fluctuations about this limit shape obey a functional limit theorem, the limit being a Brownian bridge measure.

Joint work with: Volker Betz • D. Zeindler

András József Tóbiás
Technische Universität Berlin

Thu, 14:25
HS Physiologie

Asymptotic routing properties in a Gibbsian model for highly dense multihop networks

We investigate a probabilistic model for routing in a multihop ad-hoc communication network, where each user sends a message to the single base station. Messages travel in hops via the other users, used as relays. Their trajectories are chosen at random according to a Gibbs distribution that favours low total interference in the system, measured in terms of the sum of the signal-to-interference ratios for all the hops. This model was introduced in our earlier paper 1, where we expressed, in the high-density

limit, using large-deviation theory, the distribution of the optimal trajectories as the minimizer of a characteristic variational formula.
In our current work that I will present, we derive qualitative properties of this minimizer, like the typical number of hops and the typical length of a hop, and the deviation from the straight line. We do this in two extreme regimes: (i) in the limit of a large communication area and large distances, and (ii) in the limit of a strong interference punishment. In both regimes, we encounter and quantify emerging typical pictures in analytic terms. Indeed, the typical trajectory turns out to quickly approach a straight line in both regimes, and in regime (i) we also show that the hops become equally-sized. Additionally and surprisingly, in regime (i), we observe that the typical length of a hop diverges in a logarithmical fashion as the distance of the transmitter to the base station diverges.

References:

[1] W. König, A. Tóbiás (2017). A Gibbsian model for message routing in highly dense multihop networks. arXiv:1704.03499.

Joint work with: Wolfgang König

Dominik Tomecki
Ruhr Universität Bochum

Wed, 14:00
HS Physiologie

Universality in Random Moment Spaces

For a set $E \subset \mathbb{R}$ denote by $\mathcal{M}_n(E)$ the set of vectors consisting of the first n moments of all measures supported by E. It has been shown that for a uniform distribution on $\mathcal{M}_n([0,1])$ in high dimension n the moment sequences concentrate near the moments of the arcsine distribution.
In a joint work with H. Dette and M. Venker, we introduce a general class of distributions on the moment space $\mathcal{M}_n(E)$ (for $E = [a,b]$, $E = [0,\infty)$ and $E = \mathbb{R}$) by means of continuous potentials V. As the dimension n goes to infinity, we observe laws of large numbers and central limit theorems, as well as moderate and large deviations principles. For $E = [0,\infty)$ resp. $E = \mathbb{R}$ we obtain a universal behaviour in that the moment vectors concentrate near the Marchenko–Pastur resp. semicircle distribution, with parameters depending on the choice of the potential V. In the case $E = [a,b]$ the concentraction occurs not around the arcsine law, but the more general family of Kesten McKay-Distributions.

Joint work with: Holger Dette • Martin Venker

Martin Wendler
University Greifswald

Tue, 17:55
HS Physiologie

A random walk between long and short range dependence

For independent random variables, the sequential empirical process, i.e. the centered and rescaled empirical distribution function, converges in distribution to a Gaussian process, as Müller (1970) has proved. The limit is the Kiefer–Müller process, which has rough paths and is self-similar with exponent $b = 1/2$. For long range dependent Gaussian random variables, Dehling and Taqqu (1989) have shown that the limit process is degenerate, has smooth paths and is self-similar with exponent $b > 1/2$.
A random walk in random scenery $(Y_n)_{n\in\mathbb{N}}$ is given by $Y_n = \xi_{S_n}$ for a random walk $(S_n)_{n\in\mathbb{N}}$ on $\mathbb{Z}$ and iid random variables $(\xi(n))_{n\in\mathbb{N}}$. We will show the weak convergence of the sequential empirical process for this type of random sequence. The limit process shows a new type of behavior, combining properties of the limit in the independent case (roughness of the paths) and in the long range dependent case (self-similarity). For a random walk in $\mathbb{Z}^2$, the limit process is a Kiefer–Müller process as in the independent case.

Section 4a: Finance, insurance and risk: Modelling

Paul Embrechts
ETH Zürich

Thu, 14:00
HS Anatomie

Quantile-based Risk Sharing

We address the problem of risk sharing among agents using a two-parameter class of quantile-based risk measures, the so-called Range-Value-at-Risk (RVaR), as their preferences. The family of RVaR includes the Value-at-Risk (VaR) and the Expected Shortfall (ES), the two popular and competing regulatory risk measures, as special cases. We first establish an inequality for RVaR-based risk aggregation, showing that RVaR satisfies a special form of subadditivity. Then, the Pareto-optimal risk sharing problem is solved through explicit construction. To study risk sharing in a competitive market, an Arrow-Debreu equilibrium is established for some simple, yet natural settings. Further, we investigate the problem of model uncertainty in risk sharing, and show that, generally, a robust optimal allocation exists if and only if none of the underlying risk measures is a VaR. Practical implications of our main results for risk management and policy makers are discussed, and several novel advantages of ES over VaR from the perspective of a regulator are thereby revealed.

Joint work with: Hailyan Liu • Ruodu Wang

Jonathan Ansari
Albert-Ludwigs-Universität Freiburg

Thu, 18:10
HS Chemie

Ordering properties of risk bounds in risk factor models

In partially specified risk factor models (X_i, Z) the worst case dependence structure has been identified in Bernard et al. (2016) as the conditionally comonotonic risk vector. Our main subject is to give criteria on the specified copulas of (X_i, Z) that imply ordering of the induced risk bounds. Our results are derived by some new supermodular ordering results for conditionally comonotonic distributions. The results for elliptical distributions in Ansari and Rüschendorf (2017) are extended to general criteria.

References:

[1] J. Ansari, L. Rüschendorf. *Ordering Results for Risk Bounds and Cost-efficient Payoffs in Partially Specified Risk Factor Models*, Methodology and Computing in Applied Probability (2017): pp 1–22
[2] C. Bernard, L. Rüschendorf, S. Vanduffel, R. Wang. *Risk bounds for factor models* Finance and Stochastics (2017): Volume 21 (3), pp 631–659

Joint work with: Ludger Rüschendorf

Dirk Becherer
Humboldt Universität zu Berlin

Tue, 14:25
HS Chemie

Good Deal Hedging and Valuation under Combined Uncertainty about Drift and Volatility: A 2nd order BSDE approach

We derive robust good-deal hedges and valuations for contingent claims in incomplete markets under combined model ambiguity about the drift and volatility of asset prices, in continuous time.

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For general measurable contingent claims, possibly path-dependent, the solutions can be fully characterized by 2nd-order backward stochastic differential equations, with possibly non-convex generators, by building on recent research progress on stochastic control for non-linear kernels.
Examples illustrate, how combined uncertainty makes the solution more complex than just either drift or volatility uncertainty alone.
Good-deal valuations are determined such that not just opportunities for arbitrage but also for overly attractive reward-to-risk ratios are excluded. Corresponding hedging-to-acceptability strategies are minimizing suitable dynamic risk measures. From a finance point of view, this permits for hedges and valuation bounds than are less extreme (respectively expensive) than those from the more fundamental approach of almost-sure superhedging and its corresponding no-arbitrage bounds. In mathematical terms, it requires however that not just ambiguities about the volatility but also about the drift become relevant.

References:

[1] Dirk Becherer, Klebert Kentia. Good Deal Hedging and Valuation Under Combined Uncertainty About Drift and Volatility, 2017, in 1st revision at PUQR, available at SSRN: https://ssrn.com/abstract=2951742
[2] Dirk Becherer, Klebert Kentia. Hedging Under Generalized Good-Deal Bounds and Model Uncertainty. Math. Methods Operations Research, 2017, DOI:10.1007/s00186-017-0588-y

Joint work with: Klebert Kentia

David Beßlich
Technische Universität Berlin

Wed, 11:35
HS Chemie

Information Jumps produced by Meyer-σ-fields vs. The Urge of Investment

In stochastic control problems one has to find an optimal strategy given some information flow, typically given by a filtration. In some situations, though, a more refined way of describing information flow is called for. Imagine, for instance, a moment in time when new information is known to become available. The controller will form an expectation on this new information and accordingly take precautionary measures right before the revelation of the news. Right after this has become available, further measures will have to be taken. This suggests to consider controls which are neither predictable nor merely optional. To capture this situation mathematically, we take controls that are measurable with respect to a Meyer-σ-field Λ such that it is embedded between the optional-σ-field and the predictable-σ-field for a given filtration $(\mathcal{F}_t)_{t\geq 0}$ satisfying the usual conditions and we consider an irreversible investment problem with inventory risk, i.e.

$$\text{Maximize } \mathbb{E}\left[\int_{[0,\hat{\tau})} G_t \, {}^*(\mathrm{d}C_t) - \int_{[0,\hat{\tau})} \varrho_t(C_t)\mathrm{d}R_t\right],$$

where one seeks to find Λ-measurable capacity expansions $dC_t \geq 0$ which trade off optimally the generate revenues G_t with the inventory risk described by a convex function $\varrho_t(.)$ and a random measure dR_t. For any Meyer-σ-field Λ, we explicitly construct an optimal policy from the unique Λ-measurable solution to a generalized version of a representation problem considered in Bank & El Karoui (2004). Technically, this refined result is based strongly on the properties of Meyer-σ-fields and on the *temps d'arrêt divisées* from the *théorie générale des processus stochastiques* (e.g. N. El Karoui (1981), E. Lenglart (1980)). Additionally we apply this setting to a Lévy process framework, where we calculate explicit solutions.

References:

[1] P. Bank, N. El Karoui (2004). *A stochastic representation theorem with applications to optimization and obstacle problems*, The Annals of Probability.
[2] N. El Karoui (1981). *Les aspects probabilistes du contrôle stochastique*, Springer-Verlag.

[3] E. Lenglart (1980). *Tribus de Meyer et théorie des processus*, Springer-Verlag.

Joint work with: Peter Bank

Corina Birghila
University of Vienna

Tue, 12:05
HS Chemie

Design of insurance contract under ambiguity. Applications in climate-change events.

Insurance contracts represent an efficient risk management tool for managing and mitigating losses. However, lack of data, climate-change and/or difficulty in forecasting characteristic to catastrophic events add extra risks to the insurance industry. In this talk we propose a method to incorporate model error into pricing and design of an insurance contract using a distributionally robust optimization setup. Due to coverage limitations in the insurance market, we consider the limited stop-loss contract (see Cummins and Mahul (2004)) given by $I(x) = \min(\max(x-d), \bar{I})$, with parameters deductible d and cap $\bar{I}$. More precise, we propose an optimization problem of finding the optimal balance between parameters of this contract that minimize some risk functional of the final wealth. To include contract robustness of the decision against possible model misspecification, the optimal decision is taken with respect to all probability measures within a prescribed tolerance from a suitable baseline model. As a measure of discrepancy between different models, a modified version of the well-known Wasserstein distance is considered, which is more sensitive to deviations in the tails of distributions. Based on families of models, that may explain the data, one may assign minimax strategies to assess insurance premiums as well as risk and liability management for extreme events. We study the dependence of the objective function as well as the deductible and cap levels of the insurance contract on the tolerance level change. As expected, the premium of such a contract increases with the increasing size of the ambiguity set. Performance is assessed using simulation experiments, and illustrated using a tornado damage claims dataset.

References:

[1] J. D. Cummins, Olivier Mahul (2004). The demand for insurance with an upper limit on coverage. *Journal of Risk and Insurance*, 71(2), 253–264
[2] G. Pflug, D. Wozabal (2007). Ambiguity in portfolio selection. *Quantitative Finance*, 7(4), 435–442
[3] G. Pflug, A. Timonina-Farkas, S. Hochrainer-Stigler. Incorporating model uncertainty into optimal insurance contract design (2017). *Insurance: Mathematics and Economics*, 73, 68–74

Joint work with: Georg Pflug

Frank Bosserhoff
Ulm University

Wed, 17:45
HS Chemie

Extensions of mean-variance portfolio selection

Investors are particularly concerned about downside risk, which is not properly reflected by classical mean-variance portfolio selection due to the symmetry of the second central moment. We therefore consider the following extension: Denoting by $V(T)$ the value of some portfolio consisting of a risky and a riskless asset at some time T, Itô's Representation Theorem implies the existence of some predictable square integrable process $H^V = (H_t^V)_{0\le t\le T}$ such that

$$V(T) = \mathbb{E}(V(T)) + \int_0^T H_t^V \, dW(t),$$

i.e., the terminal time portfolio value can be represented by its expected value plus some stochastic integral w.r.t. a standard Brownian motion W. The process H^V reflects the local volatility of the portfolio's terminal wealth.

Let $\pi = (\pi(t))_{0\le t\le T}$ denote the absolute amount of risky assets held. We solve the following mean-local-volatility optimization problem:

$$\max_{\pi} \mathbb{E}\left(V(T) - \gamma \int_0^T g(H_t^V)\, dt\right),$$

where g is some penalty function satisfying certain conditions and $\gamma > 0$ a risk-aversion parameter. As this optimization problem is time-inconsistent, Bellman's dynamic programming principle is not applicable.
Our contribution is twofold: From a mathematical point of view, we solve this time-inconsistent stochastic optimal control problem in continuous time by solving its discrete-time analogue; in a second step, we describe the continuous-time optimal strategy as the limit of the discrete-time one in an appropriate sense. From an economic perspective, we present a mean-local-volatility optimal portfolio strategy in discrete and continuous-time.

Matteo Burzoni

Tue, 11:15
HS Chemie

Risk measures based on benchmark loss distributions

Soon after its introduction in 1994, Value at Risk (VaR) has became the industry standard for measuring risk. In spite of its ubiquity, a variety of theoretical drawbacks of VaR have been recognized over the past years. The most fundamental deficiency of VaR is certainly its "blindness" to the tail of the loss distribution. Indeed, being VaR a quantile of a distribution, it depends only upon the frequency of losses and not upon their magnitude. With the aim to address this deficiency, Expected Shortfall (ES) soon established itself as the most prominent competitor of VaR.
We aim to enrich the debate on risk measures by introducing a new class of quantile-based risk measures that, similarly to ES, allows to take into account both the frequency and severity of losses. The underlying principles are: 1) losses should be acceptable only if they occur with a pre-specified low probability; 2) the degree of acceptability should depend on the size of the loss: higher losses will be tolerated with lower probability.
In order to translate these principles into a risk measurement procedure we specify an increasing and right-continuous function

$$\alpha : [0, \infty) \to [0, 1]$$

that assigns to each loss level $u \ge 0$ a certain probability weight $\alpha(u) \in [0, 1]$. The function α defines a criterion of acceptability: losses that exceed a certain level u will be tolerated in at most $100(1-\alpha(u))\%$ of the cases. For this reason, the function α is referred to as the "benchmark loss distribution". The risk measure associated with a benchmark loss distribution α is defined by

$$\varrho_\alpha(X) := \inf\{m \in \mathbb{R}\,;\ \mathbb{P}(X - m \le u) \ge \alpha(u),\ \forall u \ge 0\}.$$

Likewise VaR and ES, the risk measure ϱ_α admits a clear operational interpretation from a capital adequacy perspective: The quantity $\varrho_\alpha(X)$ can be interpreted as the minimal amount of capital that has to be raised and held in cash in order to align the distribution of X to the benchmark loss profile prescribed by α. The acceptability criterion induced by ϱ_α can be naturally viewed as a strengthening of the standard criterion induced by VaR. Instead of defining acceptability by imposing a condition on the probability $\mathbb{P}(X \le 0)$ alone, we consider the whole spectrum of probabilities $\mathbb{P}(X \le u)$ for any loss level $u \ge 0$. This implies that, by construction, ϱ_α is more conservative than VaR at the reference confidence level $\alpha(0)$. In the extreme case of a constant benchmark function, the risk measure ϱ_α reduces to $\mathrm{VaR}_{\alpha(0)}$.
From a practical perspective, the most important question concerns the choice of the benchmark function α. While the specific choice will clearly depend on the particular application, we describe here two general classes of benchmark functions that are suitable to be employed in a variety of financial applications.

Step functions. A natural choice for α is to consider a step function of the form

$$\alpha = \begin{cases} \alpha_1, & u_1 \le u < u_2 \\ \alpha_2, & u_2 \le u < u_3 \\ \vdots & \vdots \\ \alpha_n, & u \ge u_n \end{cases}$$

for some critical loss levels $0 = u_1 < \cdots < u_n$ and some probability weights $0 \le \alpha_1 < \cdots < \alpha_n \le 1$. The critical loss levels may be determined, for instance, as increasing fractions of some pre-specified target loss level. This class of benchmark functions has natural applications to capital adequacy and solvency regulation. Indeed, one could take α_1 to be a standard regulatory confidence level, say 0.99, and add a capital buffer on top of VaR_{α_1} by choosing more conservative confidence levels in correspondence to some critical loss thresholds. Since ϱ_α gives higher capital requirements than VaR_{α_1}, one could in principle accept a lower benchmark confidence level α_1, say 0.95, and incorporate the regulatory standard only beyond a certain critical loss threshold, which would need to be approved by regulators.
Tail-distribution functions. Another natural choice is to specify α as the tail distribution of some target loss L so that

$$\alpha(u) = \mathbb{P}(L \le u), \quad u \ge 0.$$

Note that, in this case, the acceptability condition $\varrho_\alpha(X) \le 0$ is equivalent to requiring that the loss distribution of X dominates that of L in the first stochastic order. The definition of ϱ_α allows full flexibility in the choice of the distribution of L. Depending on the specific application, one may select a loss profile that is more or less heavy tailed. For instance, the tail of the target loss L might display a (generalized) Pareto distribution with possibly infinite mean in the context of large insurance claims or operational risk but rather a Gaussian or Student distribution in the context of market risk.

Joint work with: Valeria Bignozzi • Cosimo Munari

Sören Christensen
University of Trier

Tue, 14:50
HS Chemie

Non-Smooth Verification for Impulse Control Problems

Stochastic impulse control problems are continuous-time optimization problems in which a stochastic system is controlled through finitely many impulses causing a discontinuous displacement of the state process. The objective is to choose the impulses optimally so as to maximize or minimize a reward or cost functional of the state process. This type of optimization problem arises in many branches of applied probability and economics such as optimal portfolio management under transaction costs, optimal forest harvesting, inventory control, and real options analysis.
In this talk, I will give an introduction to optimal impulse control and discuss classical solution techniques. I will then introduce a new method to solve impulse control problems based on superharmonic functions and a stochastic analogue of Perron's method, which allows to construct optimal impulse controls under a very general set of assumptions. Finally, I will show how the general results can be applied to a problem of optimal investment in the presence of constant and proportional transaction costs.

Joint work with: Christoph Belak • Frank T. Seifried

Simon Clinet
Keio University

Tue, 15:15
HS Chemie

Testing if the market microstructure noise is a function of the limit order book

In this work, we build tests for the presence of error in a model where the market microstructure noise (MMN) is a known parametric function of the limit order book (LOB). The tests compare two

novel and distinct quasi-maximum likelihood estimators of volatility, where the related model includes an additive error in the market microstructure noise or not. More precisely, we consider the following model for the noisy log-returns Z_{t_i} :

$$Z_{t_i} = X_{t_i} + \phi(Q_i, \theta_0) + \varepsilon_{t_i},$$

where X is the efficient price process, Q_i are observable variables included in the LOB while ϕ is known to the econometrician. We thus develop tests for the presence of the error ε_{t_i} at any given sampling frequency. The associated null hypothesis is such that $\varepsilon_{t_i} = 0$ and the alternative $\text{Var}[\varepsilon_{t_i}] > 0$.
The limit theory is investigated in the above general semi-parametric framework through a quasi-maximum likelihood approach, adapted from [1]. The tests correspond to extensions of Hausman tests as conducted in [2], in the case $\phi \neq 0$.
When there is no error in the model, we provide a consistent estimator of the efficient price based on the quasi maximum likelihood estimator (QMLE) of the parameter θ_0 :

$$\widehat{X}_{t_i} = Z_{t_i} - \phi(Q_i, \widehat{\theta}_{exp}),$$

where $\widehat{\theta}_{exp}$ is the QMLE. Furthermore, we show that realized volatility remains efficient when performed on the estimated price rather than on the efficient price.
When we assume a residual error in the model, we introduce a measure of goodness of fit which corresponds to the proportion of MMN variance explained by the explicative part ϕ. Such measure can be estimated using the parameter and the error variance estimates obtained with the QMLE related to the model including the error. Our second main contribution establishes the corresponding central limit theorem in case when the variance of the error stays constant. In particular, volatility estimation is naturally not as fast as when we assume no error in the model.
Finally we implement the tests over a one month period at several sampling frequencies, including tick by tick data, and find out that a simple linear signed spread model consistently stands out from many other alternatives including the so-called Roll model. The tests further reveal that the large majority of stocks can be reasonably considered as free from error with such model. Moreover, we implement the tests from [2] regarding the estimated efficient price as the given observed price. They largely corroborate the findings. Details can be found in [3].

References:

[1] Xiu, D. (2010). quasi-maximum likelihood estimation of volatility with high frequency data. Journal of Econometrics, 159(1):235–250.
[2] Ait-Sahalia, Y. and Xiu, D. (2016). A Hausman test for the presence of market microstructure noise in high frequency data. To appear in Journal of Econometrics
[3] Clinet, S. and Potiron, Y. (2017) Testing if the market microstructure noise is a function of the limit order book. arXiv preprint available at arXiv:1709.02502

Joint work with: Potiron Yoann

Camilla Damian

WU Vienna University of Economics and Business

Wed, 11:10
HS Chemie

Hidden Markov Model for the Contagion between Eurozone Spreads

The evolution of sovereign CDS spreads of Eurozone countries over time shows important co-movements, which are particularly evident during the European sovereign debt crisis. During this period, the highest increases in CDS spreads are observed in those countries mostly affected by the crisis, reflecting their lower perceived creditworthiness.
In this talk, we model these features by considering m countries and dynamics of this form:

$$d\Psi_t^i = (\langle \theta^i, X_t \rangle - \kappa^i \Psi_t^i)\, dt + \sigma^i \sqrt{\Psi_t^i}\, dW_t^i, \quad i = 1, \dots, m.$$

We assume that W^i, $i = 1, \dots, m$, are independent Brownian motions and X is an unobservable finite state Markov chain independent of W. While the parameters are allowed to be country-specific, note that the dependence between Ψ^i, $i = 1, \dots, m$, is generated via the dependence of the mean reversion level on the common Markov chain X.
We present both valuation results for portfolio products and results from a statistical calibration study, where a model of this type would be calibrated to CDS spreads.

Joint work with: Rüdiger Frey • Kevin Kurt

Paolo Di Tella
TU Dresden

Wed, 12:00
HS Chemie

Semi-Static Variance-Optimal Hedging in Stochastic Volatility Models with Fourier Representation

In a financial market model, we consider the variance-optimal semi-static hedging of a given contingent claim, a generalization of the classic variance-optimal hedging. To obtain a tractable formula for the expected squared hedging error and the optimal hedging strategy, we use a Fourier approach in a general multidimensional semimartingale factor model. As a special case, we recover existing results for variance-optimal hedging in affine stochastic volatility models. We apply the theory to set up a variance-optimal semi-static hedging strategy for a variance swap in both the Heston and the 3/2-model, the latter of which is a non-affine stochastic volatility model.

Joint work with: Martin Haubold • Martin Keller-Ressel

Markus Dietz
Technische Universität Bergakademie Freiberg

Thu, 16:30
HS Chemie

On order statistics and their copulas

In the field of stochastic modeling, copula functions are getting more and more important, because they allow us to consider the dependence structure separately from the 1-dimensional marginal distributions and to model non-linear dependence. In this context the construction of copulas is an important but non-trivial task.
We present a joint work with Klaus D. Schmidt and Sebastian Fuchs, about the problem of how to transform a copula for the distribution function of an arbitrary random vector into a copula for the distribution function of its order statistics. In the case of continuous marginal distribution functions, the problem has already been studied by Navarro and Spizzichino (2010). We drop this restriction and extend the results to random vectors with general marginal distributions.

References:

[1] M. Dietz, S. Fuchs, K. D. Schmidt (2016). *On order statistics and their copulas*, Statistics & Probability Letters 117, 165–172
[2] J. Navarro, F. Spizzichino (2010). *On the relationships between copulas of order statistics and marginal distributions*, Statistics & Probability Letters 80, 473–479

Joint work with: Klaus D. Schmidt • Sebastian Fuchs

Rüdiger Frey
Vienna University of Economics and Business, Institute for Statistics and Mathematics

Wed, 14:00
HS Chemie

Optimal Liquidation under Partial Information with Price Impact

We study the problem of a trader who wants to maximize the expected revenue from liquidating a given stock position. We model the stock price dynamics as a geometric pure jump process with local characteristics driven by an unobservable finite-state Markov chain and by the liquidation rate.

This reflects uncertainty about activity of other traders and feedback effects from trading. We use stochastic filtering to reduce the optimization problem under partial information to an equivalent one under complete information. This leads to a stochastic control problem for piecewise deterministic Markov processes (PDMPs). We carry out a detailed mathematical analysis of this problem via In particular, we derive the optimality equation for the value function, we characterize the value function as continuous viscosity solution of the associated dynamic programming equation, and we prove a novel comparison result.
The paper concludes with numerical results illustrating the impact of partial information and feedback effects on the value function and on the optimal liquidation rate.

Sebastian Fuchs
Free University of Bozen-Bolzano

Thu, 17:20
HS Chemie

Characterizations of Copulas for which the Bounds of Kendall's Tau are Attained

For the most popular measures of concordance, like Kendall's tau, Spearman's rho and Gini's gamma, the maximum value is equal to 1 and is attained by the upper Fréchet-Hoeffding bound and, in the bivariate case, the minimum value is equal to -1 and is attained by the lower Fréchet-Hoeffding bound. In this class, Kendall's tau is particular since its minimum value (which depends on the dimension $d \geq 2$) is known and is attained by several distinct copulas whenver $d \geq 3$.
In the present talk, we characterize the classes of all copulas which maximize or minimize the value of Kendall's tau. We first show that the upper Fréchet-Hoeffding bound is the only copula maximizing Kendall's tau. We then provide a characterization of the collection of all copulas minimizing Kendall's tau and we show that this collection is a singleton if and only if $d = 2$. As a complementary result, we show that the order transform of any copula minimizing Kendall's tau, which is related to the order statistic of certain random vectors, minimizes Kendall's tau as well.

Joint work with: Yann McCord • Klaus D. Schmidt

Stefan Gerhold
TU Wien

Wed, 14:50
HS Chemie

Dynamic trading under integer constraints

We investigate discrete time trading under integer constraints, that is, we assume that the offered goods or shares are traded in integer quantities instead of the usual real quantity assumption. For finite probability spaces and rational asset prices this has little effect on the core of the theory of no-arbitrage pricing. For price processes not restricted to the rational numbers, a novel theory of integer arbitrage free pricing and hedging emerges. We establish an FTAP, involving a set of absolutely continuous martingale measures satisfying an additional property. The set of prices of a contingent claim is not necessarily an interval, but is either empty or dense in an interval. We also discuss superhedging with integral portfolios.

Joint work with: Paul Krühner

Kathrin Glau
Queen Mary University of London

Thu, 14:50
HS Chemie

Parametric Monte Carlo by Chebyshev Interpolation and Applications

Urgent computational problems in stochastics are of high dimensionality and the result is required in fast run-times. This is for instance the case in uncertainty quantification and for recurrent computational tasks in finance such as pricing, calibration and risk assessment. We concentrate on Parametric Option

Pricing (POP) as a generic instance of parametric conditional expectations and show that polynomial interpolation in the parameter space promises to considerably reduce run-times while maintaining accuracy. The attractive properties of Chebyshev interpolation and its tensorized extension enable us to identify broadly applicable criteria for (sub)exponential convergence and explicit error bounds. The method is most promising when the computation of the prices is most challenging. We therefore investigate its combination with Monte Carlo simulation and analyze the effect of (stochastic) approximations of the interpolation. For a wide and important range of problems, the Chebyshev method turns out to be more efficient than parametric multilevel Monte Carlo. We conclude with a numerical efficiency study.

References:

[1] M. Gaß, K. Glau, M. Mahlstedt and M. Mair (2016). *Chebyshev Interpolation for Parametric Option Pricing*, Preprint available on arXiv.org http://arxiv.org/abs/1505.04648

Joint work with: Maxilmilian Gaß • Mirco Mahlstedt • Maximilian Mair

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Martin Peter Gerhard Herdegen
University of Warwick

Wed, 17:20
HS Chemie

Equilibrium Asset Pricing with Transaction Costs

We consider a risk-sharing equilibrium where trading is subject to quadratic transaction costs. In this context, equilibrium asset prices can be characterized by coupled systems of quadratic forward-backward SDEs. Some concrete examples can be solved explicitly, allowing to assess the impact of trading costs on volatility.

Joint work with: Johannes Muhle-Karbe

Christoph Kühn
Goethe University

Wed, 14:25
HS Chemie

How local in time is the no-arbitrage property under capital gains taxes ?

In frictionless financial markets, no-arbitrage is a local property in time. This means, a discrete time model is arbitrage-free if and only if there does not exist a one-period arbitrage. With capital gains taxes, this equivalence fails. For a model with a linear tax and one non-shortable risky stock, we introduce the concept of *robust local no-arbitrage* (RLNA) as the weakest local condition which guarantees dynamic arbitrage-freeness. Under a sharp dichotomy condition, we prove (RLNA). Since "no one-period arbitrage" is necessary for no-arbitrage, the latter is nested between two local conditions, which allows us to estimate its non-locality.
Furthermore, we show that the model with a linear tax on capital gains can be written as a model with proportional transaction costs by introducing several fictitious securities.

Aitor Muguruza Gonzalez
Imperial College London

Thu, 11:35
HS Chemie

Functional central limit theorems for rough volatility models

We extend Donsker's approximation of Brownian motion to fractional Brownian motion in a Holder space setting with any Hurst exponent (including the 'rough' case $H < 1/2$), and Volterra-like processes. Some of the most relevant consequences of our 'rough Donsker (rDonsker) Theorem' are convergence results for discrete approximations of a large class of rough models again in a Holder space setting. This justifies the validity of simple and easy-to-implement Monte-Carlo methods for path dependent option pricing, for which we provide detailed numerical recipes. We test these against the current benchmark

Hybrid scheme by Bennedsen, Lunde and Pakkanen and find remarkable agreement (for a large range of values of H in line with empirical findings).
This rDonsker Theorem further provides a weak convergence proof for the Hybrid scheme itself which was not available before. Moreover, it allows to construct binomial trees for rough volatility models and we prove that the weak convergence of the backward recursion holds for early exercise options such as American or Bermudan.

Joint work with: Blanka Horvath • Antoine Jacquier

Alfred Müller
Universität Siegen

Thu, 16:55
HS Chemie

Expectiles, Omega ratios and stochastic dominance

In the theory of risk measures expectiles have recently found increasing interest as they are the only risk measures that are coherent and elicitable. Comparing expectiles is mathematically equivalent to comparing Omega ratios, which are a well known performance measure for the comparison of the performance of investment strategies.
In this talk we explain these two concepts and investigate their relation and consistency with respect to stochastic dominance rules. In particular we introduce a new stochastic order based on expectiles that turns out to have some unexpected properties. We also give conditions under which expectiles and Omega ratios are consistent with classical first and second order stochastic dominance and with respect to the recently introduced fractional stochastic dominance between first and second order.

Joint work with: Fabio Bellini • Bernhard Klar

Ludger Overbeck

Tue, 11:40
HS Chemie

Systemic Risk Measures, an axiomatic approach

In this talk we extend the axiomatic approach to systemic risk, as introduced in Chen et al. (2013), in different directions. One direction is the introduction of systemic risk measures that do not have to be positively homogeneous. The other direction is that we allow for a general measurable space. This extends the scope of possible loss distributions of the components of a financial system to a great extent and introduces more flexibility for the choice of suitable systemic risk measures. In the second part we generalize this static approach and analyze systemic risk measures in a dynamic setting of risk measures for bounded discrete-time processes. Apart from the possibility to consider the "evolution of financial values", another important advantage of the dynamic approach is the possibility to incorporate information in the risk measurement and management process. In context of this dynamic setting we also discuss the arising question of time-consistency for our dynamic systemic risk measures.

Antonis Papapantoleon

Thu, 17:45
HS Chemie

Improved Fréchet–Hoeffding bounds, optimal transport and applications in finance

The classical Fréchet–Hoeffding bounds provide upper and lower bounds on the copula, resp. the joint distribution function, of random vectors, which can be translated into bounds on multi-asset option prices or portfolio Value-at-Risk (VaR). However, they assume that the marginal distributions are completely known and the joint distribution completely unknown, while they provide bounds on option prices and VaR which are too wide to provide useful information in practice. In this talk, we will report on recent progress on improved Fréchet–Hoeffding bounds, under the realistic assumptions that the marginal distributions are only partially known and that there exists partial information available on the joint distribution. The improved Fréchet–Hoeffding bounds provide tighter bounds on multi-asset option prices and VaR, which will be presented during the talk. Moreover, we will also report on

the mathematical properties of the improved Fréchet–Hoeffding bounds. The classical upper Fréchet–Hoeffding bound is known to be a copula again, while L. Rüschendorf showed that the lower bound is pointwise sharp. Using ideas from the theory of optimal transportation, we will discuss the sharpness of these new bounds.
This talk in based on the following articles:

References:

[1] D. Bartl, M. Kupper, T. Lux, A. Papapantoleon: Sharpness of improved Fréchet–Hoeffding bounds: an optimal transport approach. Preprint, arXiv/1709.00641, 2017.
[2] T. Lux, A. Papapantoleon: Model-free bounds on Value-at-Risk using partial dependence information. Preprint, arXiv/1610.09734, 2016.
[3] T. Lux, A. Papapantoleon: Improved Fréchet–Hoeffding bounds for d-copulas and applications in model-free finance. *Annals of Applied Probability* (forthcoming).

Thorsten Rheinländer

Thu, 11:10
HS Chemie

Brownian trading excursions

We study a parsimonious, but non-trivial model of the limit order book. In contrast to market orders which get executed instantaneously, limit orders are placed away from the current market price (which we will call mid-price), and get executed once the mid-price process hits the limit level. Hence the volume of orders in the limit order book constitutes a random field where the space parameter corresponds to the limit level relative to the mid-price. The volume field satisfies the stochastic heat equation with multiplicative noise. We will solve this equation in terms of a local time functional. Furthermore, we study different types of trades via excursion theory.

Jörn Sass
University of Kaiserslautern

Wed, 16:55
HS Chemie

Model reduction for filtering and portfolio optimization in Markov switching models

A regime switching model, where the observation process is a diffusion process whose drift and volatility coefficients jump governed by a continuous-time Markov chain, can explain some of the stylized facts of asset returns. In the special case that the volatility is constant, the underlying Markov chain can no longer be observed and has to be estimated by its filter. Portfolio decisions then depend on this filter and its dynamics. In fact it turns out that optimal portfolio policies and filter equations rely on the same signal to noise matrix. This can be used to reduce the dimension of the model to the dimension of this matrix if it has full rank. The eigenvalues of this matrix then provide a way to decompose the optimal portfolio in investments in mutual funds. In contrast to classical mutual fund theorems in continuous time, their composition is constant over time but the optimal policy is not. We provide convergence and decomposition results for optimization and filtering. Further we analyze the case of signal to noise matrices which are not of full rank and look at extensions to regime switching models and to hidden Markov models with non-constant volatility. We discuss consistency of the corresponding discrete-time and continuous-time models in view of filtering and portfolio optimization.

Joint work with: Elisabeth Leoff

Michael Schatz
ETH Zurich

Thu, 10:45
HS Chemie

A mathematical framework for inefficient market bubbles.

Following the understanding that asset price bubbles are generated by market failures, we present a framework for explosive semimartingales that is based on the antagonistic combination of (i) an excessive pre-crash process and (ii) the random time of a drawdown.

At odds with the common "rational expectations" framework for bubbles, economists like Hyman Minsky or Charles Kindleberger have put forward the idea that irrational behavior, ambiguous information or certain limits to arbitrage are essential drivers for bubble phenomena and financial crisis. We provide a unifying framework that allows one to accommodate and compare many discrete and continuous time bubble models in the literature that feature such market inefficiencies.
We claim that rational expectation bubbles are by design afflicted with an inherent error in both discrete and continuous time models that can be traced down to a problematic definition of the fundamental value. While the discrete time case has been extensively discussed in the literature and is most criticized for a structure that is based on a payoff at infinity, we show that a new version of this error also permeates the continuous, finite time "strict local martingale"-approach to bubbles.
Besides formalizing the essential stylized facts of a bubble, pivotal to our framework is the possibility of unstable behavior and finite time explosion that is countered by the possibility of a drawdown. This significantly extends the range of feasible asset price processes during times of financial speculation and frenzy and provides a strong theoretical background for future model design. Our framework will simplify and foster interdisciplinary exchange at the intersection of economics and mathematical finance and encourage further research.

Joint work with: Didier Sornette

Hanspeter Schmidli

Wed, 15:15
HS Chemie

Dividends with Tax and Capital Injection in a Spectrally Negative Lévy Risk Model

We consider a risk model driven by a spectrally negative Lévy process. From the surplus dividends are paid and capital injections have to be made in order to keep the surplus positive. In addition, tax has to be paid for dividends, but injections lead to an exemption from tax. We generalise the results for the diffusion approximation (Schmidli (2016)) and for the classical model (Schmidli (2017)), and show that the optimal dividend strategy is a two barrier strategy. The barrier depends on whether an immediate dividend would be taxed or not. For a risk process perturbed by diffusion with exponentially distributed claim sizes we show how the value function and the barriers can be determined.

Daniel Schmithals
Karlsruhe Institute of Technology (KIT)

Tue, 14:00
HS Chemie

Model-independent finance with a focus on applications

In model-independent finance the problem of interest is the martingale optimal transport problem

$$\sup_{\pi \in \mathcal{M}(\mu,\nu)} \int_{\mathbb{R}^2} c(x,y) \mathrm{d}\pi(x,y),$$

where $\mathcal{M}(\mu,\nu)$ is the set of all martingale measures with marginal distributions μ and ν and $c : \mathbb{R}^2 \to \mathbb{R}$ is measurable. The value of this problem can be understood as an upper price bound for a derivative with payoff function c.
In the talk we shortly motivate the idea of model-independent finance and introduce some basic tools and concepts. We revisit some important results in the area and start with the groundbreaking pricing-hedging duality theorem of martingale optimal transport. We then turn to results for cost functions that satisfy the so-called martingale Spence-Mirrlees condition. There we discuss how solutions to the martingale optimal transport problem and its dual may be characterized and under which further assumptions they can be determined explicitly.
After this introductory part we consider the case of discrete marginal distributions in order to investigate real world scenarios. There we improve certain optimality results, detail some algorithms to determine the solutions and consider the question of convergence and its speed when the discrete marginal distributions tend to continuous ones. We also illustrate the results with examples.

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 4a: Finance, insurance and risk: Modelling

Miriam Isabel Seifert

Wed, 18:10
HS Chemie

Financial risk measures for portfolios of light-tailed claims

We focus on a system of agents sharing financial risky claims issued by different objects. The effects of risk aggregation and risk sharing have been studied in the current literature mainly for heavy-tailed claims with a power tail decay. However, the assumption about heavy tails is not always justified in empirical finance.
For this reason, we contribute to the current research by studying portfolios of light tailed claims on risky objects with distinct exponential tail decays which correspond to different risk classes. We deduce the distributions for both individual agents' and system's risks and show that our results are qualitatively different to those established for heavy-tailed claims.
We also provide statements for value-at-risk and expected shortfall measuring individual and system's risks.

Joint work with: Claudia Klüppelberg

Julian Sester
Albert-Ludwigs-Universität Freiburg

Wed, 16:30
HS Chemie

The Optimal Martingale Transport Problem with additional Information about Variance of the Returns

We investigate the optimal transport problem with martingale constraints and its application to model-independent price bounds for financial derivatives. The novelty of this paper is the additional consideration of information about the variance of the returns of an underlying discrete-time stochastic process. This additional information is well motivated by observations of certain exotic derivatives traded on the OTC market. Our theoretical results comprise a dual version of the modified problem and we investigate the influence of the additional input parameters on lower and upper model-independent price bounds for various payoff functions. Our empirical results, which are based on market data for OTC traded options, indicate that tighter price bounds for exotic options can be obtained when taking into account such additional information on the variance of returns. In this respect, our results also have important implications for the practical applicability and relevance of model-independent price bounds.

Joint work with: Eva Lütkebohmert-Holtz

Taras Shalaiko
Uni Mannheim

Thu, 12:00
HS Chemie

The order barrier for strong approximation of rough volatility models

Consider a process $X = \{X_t, t \geq 0\}$, that models the log-price of an asset

$$X_t = -\frac{1}{2}\int_0^t e^{2Y_s}\,ds + \varrho\int_0^t e^{Y_s}\,dV_s + \sqrt{1-\varrho^2}\int_0^t e^{Y_s}\,dW_s,$$

whose log-volatility $Y = \{Y_t, t \geq 0\}$ is given by the stationary solution of the Langevin equation

$$dY_t = \lambda(\mu - Y_t)\,dt + \theta\,dB_t.$$

Above $B = \{B_t, t \in \mathbb{R}\}$, $V = \{V_t, t \geq 0\}$, $W = \{W_t, t \geq 0\}$ are respectively a fractional Brownian motion with Hurst parameter $H \in (0, 1/2)$ and two independent Wiener processes. The fractional Brownian motion B and the Brownian motion V are correlated, i.e.

$$\mathrm{E}B_t V_s = \gamma(t,s),\ t \in \mathbb{R},\ s \geq 0,$$

for some suitable, i.e. in particular positive definite, function $\gamma : \mathbb{R} \times [0, \infty) \to \mathbb{R}$, while B and W are independent. The rough volatility models of this type were introduced by J. Gatheral, T. Jaisson and M. Rosenbaum (2014).
The talk is concerned with the study of the strong approximation of the model above. Our methods are based on an equidistant discretization of the volatility process and of the driving Brownian motions respectively. For the root mean-square error at a single point the optimal rate of convergence that can be achieved by such methods is n^{-H}, where n denotes the number of subintervals of the discretization. This rate is in particular obtained by the Euler method and an Euler-trapezoidal type scheme.

Joint work with: Andreas Neuenkirch

Mikhail Urusov
University of Duisburg-Essen

Thu, 15:15
HS Chemie

Robust strategies for financing risky investments

We consider a venture capital investor who finances novel products and business models. Profitability of each product is an unobservable random variable, however, the investor sequentially gathers information about it by observing the cash flows generated by that product. We formulate the problem of loss minimization in taking the decision when to liquidate each product. One possibility would be to consider the Bayesian setting, that is, to solve the problem for a given prior distribution of the unknown profitability.
But since those financial products are new and often very different, it seems unlikely that experience with past products will allow the venture capitalist to form a precise prior about the profitability of any given project, and we, therefore, treat a certain robust formulation of that problem.
In the talk, we present a complete solution in a Brownian setting and also discuss a view on the problem as a zero-sum game, where the investor plays against nature. On the technical side, it is interesting to note that we do obtain a minimax theorem without randomizing stopping times, i.e., within a non-convex set of strategies.

Joint work with: Thomas Kruse • Philipp Strack

Section 4b: Finance, insurance and risk: Statistics

Valentine Genon-Catalot
Université Paris Descartes

Wed, 16:30
HS Anatomie

Inference for stochastic differential equations with random effects

Random effects models are of wide use in longitudinal data collected in clinical trials, epidemiology, pharmacokinetic pharmacodynamic experiments and agriculture. Random effects are incorporated to accomodate variability among subjects while the same structural model rules the dynamics of each subject.
In a series of papers, written jointly with Fabienne Comte (Université Paris Descartes, France), Maud Delattre (AgroParistech, France), Charlotte Dion (Université Pierre et Marie Curie, France), Catherine Larédo (I.N.R.A. and Université Paris Diderot, France), Adeline Samson (Université Grenoble Alpes, France), we have studied various aspects of statistical inference for stochastic differential equations with random effects. Assume that N *i.i.d.* real valued processes given by

$$dX_i(t) = b(\Phi_i, X_i(t))dt + \sigma(\Psi_i, X_i(t)dW_i(t), X_i(0) = x, \quad i = 1, \dots, N,$$

are observed on a time interval $[0, T]$, where observations may be either continuous or discrete and T may be fixed or large. The Wiener processes $W_1, \dots, W_N$ are independent, the random variables (Φ_i, Ψ_i), $i = 1, \dots, N$ are *i.i.d.* and independent of the Wiener processes. The random variables (Φ_i, Ψ_i) are the random efffects and are unobserved. It required to estimate the joint distribution of the random effects from the observed values of the processes $(X_i(t))$. We have investigated both parametric and non parametric inference for this distribution with asymptotic results as N tends to infinity while T is fixed or tends also to infinity. In the case where n discrete observations are available for each sample path, asymptotic results are obtained while both the number N of trajectories and the number n of observations per trajectory tend to infinity.

Bohan Chen
CWI

Thu, 11:10
HS Rundbau

Efficient Rare Event Simulation for Multiple Jump Events in Regularly Varying Random Walks and Compound Poisson Processes

We propose a class of strongly efficient rare-event simulation estimators for random walks and compound Poisson processes with a regularly varying increment/jump-size distribution in a general large deviations regime.
Our estimator is based on an importance sampling strategy that hinges on the heavy-tailed sample path large deviations result recently established in Rhee, Blanchet & Zwart (2016). The new estimators are straightforward to implement and can be used to systematically evaluate the probability of a wide range of rare events with bounded relative error. They are "universal" in the sense that a single importance sampling scheme applies to a very general class of rare events that arise in heavy-tailed systems.
In particular, our estimators can deal with rare events that are provoked by multiple big jumps (therefore, beyond the usual principle of single big jump) as well as multidimensional processes such as the buffer content process of a queueing network.
We illustrate the versatility of our approach with several applications that arise in the context of mathematical finance, actuarial science, and queueing theory.

References:

[1] Rhee, Blanchet & Zwart (2016). Sample path large deviations for heavy-tailed Lévy processes and random walks. eprint arXiv:1606.02795

Joint work with: Jose Blanchet • Chang-Han Rhee • Bert Zwart

Tobias Fissler
Imperial College London

Fri, 09:00
HS Rundbau

Elicitability and Identifiability of Measures of Systemic Risk

We establish elicitability and identifiability results for systemic risk measures of the form

$$R(Y) = \{k \in \mathbb{R}^n \mid \varrho(\Lambda(Y + k)) \leq 0\}.$$

Here, $\Lambda\colon \mathbb{R}^n \to \mathbb{R}$ is an increasing aggregation function, ϱ is a real-valued risk measure, and the random vector Y represents a system of n financial firms.
That means the risk measure $R(Y)$ takes an *a priori* perspective, being the set of all capital allocation $k \in \mathbb{R}^n$ which make the aggregated system $\Lambda(Y + k)$ acceptable under ϱ.
The elicitability of a risk measure, or more generally, a statistical functional amounts to the existence of a strictly consistent scoring or loss function. That is a function in two arguments, a forecast and an observation, such that the expected score is minimized by the correctly specified functional value, thereby encouraging truthful forecasts. Prominent examples are the squared loss for the mean and the absolute loss for the median. Hence, the elicitability of a functional is crucial for meaningful forecast comparison and forecast ranking, but also opens the way to M-estimation and regression.
An identification function is similar to a scoring function, however, the correctly specified forecast is the zero of the expected identification function rather than its minimizer, thus giving rise to Z-estimation and possibilities to assess the calibration of forecasts.
In this talk, we show the intimate link between the elicitability / identifiability of ϱ and R making use of an integral construction.
On the one hand, our results appear to be relevant and beneficial from an applied point of view. On the other hand, they turn out to be the first (non-trivial) results on *set-valued* functionals in the theory of elicitability, thereby establishing a novelty of theoretical interest on its own.

Joint work with: Jana Matyasovska • Birgit Rudloff

Christoph Gerhart
University of Freiburg

Wed, 11:10
HS Rundbau

Empirical Analysis and Forecasting of Multiple Yield Curves

The turmoil in the money market during the financial crisis of 2007/2008 was marked by spiking interbank spreads. Even after the crisis spreads remained at high levels opening a new era of interest rate markets characterized by multiple (tenor dependent) yield curves. This talk provides an in-depth empirical analysis of pre- and post-crisis term structures of interest rates. We suggest a consistent and stable approach for bootstrapping of multiple yield curves which we apply to market data over the time period 2005–2017. Based on the resulting daily changes of tenor-dependent yield curves we determine principal components characterizing the shape of yield curves and interest rate spreads and we relate these to various economic variables of credit and liquidity risk. Furthermore, we perform a sup-PCA and an independent principal component to study the dependence of the tenor curves. Finally, we develop a simple dynamic factor model to forecast tenor-dependent term structures of interest rates as well as of forward rates.

Joint work with: Eva Lütkebohmert-Holtz

Jakob Krause
MLU Halle-Wittenberg

Fri, 10:55
HS Rundbau

Is more data always better? Optimal data usage in non-stationary systems

Past Financial Crisis have shown that contemporary risk management models provide an unjustified sense of security and fail miserably in situations in which they are needed the most. In this paper we start from the assumption that risk is a notion that changes over time and therefore past datapoints only have limited explanatory for the current situation. Our objective is to derive the optimal amount of representative information by optimizing between the two adverse forces of estimator convergence, incentivising us to use as much data as possible, and the aforementioned non representativeness doing the opposite. In this endeavour a corner stone assumption of probability theory is weakened, identically distributed random variables and substituted by the assumption that the law of the data generating process changes over time. Hence, in this paper we give a quantitative theory on how to perform statistical analysis in non-ergodic systems.
As an application we discuss the impact of a paragraph in the last iteration of proposals by the Basel Committee on Banking Regulation.
We start from the premise that the severity of assumptions should correspond to the robustness of the system they describe. Hence, in the formal description of physical systems the level of assumptions can be much higher and therefore every concept that is carried over from the natural sciences to Economics must be checked for its plausibility in the new surroundings. Most of probability theory has been developed for the analysis of physical systems and is based on the i.i.d. assumption. In Economics both parts of the i.i.d. assumption are inappropriate. However, only dependence has, so far, been weakened to a sufficient degree. Parts of probability theory can be recast under (suitable) dependence. The corresponding theory is called ergodic theory. However, this focus makes one more vulnerable to the underlying assumptions of this theory and at the heart of those assumptions lies the notion of ergodicity, i.e. the representativeness of the past for the present. This is not appropriate and in this paper a quantitative theory of representativeness is given. The main objective of this paper is to derive the optimal amount of data within an evolutionary environment. Hence, here we weaken the 'i.d.' part of the i.i.d. assumption.
Methodically, a structure is introduced that carries the structure of representativeness in the form of an 'information metric' which measures the change in the underlying rules. For physical systems this metric is zero (or close to zero) since the laws of nature do not change (too much). In our setup we tie the information metric to people acting, i.e. market parameters. Formally we tie the information metric to the characteristics of a suitable class of semimartingales which will serve as the non-stationarity process we want to investigate.
Applications are far reaching in a variety of fields. In the paper itself we apply the results in order to analyse a paragraph in the Basel 3 framework on banking regulation. Other potential applications include the reproducibility crisis in the social sciences (but not in the natural sciences).

Ekaterina Krymova
Universität Duisburg-Essen

Thu, 12:00
HS Rundbau

Regularised empirical sieve approach for pricing kernel estimation

We study the problem of non-parametric estimation of the risk-neutral densities from options data. The underlying statistical problem is known to be ill-posed and needs to be regularised. We propose a novel regularised empirical sieve approach for the estimation of the risk-neutral densities which relies on the notion of the minimal martingale entropy measure. The proposed approach can be used to estimate the so-called pricing kernels which play an important role in assessing the risk aversion over equity returns. The asymptotic properties of the resulting estimate are analysed and its empirical performance is illustrated.

Joint work with: Denis Belomestny • Wolfgang Karl Härdle

Gunther Leobacher
University of Graz

Tue, 11:15
HS Rundbau

Utility indifference pricing of insurance catastrophe derivatives

We propose a model for an insurance loss index and the claims process of a single insurance company holding a fraction of the total number of contracts that captures both ordinary losses and losses due to catastrophes.
In this model we price a catastrophe derivative by the method of utility indifference pricing. The associated stochastic control problem is treated by techniques for piecewise deterministic Markov processes (PDMPs). We perform a numerical study that illustrates our results. This motivates research on the simulation of PDMPs in general.

Joint work with: Andreas Eichler • Michaela Szölgyenyi

Daniel Lingohr
University of Augsburg

Tue, 12:05
HS Rundbau

Continuous-time threshold autoregressions with jumps

Continuous-time autoregressive processes have been applied successfully in many fields and are particularly advantageous in the modeling of irregularly-spaced or high-frequency time series data. A convenient non-linear extension of this model are continuous-time threshold autoregressions (CTAR) introduced by Brockwell and Hyndman (1992, International Journal of Forecasting). CTAR processes allow for greater flexibility in model parameters and are able to represent a regime switching behavior. So far only Gaussian CTAR processes have been defined which are, however, not appropriate for modeling data with jumps as frequently observed in financial time series. Hence, in this talk we construct a jump-diffusion CTAR process as the first component of the solution to a stochastic differential equation which exhibits discontinuities in its drift coefficient. We prove existence of an unique weak solution as well as the weak consistency of an Euler approximation. Two estimation procedures are presented, one using an approximation of the density of the continuously observed process, and one using simulated transition probabilities. In a simulation study we asses the quality of these estimation procedures.

Joint work with: Gernot Müller

Gernot Müller
Universität Augsburg

Wed, 14:50
HS Rundbau

Modelling electricity prices using nearly alpha-stable processes

The electricity price model developed in Benth et al. (2014, Energy Economics) disentangles the spot price into three components: a trend and seasonality function, a CARMA process driven by an alpha-stable Lévy process, and an additional Lévy process for the long-term fluctuations. However, due to changing rules and regulations, changing market conditions, and a changing electricity production towards a higher proportion of renewable energies, electricity prices show a changing behaviour over time. Hence, we modify the model from Benth et al. (2014) by employing nearly alpha-stable processes which show locally a behaviour similar to alpha-stable processes, but allow for time-varying parameters. To estimate the model we develop an MCMC procedure and assess the quality of this estimation method in a simulation study. The data which motivates the project is taken from the data base of the European Energy Exchange EEX.

Joint work with: Boris Buchmann

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 4b: Finance, insurance and risk: Statistics

Vladimir Panov
Higher School of Economics

Thu, 10:45
HS Rundbau

Multivariate subordination of stable processes

Stochastic time change is a well-used tool for construction of stochastic models which are able to represent the so-called stylized features of stock prices. From mathematical point of view, the main idea is to change the deterministic time t of a stochastic process $X(t)$ (usually – of a Lévy process) by another increasing process $T(s)$. As a result, one obtains a process $Y(s) = X(T(s))$, which is referred to as a time-changed process. The economical interpretation of this model is based on the idea that the "business" time $T(s)$ may run faster than the physical time in some periods, for instance, when the amount of transactions is high. Due to this interpretation, Y_s represents the log-returns of a stock price, and a natural candidate for $T(s)$ is a cumulative number of trades till time s.
The most popular choice of a process X is a Brownian motion with or without drift. This choice is mainly based on the Monroe theorem, which says that the class of time-changed Brownian motions basically coincides with the class of all semimartingales.
In this research, we consider another case, when the class of stable processes is used for X. At the first glance, this idea doesn't bring to much to the existing theory, because the class of subordinated stable processes is included in the class of subordinated Brownian motions. Nevertheless, in the context of price modelling, the application of subordinated stable processes has several advantages. Some of these advantages can be shown numerically, and I will provide some empirical evidence that the considered model is more appropriate than the subordinated Brownian motion for describing the stock returns. Theoretically this can be explained by the observation that in our model rapid changes in log-returns are made not only due to jumps in number of trades (as in time-changed Brownian motion), but also due to stochastic factors, which are incorporated in X.
I will also present a multivariate time-changed model such that each component is a subordinated stable process and the dependence between subordinators is described via some Lévy copula. For the considered class, I will show a simulation method based on the series representation. Moreover, I will describe a method of semiparametric estimation of the parameters of copula and related distributions, and show some properties of the considered estimates. The performance of the proposed method will be illustrated by the examples related to the description of dependence between stock prices.

References:

[1] Panov, V. (2017). Series representations for multivariate time-changed Lévy models. *Methodology and computing in applied probability*, vol.19(1), pp. 97–119.
[2] Belomestny, D. and Panov, V. (2013). Estimation of the activity of jumps in time-changed Lévy models. *Electronic journal of statistics,* vol. 7. pp. 2970–3003.

Alois Pichler
TU Chemnitz

Thu, 11:35
HS Rundbau

Entropic Risk Measures

This talk introduces entropic risk measures. These coherent risk measures are based on different types of entropy. We elaborate their fundamental properties and relate them to other risk measures, to norms on specific Banach spaces. We further demonstrate their efficient use in stochastic optimization.

Matthias Reuber
Universität Siegen

Wed, 15:15
HS Rundbau

Stochastic models for hourly photovoltaic yields

The global importance of electricity provided by renewable energies and technologies such as photovoltaic (PV) has been continuously increasing. We want to evaluate the financial aspects of a PV plant transparently. Moreover, we want to analyze the impact of a rising PV production on electricity prices.

Therefore, we need stochastic models for probabilistic forecasting of the PV yield, which we develop using hourly radiation data. There already exists literature on daily PV yield models, but extensions on hourly PV yield models has not been comprehensively developed.
We introduce a general modeling framework for hourly PV yields and consider different models. Apart from the classical multivariate time series analysis methods, we also use models with a truncated Dirichlet distribution.
We compare the different models with each other and to simple benchmark models via so-called scoring rules. Besides the well known continuous ranked probability score (CRPS) we use the variogram score to evaluate the model performance with regard to hourly correlations.

Paulina Agata Rowińska
Imperial College London

Wed, 14:00
HS Rundbau

A multifactor approach to modelling the impact of wind energy on electricity spot prices

One of the main challenges of the 21^{st} century is reinforcing sustainable economic growth in order to tackle climate change. An important part of this task is a more effective use of renewable energy sources, such as wind power. From the economical point of view, these sources are notorious for being risky to invest in because of their unpredictability. This is due to their high dependence on the weather – and weather forecasts still do not reach a desirable accuracy.
Inspired by this problem, we aim to improve existing models of prices of electricity contracts. Reliable models give energy providers invaluable information that facilitates the process of decision making as well as encourages new investments in renewable energy sources.
We introduce a three-factor model for electricity spot prices, consisting of a deterministic seasonality and trend function as well as short- and long-term stochastic components, and derive a formula for futures prices. The long-term component is modelled as a Lévy process with increments belonging to a class of generalised hyperbolic distributions. We describe the short-term factor by Lévy semistationary processes: we start from a CARMA(2,1), i.e. continous-time ARMA model, and generalise it by adding a short-memory stochastic volatility. We further modify the model by including the information about the wind energy production as an exogenous variable. We fit our models to German and Austrian data including spot and futures prices as well as the wind energy production and total load data. Empirical studies reveal that taking into account the impact of the wind energy generation on the prices improves the goodness of fit.

Joint work with: Almut E. D. Veraart

Peter Ruckdeschel
Oldenburg University, Institute for Mathematics

Fri, 10:30
HS Rundbau

Robust Dynamic Regression Modelling for Extreme Value Distributions with Applications to Finance

In financial risk management, the required regulatory capital to a large extent is determined by some extreme events which makes extreme value statistics appealing for this purpose and motivates using the Generalized Pareto Distribution (GPD) as a natural candidate for the marginal distribution of the respective extreme exceedances.
To capture dynamics and potential non-stationarity, we allow for time-varying parameters of the GPD induced by a GLM-type model, where the regressors may be external or (transformed) past observations. To this end, we build up on results on L_2-differentiability for GLMs not restricted to exponential families. Still, the predictive power of a fitted GPD-GLM for risk assessment can easily be impaired by effects of non-recurrent outliers. Thus, throughout our analysis, in model selection, model fitting, and model validation, we head for robustness to immunize our modelling against such effects.
Model selection in this context is achieved by a suitable variant of gradient boosting. Model fitting uses optimally-robust influence functions and corresponding asymptotically linear estimators. The respective

fitted predictive distributions are validated with a tail continuous rating probability score adapted to a situation with potentially non-existing moments.
Our approach is computationally challenging, and good compromises between robustness and fast (classical) algorithms have to be sought.
We illustrate our approach at VW stock prize data.

Amirhossein Sadoghi
University of Hohenheim

Wed, 12:00
HS Rundbau

Attention to Bitcoin

In this paper, we investigate different channels of information to predict Bitcoin's volatility and abnormal returns. We analyze the textual data in news about blockchain technology, major currencies and macroeconomic, and we investigate the predictive and causal power of extracted information to model the dynamic of bitcoin price. We apply Latent Dirichlet Allocation technique to classify and decompose news text into topics, we then show how the sentimental value and time dimensional of the topics can predict market characteristics of bitcoin. We find that the uncertainty of economy can shift the attention of traders to an unregular market like bitcoin.

Maren Diane Schmeck
Bielefeld University

Tue, 11:40
HS Rundbau

The Seasonality in the Implied Volatility of Electricity Options

Seasonality is an important topic in electricity markets, as both supply and demand are dependent on the time of the year. Clearly the level of prices shows seasonal behaviour, and it is to expect that also the fluctuations are seasonal. We investigate empirically the seasonality in implied volatility of options on electricity futures. It turns out that the implied volatility can be described very well with a combination of a linear and an exponential term, corresponding to a classical long term – short term two factor model. Moreover, we find clear seasonal patterns in the level of the volatility depending on the delivery month of the futures, and compare the performance of several implementations of seasonality in the theoretical two factor framework.

Joint work with: Maren Diane Schmeck • Viviana Fanelli

Armin Seibert
University of Augsburg

Wed, 10:45
HS Rundbau

Central Bank Interest Rate Policy – Bayesian Analysis Using a Cross Nested AOP Model

The decisions of the FED or other central banks to lower or raise the key interest rate have a high impact on macroeconomic conditions like asset prices, employment or other interest rates. We investigate a model for these interest rates consisting of three (cross nested) autoregressive ordered probit models (CNAOP) considering different economic covariates. The major statistical work is to find the most suitable covariates. In this talk we focus on the stochastic part of the model. The hierarchy of the probit models is intended to mimic different levels of the decision. It can handle the high number of zeros very well (most times the interest rate is unchanged). Due to the presence of latent variables a maximum likelihood analysis is not feasible. We develop an MCMC estimation algorithm and test it in a simulation study. Finally, we apply the model on US data and make a forecast.

Joint work with: Gernot Müller • Andrei Sirchenko

Wayne Tarrant
Rose-Hulman Institute of Technology

Wed, 11:35
HS Rundbau

The utility of Basel III rules on excessive violations of internal risk models

The Basel III international regulatory framework for banks calls for the adoption of historical empirical distributions in the case that a bank's internal models fail in a significant way. If the historical distribution is the fallback to an internal model, it is important to know if the empirical distribution gives a better view of future reality. In this paper we look at the efficacy of risk measures on energy markets and across several different stock market indices. We calculate both the Value at Risk and the Expected Shortfall on each of these data sets. We consider several different durations and levels for the historical risk measures, looking at the numbers of violations that Basel III measures for its requirements. We also calculate different error measurements for the VaR and ES. Through our results we make some recommendations concerning the Basel III framework, with the computations here strongly indicating that the Bank for International Settlements should adopt harsher guidelines than are presently in place. We would offer firms the option of using internal models and reporting multiple risk measures or using historical empirical measures and only reporting a single measure.

Jeannette Woerner

Wed, 14:25
HS Rundbau

Modelling and inference for electricity prices by oscillating Ornstein–Uhlenbeck processes

Recently there have been proposed many models for electricity spot prices trying to capture the characteristic features of seasonalities and spikes in the prices. A common approach, motivated by time series analysis, is to remove the seasonalities first and then divide the remaining random part in a stochastic process accounting for the normal variations of the prices and one modelling the spikes, e.g. with a combination of Ornstein–Uhlenbeck processes with different speed of mean reversion.
We now propose to generalize the underlying stochastic process in such a way that we can include the seasonalities into our stochastic process and also reproduce the oscillating behaviour of the empirical autocorrelation function of the prices. We consider oscillating Ornstein–Uhlenbeck processes which belong to the class of continuous-time moving average processes and share the properties that the marginal distribution is determined by the driving process, hence infinitely divisible, and the correlation structure is determined by the kernel, hence in our case oscillating in combination with an exponential decay.
We show that a linear combination of the oscillating Ornstein–Uhlenbeck processes together with an Ornstein–Uhlenbeck process well fits the autocorrelation function of electricity spot prices and reproduces the spikes and on the other hand allows for an explicit formula for the forward price. Finally, we show, how we may infer the model parameters using empirical moments.

Joint work with: Daniel Kobe

Johanna F. Ziegel
University of Bern

Fri, 09:25
HS Rundbau

Robust forecast evaluation of expected shortfall

Motivated by the Basel 3 regulations, recent studies have considered joint forecasts of the important risk measures Value-at-Risk and Expected Shortfall. A large family of scoring functions can be used to evaluate forecast performance in this context. However, little intuitive or empirical guidance is currently available, which may render the choice of a scoring function awkward in practice. We therefore develop graphical checks (Murphy diagrams) of whether one forecast method dominates another under a relevant class of scoring functions, and propose an associated hypothesis test. We illustrate these tools with simulation examples and an empirical analysis of S&P 500 and DAX returns.

Joint work with: Krüger Fabian • Alexander Jordan • Fernando Fasciati

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Section 5a: Stochastic modelling in Physics

Margherita Disertori
Universität Bonn

Thu, 17:20
HS Anatomie

Random operators in quantum diffusion and history dependent stochastic processes.

Random operators play an important role in the study of physical properties of disordered materials. The prominent examples are random Schroedinger operators and random band matrices. In recent years they also proved to have unexpected connections to certain history dependent stochastic processes. I will give an overview and some results.

Diana Ackermann

Tue, 15:15
HS II Geolog.

Adaptive Calculation of Global Sensitivity Indices

Sensitivity analysis deals with quantifying the influence of random input variables on response functions of any kind, for example results from statistical or simulation models, as well as real measurements of complex systems. Aiming at a comprehensive analysis, namely for a whole range of possible input values, methods of global sensitivity analysis are effective, in contrast to a local view valuable at regions around specific parameter choices. Variance based sensitivity indices (also known as Sobol indices) quantify influences as proportions of the total variance caused by the input variables. To calculate these indices, variances of conditional expectations defined by multidimensional integrals are needed. This is often handled via (Quasi-) Monte Carlo or other numerical methods, in which the number of function evaluations is high. The integrals can also be approximated with multidimensional cubature rules.
We propose a novel algorithm that is based on adaptive approximation of the underlying integrals. A modification of the so called higher order sigma points serves as basis rule and is executed recursively via subdivision of the integration intervals. The sigma point method tries to approximate moments of a nonlinear function of random inputs with a deterministic set of points. It is based on the assumption that an approximation of probability densities is easier than of non-linear functions in general. It was designed to be applied in the sigma point Kalman filter that is widely used from signal processing to financial time series.
The new algorithm uses an adaptive refinement by subdivision and locally approximates the conditional and unconditional moments of the function needed for the sensitivity indices. Deciding upon a refinement is based on measures of the residuals when applying a linear model with quadratic terms. Compared to Quasi Monte Carlo methods the new algorithm leads to a reduced number of function evaluations while the precision can be controlled by the degree of refinement. If the global sensitivities depend on external design variables the precisely estimated sensitivity indices and conditional variances can then be used for experimental design, for example place new measurements where sensitivity to the parameters of interest is high. This can be compared to the standard approach based on local sensitivities and the Fisher Information Matrix.
The new algorithm is applied to an example in chemical reaction engineering. In this example the liquid phase complexation reactions of a promising lithium electrolyte, namely lithium bis(fluorosulfonyl)imide, in the solvent valeronitrile (VN) is investigated by Raman spectroscopy at ambient pressure and a temperature of 298 K. The sensitivity indices of the chemical equilibrium constants of each reaction on the observed Raman signals of the VN, which is bonded in a complex, and the signals of the unbonded

VN molecules are investigated for varied concentration of electrolyte and compared to the usually calculated local sensitivities.

Joint work with: Michael Bortz • Johannes Neuhaus • Erik von Harbou • Jörn Sass

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Diana-Camelia Conache
TU München

Tue, 11:15
HS II Geolog.

On the projection of the two-dimensional Ising model onto a line

This very simple model obtained by restricting the pure phases of the ferromagnetic nearest-neighbour Ising model on $\mathbb{Z}^2$ in the sub-critical regime to a line, e.g. $\mathbb{Z}0$, was introduced by Schonmann as an example of non-Gibbsian measures, in particular, as an example where the corresponding specification has an essential point of discontinuity. In the spirit of Dobrushin's idea of restoration of Gibbsianness, there were many attempts at investigating whether the Schonmann projection is a weak, respectively an almost Gibbs measure. The answer to the first question is yes, but the second question remains unanswered. In the same spirit, in a joint project with S. A. Bethuelsen, we investigate the one-sided point of view of this question, namely, if the Schonmann projection is a g-measure.

Joint work with: Stein Andreas Bethuelsen

Anton Klimovsky
Univerisät Duisburg-Essen

Wed, 11:35
HS II Geolog.

Fluctuations and the phase diagram of the complex BBM energy model

Branching Brownian motion (BBM) viewed as a random energy model (REM) plays a special rôle in the context of large strongly correlated random systems: the BBM energy model lies exactly at the border between the models with weak and strong correlations.
Motivated by the Lee and Yang theory of phase transitions, quantum physics, relationships with Riemann's ζ-function, we consider the complex BBM energy model with arbitrary correlations between real and imaginary parts of the energies.
We show that the phase diagram features three phases (I, II, III) which are exactly the same as in the complex Derrida's REM – a model with independent energies. We study the fluctuations of the rescaled partition function in all three phases as well as at the boundaries between them. It turns out that the fluctuations are different from those in the REM. In Phase I, and at the boundary I/II, we prove an a.s. and L^1 martingale convergence. Phase II is the so called glassy phase, where the partition function is dominated by the BBM particles with extremal positions. In Phase III and at the boundaries I/III and II/III, we prove a central limit theorem with a random variance. It turns out that in all phases the normalizing factors for the fluctuations does not depend on the correlation between the real and imaginary parts of the random energy.

Joint work with: Lisa Hartung

Jeanette Köppe

Tue, 14:25
HS II Geolog.

Stochastic optimal control theory for quantum systems

In 1966, E. Nelson established a new interpretation of quantum mechanics, whereby the particles follow some conservative diffusion process, i.e. forward-backward stochastic differential equations (FBSDEs), which are equivalent to the Schrödinger equation [1]. Until now, this equivalence has been applied in such a way that a known solution to the Schrödinger equation is used to integrate the stochastic differential equations numerically and analyze the statistical properties of the sample paths. Compared to the options available to treat classical systems this is limited, both in methods and in scope.
However, in analogy to classical mechanics, we show that finding the Nash equilibrium for a stochastic optimal control problem, which is the quantum equivalent to Hamilton's principle of least action, allows

to derive two aspects [2]: i) the Schrödinger equation as the Hamilton-Jacobi-Bellman equation of this optimal control problem and ii) a set of quantum dynamical equations which are the generalization of Hamilton's equations of motion to the quantum world. We derive their general form for the n-dimensional, non-stationary and the stationary case.
The resulting FBSDEs can be solved numerically without using the solution of the Schrödinger equation, which is done for many different systems, e.g. one- and two-dimensional harmonic oscillator, one-dimensional double-well potential or hydrogen atom.

References:
[1] E. Nelson (1966). Derivation to the Schrödinger Equation from Newtonian Mechanics. *Phys. Rev.* 150(4), 1079–1085
[2] J. Köppe, W. Grecksch, W. Paul (2017). Derivation and application of quantum Hamilton equations of motion. *Ann. Phys.* 529(3), 1600251

Joint work with: Michael Beyer • Markus Patzold • Wilfried Grecksch • Wolfgang Paul

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Lutz Mattner
Universität Trier

Tue, 14:50
HS II Geolog.

Empiristic probability theory: A new view of von Mises collectives

Probability theory, as established by Kolmogoroff (1933), is usually taught without sufficient clarification of its link to the physical world. Such a clarification was in principle provided by von Mises through the introduction of collectives in several publications from 1919 onwards, but in a somewhat informal and initially, under some natural formal interpretation, even inconsistent way. Although a satisfactory formalization (of collectives as such, but not of their role as links between the world and classical probability theory) and an existence theorem were soon obtained by Wald (1937) and improved by Feller (1939), the von Mises approach (which we call empiristic probability theory) apparently didn't really catch on.
With the aim of clarifying empiristic probability theory a bit further, we propose in our "one definition, no theorem" talk a formalization of the role of collectives as links between a (mathematical, more precisely Boolean) world and probability theory. In the empiristic probability theory thus obtained, of course probabilities are limits of relative frequencies, and for example the formula for elementary conditional probabilities is a theorem, but also, and importantly we think, it becomes very obvious that world events don't have probabilities.

References:
[1] W. Feller (1939). Über die Existenz von sogenannten Kollektiven. *Fundamenta Mathematicae* 32, 87–96.
[2] A. Kolmogoroff (1933). *Grundbegriffe der Wahrscheinlichkeitsrechnung*, Springer.
[3] R. von Mises (1928, 1936, 1951, 1972). *Wahrscheinlichkeit, Statistik und Wahrheit.*, four editions, Springer. The third edition is the final autoritative one, the fourth is "durchgesehen von Hilda Geiringer".
[4] A. Wald (1937). Die Widerspruchsfreiheit des Kollektivbegriffs der Wahrscheinlichkeitsrechnung, *Ergebnisse eine Mathematischen Kolloquiums* 8, 38–72.

Peter Nejjar
IST Austria

Tue, 11:40
HS II Geolog.

Second Class Particles at Shocks in TASEP

We consider the totally asymmetric simple exclusion process (TASEP) with a non-random initial condition that has a discontinuity (shock) in the particle density. If one inserts a "second class particle" in the system, it will follow the shock. For large time t, we show that the position of the second class particle fluctuates on the $t^{1/3}$ scale and we determine its limiting law.

Joint work with: Patrik Ferrari • Promit Ghosal

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Silke Rolles
TU Muenchen

Wed, 10:45
HS II Geolog.

Convergence of vertex-reinforced jump processes to an extension of the supersymmetric hyperbolic nonlinear sigma model

Vertex-reinforced jump processes are stochastic processes in continuous time that prefer to jump to sites that have accumlated a large local time. Sabot and Tarres showed interesting connections between vertex-reinforced jump processes and a supersymmetric hyperbolic nonlinear sigma model introduced by Zirnbauer in a completely different context.
In the talk, I will present an extension of Zirnbauer's model and show how it arises naturally as a weak joint limit of a time-changed version of the vertex-reinforced jump process.
It describes the asymptotics of rescaled crossing numbers, rescaled fluctuations of local times, asymptotic local times on a logarithmic scale, endpoints of paths, and last exit trees.

Joint work with: Franz Merkl • Pierre Tarres

Jan M. Swart

Wed, 11:10
HS II Geolog.

A fresh look at R-positivity

Let $(A(x,y))_{x,y\in S}$ be an aperiodic, irreducible, nonnegative matrix,
indexed by some finite set S. Then the classical Perron–Frobenius theorem tells us that there exists a function $f : S \to (0,\infty)$, which is unique up to scalar multiples, and a unique constant $c > 0$, such that $Af = cf$.
Here $c = \varrho(A)$, the *spectral radius* of A, which is defined as

$$\varrho(A) := \lim_{n\to\infty} \bigl(A^n(x,x)\bigr)^{1/n} \qquad (x \in S).$$

Using the Perron–Frobenius eigenfunction, A can be transformed into a probability kernel through the formula

$$P(x,y) := c^{-1} f(x)^{-1} A(x,y) f(y) \qquad (x,y \in S) \qquad (*).$$

This kernel has the following interpretation. Define a probability measure on the space of functions $\omega : \{0,\dots,n\} \to S$ by

$$\mu^{A,n}_{x,y}(\omega) := A(x,y)^{-1} \prod_{k=1}^{n} A(\omega_{k-1},\omega_k).$$

Then $\mu^{A,n}_{x,y}$ is a Gibbs measure with *transfer matrix* A and boundary conditions x, y. It is not hard to prove that in the one-sided infinite volume limit, as $n \to \infty$ for fixed x, the Gibbs measure $\mu^{A,n}_{x,y}$ converges to the law of a Markov chain with transtion kernel P and initial state x.
In the 1960ies, David Vere-Jones proved that if S is countably infinite and A can be transformed into a recurrent probability kernel P as in $(*)$, then such a P is unique. The matrix A is called *R-recurrent* if such a P exists and *R-transient* otherwise. If P is positive recurrent, then A is called *R-positive*.
Let us say that A is *strongly R-positive* if P is positive recurrent and its return times have exponential moments of some positive order. Then I will prove the following two statements:

- A is strongly R-positive if and only if lowering the value of finitely many matrix entries lowers the spectral radius.
- A is R-transient if and only if it is possible to raise the value of finitely many matrix entries without raising the spectral radius.

This is an improvement compared to existing conditions for R-positivity which require explicit knowledge of $\varrho(A)$. I will show how the new conditions can be used to prove sharpness of the phase transition for a large class of pinning models.

Martin Venker
Ruhr-Universität Bochum

Wed, 12:00
HS II Geolog.

The Elliptic Fixed Trace Ensemble: Universality at Strong and Weak non-Hermiticity.

In this talk, we consider spectral statistics of fixed trace ensembles of $N \times N$ random matrices with complex entries. Heuristically speaking, these are obtained by fixing the trace $\mathrm{Tr}(XX^*)$ of the matrix X from the elliptic Ginibre ensemble. In contrast to the well-studied elliptic ensemble, these random matrices are non-Gaussian and possess non-determinantal joint densities of the complex eigenvalues. We study global and local bulk statistics, in particular in the limit of weak non-Hermiticity introduced by Fyodorov, Khoruzhenko and Sommers. Here, the matrices are almost Hermitian and the support of the limiting measure collapses to the real line. This limit was motivated by physics applications and interpolates between the celebrated sine and Ginibre kernels. Our results constitute a first proof of universality of the interpolating kernel and give the first large N asymptotics for non-Hermitian fixed trace ensembles. Furthermore, in the limit of strong non-Hermiticity, where the support of the limiting measure is an ellipse in the complex plane, we obtain local Ginibre statistics in the bulk of the spectrum.

Joint work with: Gernot Akemann • Milan Cikovic

Steffen Winter
Karlsruhe Institute of Technology

Tue, 12:05
HS II Geolog.

Geometric Functionals of Fractal Percolation

Fractal percolation is a family of random sets suggested by Mandelbrot in the seventies to model certain aspects of turbulence. They are known to undergo a very sharp phase transition from a totally disconnected to a percolating regime, when the continuous parameter of the models passes some threshold. The exact values of these percolation thresholds remain unknown until today, and the known rigorous upper and lower bounds are still rather far from each other.
In the recent physics literature (see e.g. Mecke, Neher, Wagner, J. Stat. Mech. 2008; Klatt, Schröder-Turk, Mecke, J. Stat. Mech. 2017) the idea is explored that the sharp topological transition at the threshold in percolation models should be visible in geometric functionals such as the (expected) Euler characteristic of these sets. Indeed, simulations suggest a close relation between percolation thresholds and the zeros of the Euler characteristic (as a function of the model parameter) in many percolation models. Motivated by the desire to find better bounds on percolation thresholds for fractal percolation, we study the expectations of some geometric functionals of the construction steps of fractal percolation (or rather their rescaled limits). These functionals are closely related to fractal curvatures. We obtain explicit formulas for some of these limit functionals including some rescaled Euler characteristic and compare them to the known bounds for percolation thresholds.

Joint work with: Michael Klatt

Section 5b: Stochastic modelling in Biology

Alison Etheridge
University of Oxford

Thu, 16:30
HS Anatomie

Modelling populations under fluctuating selection

It has been recognised for a very long time that natural selection is not necessarily a constant force acting on a population; for example the genetic types favoured in a wet year may be different from those favoured in a dry year. As a result, fluctuating environmental conditions can maintain a balance between the different genotypes over extended periods. If, for example, we suppose that selection is acting on a single gene, then it is straightforward to write down a stochastic (ordinary) differential equation that captures the evolution of the frequencies of the different types of that gene (alleles) in the population. Crucially, such models can also capture genetic drift – the randomness due to reproduction in a finite population. What is much less studied is the evolution of allele frequencies in a population that is spatially structured.
Here we discuss one such model, based on the so-called spatial Lambda-Fleming–Viot process, that can capture something of the interplay between fluctuating selection and genetic drift. We shall see that when viewed over sufficiently large spatial and temporal scales, in at least two spatial dimensions, allele frequencies are dominated by the fluctuations due to the environment and can be captured by an spde. Ideally, one would be able to capture family struture in the population. As time permits we shall explain some partial results in this direction.

Luisa Andreis
Weierstraß-Institut für Angewandte Analysis und Stochastik (WIAS), Berlin

Thu, 12:00
HS II Geolog.

Ergodicity of a system of interacting random walks with asymmetric interaction

We consider a system of interacting one-dimensional random walks where an asymmetric mean-field interaction may give ergodicity. For a fixed $N \geq 2$, we consider N particles evolving in $\mathbb{N}$. We provide every particle with an intrinsic dynamics given by a biased random walk reflected in zero, which gives clearly a transient process. Therefore, we add an asymmetric interaction that pushes each particle towards the origin and depends only on the fraction of particles *strictly at its left*. We focused on the critical interaction strength above which the N particle system and its corresponding nonlinear limit have a stationary measure, balancing the tendency of the biased random walks to escape to infinity. Similar models have been treated in the continuous setting with diffusive dynamics, considering systems of particles interacting through their *cumulative distribution function*. The discrete model we consider displays a peculiar difference: the particles can form large clusters on a single site and, according to our description, they cannot interact. This gives rise to non-trivial expression for the critical interaction strength and the stationary measures, unexpected from the analysis of the continuum model.

Joint work with: Amine Asselah • Paolo Dai Pra

Gabriel Hernan Berzunza Ojeda
Georg-August-Universität Göttingen

Thu, 11:10
HS II Geolog.

On interacting particle systems and Darwinian evolution

The study of interactions between organisms and their environment that influence their performance, reproductive success, and contribute to phenotype variation, i.e. Darwinian evolution, it is a major

problem in evolutionary ecology and population genetics. In this talk, we are interested in modelling the dynamic of populations as a Markov point process whose generator captures the dynamics over continuous time of a branching process with mutation which behavior may depend on each individual's trait and the iterations between them, namely the competition between individuals for limited resources. Traits are hereditarily transmitted from a parent to its offspring unless a mutation occurs. In this case, the offspring makes an instantaneous mutation step at birth to new trait values. We are interested in generalize previous microscopic point of views by allowing individuals to have multiple offspring at the reproduction event. Moreover, the reproduction law may also be influenced by the phenotype variation due to mutation. In the context of ecology most of the models that have been used for the study of cell division rely on binary fission. However, some organisms follow alternative reproductive strategies in order to remain competitive and propagate, which include multiple offspring mechanisms. By combining various scalings on population size, birth and death rates, mutation rate, mutation step, we establish a superprocess limit for the interacting particle system described previously. This new superprocess appears as a generalization of the existing models for spatially structured populations.

Joint work with: Anja Sturm • Anita Winter

Bjarki Eldon

Wed, 15:15
HS II Geolog.

Modeling gene genealogies in highly fecund populations

Highly fecund populations abound in nature, yet traditional mathematical population genetic models do not capture high fecundity. Only very recently have models begun to emerge which explicitly formulate *high fecundity coupled with sweepstakes reproduction* (abbreviated HFSR). Of immediate concern is how to detect HFSR in genetic and genomic data. We address this problem by considering coalescent processes derived from population models of HFSR. In particular, we are interested in the impact of 'large' sample size on the coalescent approximation of gene genealogies in finite HFSR populations.
Our results identify limits of population genetic data in distinguishing between models. We also investigate how the genomic (or multi-locus) genealogy of a sample compares to the genomic genealogy of the whole population. Our work asks fundamental questions of the coalescent approach — i.e. what can we really conclude from inference methods that apply the coalescent approach.

Joint work with: Alison Etheridge

Fabian Freund
University of Hohenheim

Wed, 14:50
HS II Geolog.

Coalescent trees - do subsamples reach the root?

We consider Λ-n-coalescents, which are exchangeable Markovian processes whose state space is the set of the partitions of $\{1, \dots, n\}$, all transitions are mergers of partition blocks. A Λ-n-coalescent can be interpreted as a random trees with n leaves and random branch lengths, its distribution is characterized by a finite measure Λ on $[0, 1]$.
Consider now a subsample of m of the n leaves drawn at random and the subtree spanned by them. What is the probability that the root of the subtree is the root of the complete coalescent tree?
For Kingman's n-coalescent (Λ being the point mass in 0), which allows only for binary mergers, this probability equals $\frac{m-1}{m+1}\frac{n+1}{n-1}$, see [1]. For the more general class of Λ-n-coalescents, we show that this probability can be computed recursively and analyse the asymptotics for m fixed, $n \to \infty$. For Beta-n-coalescents (Λ being a Beta distribution with parameters $(2-\alpha, \alpha)$ with $\alpha \in [1, 2)$), we express the limiting probability via independent Bernoulli variables ($\alpha = 1$) or random variables following Slack's distribution.
Kingman's n-coalescent is a standard model for the genealogy of n individuals in a large randomly mating population, while Λ-n-coalescents have been proposed as genealogy models for samples from populations with highly skewed offspring distributions. We discuss the implications of our theoretical results for the planning and analysis of population genetic studies.

References:

[1] Saunders, Ian W., Simon Tavaré, and G. A. Watterson. "On the genealogy of nested subsamples from a haploid population." Advances in Applied probability 16.3 (1984): 471–491.

Joint work with: Bjarki Eldon • Alison Etheridge

Carolin Herrmann
Bielefeld University

Thu, 14:50
HS II Geolog.

Ancestral lines under selection and recombination

This talk deals with the deterministic limit of the Moran model under selection and recombination that take place on the same time scale.
We begin with a single selected site and one linked neutral site and formulate their ancestral selection-recombination graph.
The benefit of using the ancestral selection-recombination graph is twofold: It allows us to determine the type distribution of individuals along with their genealogy, and it yields a closed solution of the deterministic selection-recombination equation.
We generalize the results to one selected site with two, and then with an arbitrary number of linked neutral sites.

Joint work with: Ellen Baake

Markus Heydenreich
LMU München

Thu, 11:35
HS II Geolog.

Uniformity of hitting times of the contact process

We consider the supercritical contact process started from a single infected particle conditioned on survival. Like many other growth processes, it exhibits a shape theorem, which states that the "once infected area"

$$H_t = \{x \in \mathbb{Z}^d : x \text{ is infected before time } t\}, \quad t \geq 0,$$

grows linearly in time.
The shape theorem and its variants describe the global picture of the infection, that is, how fast is the infection spreading through space macroscopically. What can be said about the evolution on a microscopic level is not covered. Moreover, the shape theorem alone does not make predictions on how wildly hitting times fluctuate locally or to what degree of monotonicity sites are visited in the order of increasing distance to the origin.
This talk zooms in on the boundary of the set H_t, and we prove that H_t grows in a highly uniform way. To this end, we establish two uniformity results for the hitting times $t(x)$, defined for each site x as the first time at which it becomes infected. First, the family of random variables $(t(x) - t(y))/|x - y|$, indexed by $x \neq y$ in $\mathbb{Z}^d$, is stochastically tight. Second, for each $\varepsilon > 0$ there exists x such that, for infinitely many integers n, $t(nx) < t((n+1)x)$ with probability larger than $1 - \varepsilon$. A key ingredient in the proofs is a tightness result concerning the essential hitting times of the supercritical contact process introduced by Garet and Marchand (Ann. Appl. Probab., 2012).

Joint work with: Christian Hirsch • Daniel Valesin

Sebastian Hummel
Bielefeld University

Thu, 14:00
HS II Geolog.

Lines of descent in a deterministic model with mutation, selection and pairwise interaction

We consider a classical deterministic model for the evolution of a haploid population with two allelic types which is subject to mutation, selection, and a special form frequency-dependent selection. The deterministic model arises (also) as the large population limit of the Moran model, in which neither parameters nor time are rescaled. Despite the deterministic nature of this limiting process, the ancestry of single individuals in the population is still stochastic. In the case with mutation and selection, we describe it via a killed ancestral selection graph and connect it to the deterministic process via duality; this leads to a stochastic representation of the deterministic solution. In particular, the stationary state obtains a nice probabilistic interpretation. We generalise the construction to the case with frequency-dependent selection.

Joint work with: Fernando Cordero • Ellen Baake

Elisabeth Huss
Albert-Ludwigs-Universität Freiburg

Thu, 14:25
HS II Geolog.

Tree lengths under additive selection

When studying evolutionary models of a constant-size population, individuals are related through joint ancestry, which lead to the genealogy relating all individuals of the population. While neutral evolution leads to Kingman's coalescent, we are interested in a scenario of two allelic types under weak selection. It is generally believed that genealogical distances under additive selection are shorter than under neutrality. For a sample of size two, this is shown by Depperschmidt, Greven and Pfaffelhuber (2012), who investigate the Laplace-transform of pairwise genealogical distances in the selective case for small selection coefficients. We extend this result and give an explicit formula for the Laplace-transform of the total tree length of n sampled points. We do so by investigating the equilibrium of the tree-valued Fleming–Viot process with mutation and selection.

References:

[1] A. Depperschmidt, A. Greven, P. Pfaffelhuber (2012).Tree-valued Fleming-Viot dynamics with mutation and selection. *The Annals of Applied Probability* 22(6), 2560–2615

Richard Kraaij

Thu, 10:45
HS II Geolog.

Freidlin–Wentzell type large deviations for population dynamics

We consider path-space large deviations around the limiting behavior of multi-species population dynamics. We approach this problem via an analytic method introduced by Feng and Kurtz [1] based on uniqueness of solutions to a class of associated Hamilton–Jacobi equations.
The natural state-space for the limiting dynamics is given by $(\mathbb{R}^+)^d$, where d is the number of involved species. This nature of the discrete models introduces non-standard boundary conditions for the Hamilton–Jacobi equation. We show that (among others) we can treat a broad class of models in which there is immigration and emigration for each species.

References:

[1] J. Feng, T.G. Kurtz (2006). *Large Deviations for Stochastic Processes*, American Mathematical Society

Joint work with: Louis Mahé

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Section 5b: Stochastic modelling in Biology

Anna Katharina Kraut

Wed, 16:30
HS II Geolog.

A stochastic individual-based model for cancer immunotherapy

We present an extension of a standard stochastic individual-based model for evolution in an asexual population which broadens the range of biological applications and is in particular able to describe some experiments in cancer immunotherapy, where tumours avoid detection through inflammation-induced reversible dedifferentiation to a therapy resistant form.
In the standard model a population consisting of different traits with a large but non-constant population size is characterized by its natural birth rates, logistic death rates modelling competition, and the probability of mutation at each birth event. The evolution of the population is then described by a measure-valued Markov process.
In the extended model we distinguish between three different types of actors: tumour cells (characterized by their pheno- and genotypes), cytotoxic T-cells, and cytokines. The T-cells interact with the tumour cells displaying the differentiated phenotype in a predator-prey-like way. Furthermore, we include an environment-dependent switch between phenotypes, not affecting the genotype. We argue why understanding purely stochastic events may help to understand the resistance of tumours to various therapeutic approaches and may have non-trivial consequences on tumour treatment protocols.
Recently, new experiments have lead to a further modification of the model. The possibility of mutation to a different genotype that permanently displays the resistant phenotype has been added and also the effects of T-cell exhaustion and the spatial structure of the tumour have gained importance in the new setting and are now included. We study the interplay of genetic mutations and phenotypic switches on different timescales, where the originally unfit resistant mutant can grow under therapy and thus even help the wildtype's survival.
The extended model has been implemented as an Gillespie-like algorithm to simulate the process of immunotherapy. Since the number of cells in a tumour is large, we combine deterministic simulation of frequent events and stochastic simulation of rare events to decrease the running time of the algorithm.

Joint work with: Martina Baar • Anton Bovier

Martin Möhle

Wed, 14:25
HS II Geolog.

The collision spectrum of Λ-coalescents

Λ-coalescents model the evolution of a coalescing system in which any number of blocks randomly sampled from the whole may merge into a larger block. For the coalescent restricted to initially n singletons we study the collision spectrum $(X_{n,k} : 2 \leq k \leq n)$, where $X_{n,k}$ counts, throughout the history of the process, the number of collisions involving exactly k blocks. Our focus is on the large n asymptotics of the joint distribution of the $X_{n,k}$'s, as well as on functional limits for the bulk of the spectrum for simple coalescents. Similarly to the previous studies of the total number of collisions, the asymptotics of the collision spectrum largely depends on the behaviour of the measure Λ in the vicinity of 0. In particular, for beta(a,b)-coalescents different types of limit distributions occur depending on whether $0 < a \leq 1$, $1 < a < 2$, $a = 2$ or $a > 2$.

Joint work with: Alexander Gnedin • Alexander Iksanov • Alexander Marynych

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Stephanie Nargang
TU Dresden

Wed, 17:20
HS II Geolog.

Relaxed Network Deconvolution

Network deconvolution is the task of distinguishing between links that represent direct relationships and links that represent indirect relationships in observed networks. In this talk, we present a 'relaxed' method for network deconvolution, which is a further development of an algorithm introduced by [Feizi (2013)]. With this new algorithm we are able to infer direct network links from observation of

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indirect links, robust with respect to observation error. Also the algorithm allows to incorporate a priori information on the network structure.
Let A denote the weighted adjacency matrix of a network. By dividing each row of A by its rowsum, we obtain the transition matrix P of a random walk, which moves from node i to node j with probability proportional to the strength of the link from i to j, relative to all outgoing links of i. The probabilities of k-step transitions are described by P^k. Moreover assume, that the random walk terminates after each step with a fixed probability $\alpha \in (0,1)$. Then the emergence of direct effects from indirect effects can be described by the following 'network convolution' equation:

$$P_{\text{obs}} = (1-\alpha)\, P_{\text{dir}} \left(I - \alpha P_{\text{dir}}\right)^{-1}.$$

With simple matrix algebra, we obtain the reversal of this process, which is called 'network deconvolution'.

$$P_{\text{dir}} = \frac{1}{1-\alpha} P_{\text{obs}} \left(I + \frac{\alpha}{1-\alpha} P_{\text{obs}}\right)^{-1}, \qquad \text{for } \alpha > \frac{1}{2}. \tag{0.1}$$

Still, when using real data, the input matrix is most likely contaminated and (0.1) gives no guarantee for perfect recovery. Therefore we introduce the 'relaxed network deconvolution', which means that instead of solving the deconvolution equation, we solve its linear relaxation

$$\min_{P_{\text{dir}} \in \mathcal{S}} \left\| \alpha P_{\text{dir}} P_{\text{obs}} + (1-\alpha)\, P_{\text{dir}} - P_{\text{obs}} \right\|_2^2$$

where $\mathcal{S}$ is the set of stochastic matrices.
In addition to the theoretic discussion, we show an application to gene regulatory networks (data provided by the DREAM5-Challenge) and show the significant improvement of our algorithm upon previous methods from [Feizi (2013)] as well as other known methods.

References:

[1] S. Feizi, D. Marbach, M. Médard, M. Kellis (2013). *Network deconvolution as a general method to distinguish direct dependencies in networks*, Nature biotechnology

Joint work with: Martin Keller-Ressel

Cornelia Pokalyuk
Universität Frankfurt

Thu, 15:15
HS II Geolog.

Maintenance of diversity in a parasite population capable of persistence and reinfection

We study the dynamics and the maintenance of diversity in a population of parasites distributed over its hosts, if the parasite is capable to reinfect and persist in its host and balancing selection maintains diversity within hosts.
We model the evolution of a two-type parasite population by a Markov jump process $X^{N,M}$ whose evolution is driven by three factors: a) parasite reproduction, b) host replacement and c) reinfection. Within hosts, parasites reproduce subject to balancing selection. Whenever a host dies, it is replaced by a new, so far uninfected host, which instantly suffers a primary infection by a randomly chosen infected host. At primary infection the host is infected with a single type chosen randomly according to the type frequencies in the infecting host. At reinfection a single parasite in the reinfected host is replaced by a randomly chosen parasite transmitted from the infecting host. Only some of these reinfections are "successful", in the sense that reinfection takes the type frequency of a beforehand single-type infected host to the (quasi-)equilibrium.
Now assume that parasite reproduction is much faster than host replacement, and successful reinfection and host replacement act on the same time scale. Then in the limit of a large parasite population ($N \to \infty$) and large host population ($M \to \infty$) we show that $X^{N,M}$ converges under moderate

selection to a mean-field limit, in which host type frequencies concentrate on the three values 0,1 and the equilibrium frequency of the balancing selection. In particular, there exists a stable equilibrium distribution, at which all three host types are present at a non-trivial amount.
This evolutionary model for a parasite population is motivated from DNA data of the cytomegalovirus, a widespread herpesvirus leading in the majority of hosts to an asymptomatic infection, which nevertheless is of high medical relevance in immunocompromised hosts, like transplantation patients, HIV patients or fetuses. Under the assumption that within-host-diversity is necessary for parasite survival, our analysis shows that the capability of the parasite for persistence and reinfection allows the parasite to maintain the diversity on a longterm scale even in the absence of frequent mutation.

Joint work with: Anton Wakolbinger

Sebastian Probst
Bielefeld University

Fri, 10:55
HS II Geolog.

How large is infinity? Simulations and heuristics for a stochastic model of Lenski's long-term evolution experiment

Based on the law of large numbers limit in [1] for the long-term evolutionary experiment (LTEE) of Richard Lenski [2], we develop heuristics and stochastic simulations for the Cannings model that describes the LTEE for finite population size. Both the heuristics and the simulations convincingly reproduce the observations of the LTEE, and allow to estimate the corresponding model parameters. We quantify
the contributions of various effects to the relative fitness curve, namely, the interaction of mutations in the same individual (so-called epistasis), the interaction of mutations in different individuals (clonal interference), the design of the experiment (resulting in a run-time effect), as well as the effect of moment closure (used in the approximation).
This is joint work with Adrián González Casanova and Anton Wakolbinger.

References:

[1] A. González Casanova, N. Kurt, A. Wakolbinger, and L. Yuan (2016). An individual-based model for the Lenski experiment, and the deceleration of the relative fitness. *Stoch. Proc. Appl.* 126(8), 2211–2252
[2] M. J. Wiser, N. Ribeck, and R.E. Lenski (2013). Long-term dynamics of adaptation in asexual populations. *Science* 342(6), 1364–1367

Joint work with: Ellen Baake • Adrián González Casanova • Anton Wakolbinger

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Christian Rau

Wed, 16:55
HS II Geolog.

On the Averaging of Gram Matrices in Random Tomography

The stochastic Radon transform of V. Panaretos provides a statistical framework for investigating the structure of biological particles with cryo-electron microscopy. The main challenge of this model consists in the fact that the data are tomographic projections at randomly (Haar) distributed orientations.
In order to reduce the reconstruction problem to finite dimensions, Panaretos modeled the particle as a mixture of spherical Gaussians.
The practical implementation of the estimation in Panaretos and Konis (2011) faced considerable challenges, in particular regarding the labeling of the modes of the Gaussian components with the aid of the mixing weights.
We clarify the interplay of the model parameters by way of a new probabilistic interpretation.
This and other insights suggest modifications to the reconstruction procedure in various places, as we will explain.

References:

[1] V. M. Panaretos, K. Konis (2011). Sparse approximations of protein structure from noisy random projections. *Annals of Applied Statistics* 5(4), 2572–2602

Anja Sturm

Universität Göttingen

Wed, 14:00
HS II Geolog.

On classifying genealogies for general diploid exchangeable population models

The genetic variation in a sample of individuals/genes depends on their relatedness which is described by their genealogy. In this talk we consider the genealogies of exchangeable diploid population models with fixed size N asymptotically as N tends to infinity.
This result complements work by Möhle and Sagitov (2001) who characterized all possible limit processes for haploid Cannings models in which each individual is represented by one of its genes and thus each offspring (gene) has a unique parent. In contrast we study the diploid bi-parental analogues of the Cannings model. Here, the next generation is composed of offspring of parent pairs, which form an exchangeable (symmetric) array. Also, every individual carries two gene copies, each of which is inherited from one of its parents.
Our main result classifies the limiting coalescent processes describing the gene genealogies in this case. Using this general result we determine the limiting coalescent in a number of examples of which some have been studied previously (in special cases) and some are new. For these models we show that depending on the tail behavior of the offspring numbers the limit process is Kingman's coalescent with coalescence of pairs or is given by coalescents with simultaneous multiple mergers, in which several larger groups may find a common ancestor at the same time.

Joint work with: Matthias Birkner • Liu Huili

Anton Wakolbinger

Fri, 10:30
HS II Geolog.

Scaling limits in a stochastic model for Lenski's long term evolution experiment

The long term evolution experiment of Richard Lenski [2], which by now has been going on in a daily rhythm for 30 years, not only provides fascinating insights into the biological evolution of E. coli, but also turns out to be a challenge for stochastic modeling and analysis, not least because the experiment provides a picture book scenario for a Cannings model from population genetics. We will report on joint work with A. Gonzáles Casanova, N. Kurt and L. Yuan [1], which for a suitable parameter regime leads to a dynamical law of large numbers limit for the curve of the relative fitness. The talk of S. Probst and E. Baake will show comparisons of this limit result to simulation studies that incorporate the discrete nature of the fitness increments as well as the effects of the so-called clonal interference.

References:

[1] A. González Casanova, N. Kurt, A. Wakolbinger and L. Yuan (2016), An individual-based model for the Lenski experiment, and the deceleration of the relative fitness, *Stoch. Processes Appl.* 126 (2016), 2211–2252
[2] R. E. Lenski (2017), The E. coli long-term experimental evolution project site. http://myxo.css.msu.edu/ecoli

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Section 6: Stochastic optimization and operations research

Andrzej Ruszczynski
Rutgers University New Brunswick

Tue, 17:30
HS Anatomie

Risk-Averse Control of Partially Observable Markov Systems

We consider risk measurement in controlled partially observable Markov systems in discrete time. In such systems, part of the state vector is not observed, but affects the transition kernel and the costs. We introduce new concepts of risk filters and study their properties. We also introduce the concept of conditional stochastic time consistency. We derive the structure of risk filters enjoying this property and prove that they can be represented by a collection of law invariant risk measures on the space of function of the observable part of the state. We also derive the corresponding dynamic programming equations. Then we illustrate the results on a clinical trial problem and a machine deterioration problem. In the final part of the talk, we shall discuss risk filtering and risk-averse control of partially observable Markov jump processes in continuous time.

Todor Bilarev

Wed, 11:10
SR Geologie

Optimal Liquidation under Stochastic Liquidity

We solve explicitly a two-dimensional singular control problem of finite fuel type for infinite time horizon. The problem stems from the optimal liquidation of an asset position in a financial market with multiplicative and transient price impact. Liquidity is stochastic in that the volume effect process, which determines the inter-temporal resilience of the market, is taken to be stochastic, being driven by own random noise. The optimal control is obtained as the local time of a diffusion process reflected at a non-constant free boundary.To solve the HJB variational inequality and prove optimality, we need a combination of probabilistic arguments and calculus of variations methods, involving Laplace transforms of inverse local times for diffusions reflected at elastic boundaries.

Joint work with: Dirk Becherer • Peter Frentrup

Sascha Peter Desmettre
TU Kaiserslautern

Wed, 17:45
SR Geologie

Worst-Case Optimal Investment in Incomplete Markets

We study the worst-case optimal portfolio problem as pioneered in [1] of an investor with logarithmic preferences facing the possibility of a market crash with stochastic market coefficients by adapting the martingale approach developed in [2]. With the help of backward stochastic differential equations (BSDEs) as in [3] we are able to characterise the resulting indifference optimal strategies in a fairly general setting. We also deal with the question of existence of those indifference strategies for market models with an unbounded market price of risk by a suitable approximation and a corresponding convergence result. Our approach is subsequently demonstrated for the Heston stochastic volatility model and the Scott model for a stochastic excess return. We therefore solve the corresponding BSDEs via solving their asscociated PDEs using a utility crash-exposure transformation.

References:

[1] Korn, R., Wilmott, P., 2002, Optimal Portfolios under the Threat of a Crash, International Journal of Theoretical and Applied Finance 5 (2), 171–187.
[2] Seifried, F.T., 2010, Optimal Investment for Worst-Case Crash Scenarios: A Martingale Approach, Mathematics of Operations Research 35, 559–579.
[3] El-Karoui, N., Peng, S., Quenez, M.C., 1997, Backward Stochastic Differential Equations in Finance, Mathematical Finance 7(1), 1–71.

Joint work with: Sebastian Merkel

Christian Drescher
University of Augsburg

Fri, 10:55
SR Geologie

Efficient Computation of the Prokhorov Metric for Discrete Distributions

On the space of probability measures on a metric Polish space, the Prokhorov metric represents one of the most popular distances between probability distributions.
As it is the sole metric equivalent to the weak topology without further assumptions, it is mostly considered from a theoretical point of view.
The first and only work regarding the computation of the Prokhorov metric for discrete distributions is by Garel & Massé (2009), utilizing the connection to the Ky Fan metric (Strassen, 1965).

In our presentation, we first demonstrate that their approach fails for specific problem instances, before we introduce an alternative fully effective approach.
By distinguishing three different settings, we are able to provide algorithms with proven correctness, together with their worst case complexities.
While the first two algorithms work for the general case without any assumptions, we introduce the notion of a quasiconvex metric to obtain faster algorithms for totally ordered spaces.
We conclude with a quasilinear algorithm for the most important case of real numbers with the usual metric.

References:

[1] Garel, B. & Massé, J. C. (2009). Calculation of the Prokhorov distance by optimal quantization and maximum flow. *Advances in Statistical Analysis* 93(1), 73 – 88
[2] Strassen, V. (1965). The Existence of Probability Measures with Given Marginals. *The Annals of Mathematical Statistics* 36(2), 423–439

Joint work with: Jonas Schwinn • Ralf Werner

Giorgio Ferrari

Wed, 11:35
SR Geologie

On a Dividend Problem with Capital Injection over a Finite Horizon

At the end of the 1980s, Nicole El Karoui and Ioannis Karatzas established the connection between the so-called reflected follower stochastic control problem of a Brownian motion and an optimal stopping problem with absorption at zero.
In this talk we prove a similar link in the case in which the controlled process is a Brownian motion with drift, and its reflection at zero is costly. These results pave the way for analysing an optimal dividend problem with capital injection over a finite time-horizon.

Joint work with: Patrick Schuhmann

Markus Fischer
University of Padua

Fri, 09:25
SR Geologie

Subsolutions for convex optimal control problems

We illustrate an iterative procedure for constructing subsolutions for some deterministic or stochastic optimal control problems in discrete time with continuous state space. The procedure generates a non-decreasing sequence of subsolutions, giving true lower bounds on the minimal costs (value function). In each step, state trajectories starting from some fixed initial points are computed which serve to update the current subsolution. The functions thus constructed are shown to converge from below to the value function at the fixed initial points; moreover, they provide a posteriori bounds on the minimal costs at any point of the state space. If the Bellman operators of the control problem preserve convexity, then the subsolutions can be updated by adding supporting hyperplanes, in analogy with the cutting plane algorithm from convex optimization. No discretization of the state space is needed. Besides convergence results, we present numerical experiments for discrete-time problems derived from convexity-preserving controlled Itô diffusions. Possible extensions of the method might also be discussed.

Joint work with: Gianmarco Bet

Asgar Jamneshan
University of Konstanz

Wed, 16:55
SR Geologie

Stochastic vector optimization and parameter-dependent stochastic optimal control

In this talk, I present two contributions to stochastic optimization. First, a solution to a parameter-dependent (state-dependent) stochastic optimal control problem is elaborated which can be viewed as the optimization of a coupled forward backward system in finite discrete time over a set of state-dependent control processes. Applications to wealth-dependent utility maximization and dynamic risk sharing are provided. Second, I present a Fenchel–Moreau duality for vector-valued functions based on which regularity conditions for strong duality in stochastic vector optimization are developed. Connections to vector duality in Banach spaces (e.g. Radon–Nikodým property) and a new Hahn–Banach type extension and separation theorem are discussed. If time permits, applications to mathematical finance are given.

References:

[1] S. Drapeau, A. Jamneshan and M. Kupper (2017). A Fenchel-Moreau theorem for $\bar{L}^0$-valued functions. Preprint, available online at arxiv.org:1708.03127.
[2] S. -M. Grad and A. Jamneshan. Regularity conditions for strong duality in vector optimization and applications. In preparation.
[3] A. Jamneshan, M. Kupper and J. Zapata (2017). Parameter-dependent stochastic optimal control in finite discrete time. Preprint, available online at arxiv.org:1705.02374.

Joint work with: Samuel Drapeau • Sorin-Mihai Grad • Michael Kupper • Jose Zapata

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Michael Kupper

Wed, 16:30
SR Geologie

On the pointwise superhedging duality in continuous time

We focus on the pathwise superhedging duality in continuous time. On subsets (prediction sets) of the path space of continuous functions we show that the minimal superhedging price of every upper semicontinuous contingent claim is equal to the supremum over all its expectations with respect to martingale measures. As an application we discuss semi-static hedging and the link to Vovk's outer measure. The focus lies on general prediction sets.

Joint work with: Daniel Bartl • Ariel Neufeld • David Prömel • Ludovic Tangpi

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Kristoffer Lindensjö

Wed, 10:45
SR Geologie

On Finding Equilibrium Stopping Times for Time-Inconsistent Markovian Problems

Standard Markovian optimal stopping problems are consistent in the sense that the first entrance time into the stopping set is optimal for each initial state of the process. Clearly, the usual concept of optimality cannot in a straightforward way be applied to non-standard stopping problems without this time-consistent structure. This research project is devoted to the solution of time-inconsistent stopping problems with the reward depending on the initial state using a game-theoretic approach in which each state of the process corresponds to a player in the game. More precisely, we give a precise equilibrium definition — of the type subgame perfect Nash equilibrium based on pure Markov strategies. Such equilibria do not always exist. We, however, develop an iterative approach to finding such equilibrium stopping times for a general class of problems and apply this approach to one-sided stopping problems on the real line. We furthermore prove a verification theorem based on a set of variational inequalities which also allows us to find equilibria. As an application of the developed theory we study a selling strategy problem under exponential utility and endogenous habit formation.

Joint work with: Sören Christensen

Mick Schaefer
University of Hamburg

Wed, 12:00
SR Geologie

Optimal Stopping at Random Intervention Times

We propose a Markovian model to value American-style complete contracts of agents who are temporarily inattentive. Exercise decisions maximizing the contract's payoff are not admissible continuously but at random intervention times. Further, premature forced exercise events can occur randomly accounting for e.g. liquidity needs or mortality. Exercise events are modeled with possibly market and time dependent arrival intensities.
The solution to a discrete optimal stopping problem provides the fair contract value which can be obtained numerically by the forward improvement iteration (FII), see Irle (2006). We follow the intensity based approach from the credit risk literature, see e.g. Bielecki and Rutkowski (2013), and assume the random intervention times to be jump times of a conditional Poisson process with possibly stochastic intensity. As central result, we describe the contract value in terms of optimal control by averaging out the stopping times announcing rational and forced exercise events. The optimal control characterisation enables well performing least squares Monte-Carlo (LSM) methods to be applied. If the underlying process is a jump diffusion, standard arguments from stochastic control, see e.g. Øksendal and Sulem (2004), provide a verification theorem and the respective partial integro differential equation characterization of the contract value. This gives access to standard finite differences schemes which are commonly used to solve related problems.
As toy example, all numerical methods are applied to an American put option in the Black Scholes market with random intervention times. The FII requires least structural requirements on the model of all considered methods but its general applicability comes to the price of weaker numerical performance. Most practical applications and in particular our toy example satisfy all requirements needed to transfer the initial problem to optimal control. Hence, we are enabled to apply an efficient LSM algorithm related to Longstaff and Schwartz (2001) and Belomestny, Kolodko and Schoenmakers (2010) which is easy to implement and applicable to multi-dimensional settings.
Since our example considers a one dimensional diffusion setting, also the FD Crank–Nicolson scheme can be applied and provides the most accurate and robust values.

Joint work with: Alexander Szimayer

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 6: Stochastic optimization and operations research

Sebastian Olivier Schneider
Max Planck Institute for Research on Collective Goods

Fri, 09:00
SR Geologie

The min MSE Approach to Treatment Assignment for One and Multiple Treatment Groups

We present a new approach to treatment assignment in (field) experiments for the case of one or multiple treatment groups.
This approach—which we call the minimizing Mean Squared Error (MSE) approach—uses sample characteristics (that can be multivariate and/or continuous) to obtain balanced treatment groups in the sense of a statistic derived in this paper.
The importance of balanced treatment groups has already been emphasized by Fisher (1935), who illustrated that simple random assignment of experimental subjects to treatment or control can yield misleading results:
An unbiased experiment alone, he notices, does not "ensure the validity of the estimates" of the outcome of the experiment, as treatment groups might still differ considerably.
When relying on randomization only, balanced or similar groups are, depending on the sample size, often rather an exception.
Further, it is not guaranteed, especially when sample size is small, that all characteristics appear in all experimental groups; this is a problem, when subgroup analysis is desired to study heterogeneous treatment effects.
Our statistic of balance builds on the literature on optimal design in experiments (starting with Smith, 1918).
Kasy (2016) introduced the concept to treatment assignment and suggests minimizing the mean squared error, i.e. the sum of variance and bias, of the estimator for the treatment effect of interest, amongst others, in a linear model.
Unlike Kasy, we introduce this linear model in a frequentist setting, which eliminates—at no price in this setting—the need of specifying a prior distribution and the model variance explicitly.
As these parameters are difficult to specify without prior knowledge about the detailed relation between sample characteristics and the outcomes of interest, this makes the method considerably more applicable in the respective fields of application.
Moreover, we increase applicability by extending the statistic to the case of multiple treatments and by providing software in form of a Stata ado-package.
We show that, under certain conditions, this statistic balances the sum of second moments of covariates for orthogonal covariates across treatment groups and incorporates dependencies between covariates in case they are not orthogonal.
This statistic may be used for optimization as a function of treatment assignment e.g. with a limited number of iterations of the simulated annealing algorithm (the implementation we use), which makes the approach a so called rerandomization approach.
Compared to other theoretically founded rerandomization approaches (Morgan and Rubin, 2012; Bertsimas et al., 2015) the min MSE procedure additionally aims at balancing within-group dependencies of covariates and it focuses on the second moment instead of the first moment of covariate distributions, which is to be preferred if treatment effects depend on covariates and thus vary across individuals.
Moreover, we provide an extension for the case of multiple treatment groups.
In a simulation study using several datasets, the minimizing MSE approach is shown to perform superior or comparable to competing methods, such as stratification (Fisher, 1935) or pairwise matching (Greevy et al., 2004), in most of the commonly used measures of balance.
However, the min MSE procedure is attrition tolerant, offers greater flexibility with respect to the number of treatments and the number of units and it can conveniently be implemented.
The software implementation uses Stata's efficient Mata language for computation, and thus the process is quite fast: 500 iterations for a sample size of 100 (or 100 randomization units) considering 10 covariates usually takes less than 5 minutes on a 2.3GHz dual-core processor (as found in modern laptops).
An option for sequential treatment allocation is provided.

References:

[1] Bertsimas, D., M. Johnson, and N. Kallus (2015). The Power of Optimization Over Randomization in Designing Experiments Involving Small Samples. *Operations Research* 63(4), 868–876
[2] Fisher, R. A. (1935). *The design of experiments*. Oliver and Boyd
[3] Greevy, R., B. Lu, J. H. Silber, and P. Rosenbaum (2004). Optimal multivariate matching before randomization. *Biostatistics* 5(2), 263–275
[4] Kasy, M. (2016). Why Experimenters Might Not Always Want to Randomize, and What They Could Do Instead. *Political Analysis* 24(3), 324–338
[5] Morgan, K. L. and D. B. Rubin (2012). Rerandomization to improve covariate balance in experiments. *The Annals of Statistics* 40(2), 1263–1282
[6] Smith, K. (1918). On the standard deviations of adjusted and interpolated values of an observed polynomial function and its constants and the guidance they give towards a proper choice of the distribution of observations. *Biometrika* 12(1/2), 1–85

Joint work with: Martin Schlather

Anton A. Shardin
BTU Cottbus-Senftenberg, Institute of Mathematics

Fri, 10:30
SR Geologie

A Regime-Switching Model for Energy Storage Valuation and Optimal Operation

We address the valuation of an energy storage facility in the presence of stochastic energy prices as it arises in the case of a hydro-electric pump station.
The valuation problem is related to the problem of determining the optimal charging/discharging strategy that maximizes the expected value of the resulting discounted cash flows over the lifetime of the storage. We use a regime-switching model for the energy price which allows for a changing economic environment described by a finite state Markov chain. For the latter we consider the fully as well as the partially observed case.
The valuation problem is formulated as a stochastic control problem with regime-switching in continuous time. For this control problem we derive the associated Hamilton-Jacobi-Bellman (HJB) equation which is not strictly elliptic. Therefore we study the HJB equation using regularization arguments.
We use numerical methods for computing approximations of the value function and the optimal strategy. Finally, we present some numerical results.
The talk is based on the paper

References:

[1] Shardin, A. A., Wunderlich, R.: Partially Observable Stochastic Optimal Control Problems for an Energy Storage. *Stochastics*, 89(1):280–310, 2017.

Joint work with: Ralf Wunderlich

Ralf Werner

Wed, 17:20
SR Geologie

On almost sure rates of convergence for sample average approximations

In this presentation we provide rates at which strongly consistent estimators in the sample average approximation approach (SAA) converge to their deterministic counterparts. To be able to quantify these rates at which a.s. convergence occurs, we consider the law of the iterated logarithm in a Banach space setting.
We first establish convergence rates for the approximating objective functions under relatively mild assumptions. These rates can then be transferred to the estimators for optimal values and solutions of the approximated problem.

Based on these results, we further show that under the same assumptions the SAA estimators converge in mean to their deterministic equivalents, at a rate which essentially coincides with the one in the almost sure sense.

Joint work with: Dirk Banholzer • Joerg Fliege

Section 7: Stochastic processes

Leonid Mytnik
Israel Institute of Technology

Wed, 10:45
HS Anatomie

Dimension of the boundary of the super-Brownian motion

We study the boundary of the super-Brownian motion in dimensions less or equal to 3. The Hausdorff dimension of the boundary is established.

Joint work with: E. Perkins

Eduardo Abi Jaber
Université Paris Dauphine

Thu, 17:45
HS Weismann

Affine Volterra processes

A growing body of empirical research indicates that volatility fluctuates more rapidly than Brownian motion, which is inconsistent with standard semimartingale models. Fractional volatility models and their relatives have emerged as compelling alternatives; however, their non-Markovian structure makes computations more difficult. We show that, for a large class of such models, it is nonetheless possible to compute the characteristic function by solving an integral equation similar to the Riccati equations associated with standard affine processes.

Joint work with: Martin Larsson • Sergio Pulido

Frank Aurzada
Technische Universität Darmstadt

Thu, 17:45
HS II Geolog.

Small deviations of fractional Gaussian sums

We consider the small deviation probabilities for sums of stationary Gaussian sequences, i.e. if (ξ_i) is a stationary centered Gaussian sequence and $S_n := \sum_{i=1}^n \xi_i$, we study the probability

$$P(\max_{n=1,\dots,N} |S_n| \le f_N)$$

when $N \to \infty$, where (f_N) is such that the standard deviation of S_N is of larger order than f_N.
For example, we focus our attention on the discrete analogs of fractional Brownian motion, where with ℓ slowly varying

$$\sum_{i=1}^n \sum_{j=1}^n E[\xi_i \xi_j] = n^{2H} \ell(1/n).$$

In this case, the scaling limit of (S_n) is fractional Brownian motion. The results deeply use the spectral structure of the underlying stationary sequence.
The corresponding results for independent (ξ_i) by Chung (1948) are classical.

References:

[1] F. Aurzada, M.A. Lifshits (2016). Small deviations of sums of correlated stationary Gaussian sequences. *Theory of Probability and Its Applications* 61, 626–658 (Russian), English version to appear, arXiv:1606.01072.

[2] K.L. Chung (1948). On the maximum partial sums of sequences of independent random variables. *Transactions of the American Mathematical Society* 64, 205–233.

Joint work with: Mikhail Lifshits

Hendrik Baumann

Wed, 18:10
HS Weismann

Inherent Numerical Instability in Computing Invariant Measures of Markov Chains

Invariant measures of Markov chains in discrete or continuous time with a countable set of states are characterized by its steady state recurrence relations. Exemplarily, we consider transition matrices and Q-matrices with upper bandwidth n and lower bandwidth 1 where the invariant measures satisfy an $(n+1)$-order linear difference equation. Markov chains of this type arise from applications to queueing problems and population dynamics. It is the purpose of this talk to point out that the forward use of this difference equation is subject to numerical instability which is due to the fact that the invariant measure is a dominated solution of the difference equation. We will sketch the proof which uses the concept and the convergence theory of generalized continued fractions (GCFs).
The GCF-based approach is not only helpful for proving that the invariant measure is a dominated solution; additionally, it provides a decoupled recursion in which the phenomenon of numerical instability does not appear. The procedure results in an iteration scheme for successively computing approximants of the desired invariant measure depending on some truncation level N. Increasing N leads to the desired solution. For demonstrating the effect of instability of forward computing as well as the advantages of the GCF-based approach, we will present a comparison study for Q-matrices with upper bandwidth 1 and 2.

References:

[1] H. Baumann, T. Hanschke (2017). Inherent Numerical Instability in Computing Invariant Measures of Markov Chains. *Applied Mathematics*, 8(9), 1367–1385

Joint work with: Thomas Hanschke

Stein Andreas Bethuelsen
Technische Universität München

Thu, 16:30
HS Weismann

Stochastic domination in space-time for the supercritical contact process

The contact process is a classical interacting particle systems, originally introduced as a model for the spread of infections in a population. In this talk, we focus on the contact process in the supercritical regime for which infections may spread forever with positive probability. Our goal is to understand how the contact process behaves compared with a process having no spatial correlations. In particular, does the contact process stochastically dominate a non-trivial independent (in space) spin-flip process?
Such questions were studied by Liggett and Steif (2006), who proved that, at fixed times, the stationary contact process on $\mathbb{Z}^d$ stochastically dominates a non-trivial iid Bernoulli product measure. We present in this talk some space-time versions of their results.
One of our main results concerns the contact process on regular trees: observed on certain subsets of the vertices containing a "positive fraction" of all the vertices, for large infection rate, the contact process stochastically dominates a non-trivial independent spin-flip process. (This is known to be false for the contact process on $\mathbb{Z}^d$.)
From our methods, we furthermore deduce strong (uniform) mixing properties for certain space-time projections of the contact process. The talk is based on joint work with Jacob van den Berg (CWI Amsterdam and VU Amsterdam).

References:

[1] T . Liggett, J. Steif (2006). Stochastic domination: the contact process, Ising models and FKG measures. *Ann. Inst. H. Poincare Probab. Statist.*, 42(2), 223–243

[2] J. van den Berg, S. A. Bethuelsen (2017). Stochastic domination in space-time for the super-critical contact process. arXiv:1606.08024, accepted for publication in *Random Structures and Algorithms*

Micha Buck

Thu, 14:00
HS Weismann

Persistence probabilities of fractional Gaussian sequences

Persistence concerns the probability that a stochastic process has a long negative excursion. In this talk we study the rate of decay of the persistence probability

$$\mathbb{P}(Z_n \leq 0 \colon |n| \leq N), \quad \text{as} \quad N \to \infty,$$

for some two-sided Gaussian sequences $(Z_n)_{n\in\mathbb{Z}}$ that are discrete-time analogs of fractional Brownian motion and integrated fractional Brownian motion, respectively. Our results extend the corresponding ones in continuous time by Molchan (Commun. Math. Phys., 1999) and Molchan (J. Stat. Phys., 2017) to a wide class of discrete-time processes.

Joint work with: Frank Aurzada

Alekos Cecchin

Fri, 10:30
HS Weismann

On the convergence problem in Mean Field Games: a two state model without uniqueness

Mean Field Games were introduced as limit models for symmetric non-zero-sum non-cooperative N-player dynamic games when the number N of players tends to infinity.
Here we focus on finite time horizon problems with continuous time dynamics, where the position of each agent belongs to $\Sigma = \{-1, +1\}$, in a first analysis. The players control their transition rate in order to minimized a cost functional, assumed to be symmetric. The limiting dynamics is given by a finite state Mean Field Game (MFG) system made of two coupled forward-backward 1d ODEs:

$$\begin{cases} \dot{z} = \frac{z|z|}{2} \\ \dot{m} = -m|z| + z \\ z(T) = 2m(T) \\ m(0) = m_0, \end{cases} \tag{0.1}$$

where the variable z represents the optimal switching rate and m is the mean of the optimal process.
We study the problem of convergence of the feedback Nash equilibria for the N-player game to solutions of the Mean Field Game, when the number of players goes to infinity.
The feedback Nash equilibrium for the N-player game is unique, symmetric, and is provided by the value functions V^N, which are the solutions of a system of $2N$ ODEs, the Nash system.
In [2] we assumed the monotonicity assumptions of Lasry and Lions, which ensure that the MFG system (0.1) admits a unique solution for any time horizon T. Applying the idea developed in [1] for the continuous state space case, we proved the convergence of the Nash system to the unique classical solution of the Master Equation, a first order PDE stated in the symplex probability measures, whose characteristic curves are given by the Mean Field Game system. Such convergence provided also a propagation of chaos property for the N-player optimal trajectories, as well as a Central Limit Theorem and a Large Deviation Principle for the associated empirical measures.
In this work, we consider more general cost functionals, without assuming monotonicity. As a motivating example, we let the terminal cost be antimonotonous, meaning that players prefer to aggregate, rather than to spread. We show that system (0.1) admits a unique classical, or strong, solution if T is less than $1/2$, while there are exactly three solutions, for any initial distribution m_0, if $T > 2$.

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In this framework, the Master Equation is

$$\begin{cases} -\frac{\partial Z}{\partial t} + \frac{Z|Z|}{2} - \frac{\partial Z}{\partial m}(-m|Z| + Z) = 0 \\ Z(T, m) = 2m, \end{cases} \tag{0.2}$$

which can be seen as a scalar conservation law in one space dimension with space-dependent flow, m belonging to $[-1, 1]$.
Equation (0.2) has no classical solutions built via the characteristics. However, we see that there is a unique way of choosing a solution of (0.1) in a way such that the solution to (0.2) defined gluing together these characteristics is continuous in time.
Such solution has a unique discontinuity in $m = 0$, for any time greater than $1/2$.
Our main result is the convergence of the value functions of the N-player game to the unique entropy admissible weak solution to the Master Equation, which turns out to be the one continuous in time defined above. As a consequence, we show that there is propagation of chaos for the N-player optimal trajectories, if the initial average is not 0, i.e. outside the discontinuity. Although there is no uniqueness in the limit, this result says that the N-player game selects a unique (strong) MFG solution. In fact there is a limiting (strong) solution which is better than the others, the one which exists also for small time horizon.
We also study the behavior of the system when starting with initial average 0. We show that in this case there is no propagation of chaos, meaning that the N-player empirical measure μ^N associated with the optimal trajectories does not converge to a deterministic measure
(which would be a strong solution of the Mean Field Game).
Equivalently, the law of μ^N does not converge to a Dirac's delta. Therefore a suitable definition of weak Mean Field Game solution is needed. We prove that the empirical measure converges to a weak MFG solution whose support consists of two strong MFG solutions. Namely,

$$\lim_N Law(\mu^N) = \frac{1}{2}\delta_{m^+} + \frac{1}{2}\delta_{m^-},$$

where $m^+ > 0$ and $m^- < 0$ represent the solutions to (0.1) with $m_0 = 0$; the third solution, which exists for any time, is the constant 0.
Finally, our results are extended to more general running and terminal costs.

References:

[1] P. Cardaliaguet, F. Delarue, J.M. Lasry, P.L. Lions. The master equation and the convergence problem in mean field games. Preprint 2015, arXiv:1509.02505
[2] A. Cecchin, G. Pelino. Convergence, Fluctuations and Large Deviations for finite state Mean Field Games via the Master Equation. Preprint 2017, arXiv:1707.01819

Joint work with: Paolo Dai Pra • Markus Fischer • Guglielmo Pelino

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Imma Valentina Curato

Thu, 11:35
HS Weismann

Weak dependence and GMM estimation for supOU and mixed moving average processes

We consider a mixed moving average process X driven by a Lévy basis and prove that is a weakly dependent process.
Using this property, we show that sample mean and autocovariances of X have a limiting normal distribution.
As an application, we can then use a Generalized Method of Moments estimation for the supOU process and the supOU stochastic volatility model after choosing a suitable distribution for the mean reverting parameter. For these estimators, we analyze the asymptotic behavior in detail.

Joint work with: Robert Stelzer

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Stephan Eckstein
University of Konstanz

Thu, 14:25
HS Weismann

Robust LDP for Markov chains through an extended Laplace principle

The usual Laplace principle for empirical measures of a Markov chain can be formulated in a way that builds on the relative entropy and its convex dual. Under standard (in terms of large deviations theory) assumptions on the underlying Markov chain, the Laplace principle can be proven in an abstract form for a whole class of convex functionals resembling the relative entropy.
Using this abstract Laplace principle for a specific functional gives rise to a robust large deviations principle for empirical measures of a Markov chain, where "robust" refers to uncertainty about the true transition kernel and initial distribution of the Markov chain, in the sense that single measures are replaced by (convex and closed) sets of measures. The robust large deviations principle gives information about worst case rates of convergence over all measures in the sets. Similarly, a robust law of large numbers can be derived. The concept of robust Markov chains in this application bears a close resemblance to the theory of Markov set chains (also called imprecise Markov chains or Markov chains with interval probabilities).

Julian Gerstenberg
Leibniz Universität Hannover, Institut für Mathematische Stochastik

Thu, 16:30
HS II Geolog.

General Erased-Word Processes: Ergodic laws and product type filtrations

In this talk we investigate a class of stochastic processes and the backwards filtrations they generate. A general erased-word process over a finite alphabet A is a stochastic process $(W_n, \eta_n)_{n\geq 1}$ such that

- W_n is a random word of length n over A,
- η_n is uniformly distributed on the set $\{1, \dots, n+1\}$ and independent of the future σ-field $\mathcal{F}_{n+1} := \sigma(W_m, \eta_m : m \geq n+1)$,
- if one erases the η_n-th letter in W_{n+1}, the resulting word equals W_n almost surely.

We will describe all (laws of) general erased-word processes up to homeomorphism by drawing a connection to exchangeability (much as in [1]) and show that the backwards filtrations $(\mathcal{F}_n)_{n\geq 1}$ generated by such processes are always of product-type (a.s. generated by a sequence of independent RVs). The latter generalizes a result by S. Laurent concerning (ordinary) erased-word processes (see [2]).

References:

[1] Choi, Hye Soo and Evans, Steven N, *Doob–Martin compactification of a Markov chain for growing random words sequentially*, Stochastic Processes and their Applications, vol. 7, 127, p. 2428–2445, 2017
[2] Laurent, Stéphane, *Filtrations of the erased-word processes*, Séminaire de Probabilités XLVIII, p. 445–458, 2016

Lorenz Alexander Gilch
Universität Passau / Technische Universität Graz

Wed, 14:00
HS Weismann

Fastest and entropy-maximising random walks on groups

In this talk we consider a finitely supported random walk μ on a finitely generated group G. In the past few years a lot of research has been done in the direction of analysing the rate of escape (i.e, the asymptotic speed at which the random walk converges to infinity) and the asymptotic entropy. Besides many partial results from several authors it has been finally shown by Gouézel that the rate of escape and entropy vary real-analytically in terms of probability measures of constant support, which

describe the random walk. However, many further analytic properties of both constants are still open. This includes the question which random walk μ maximises the speed and entropy when keeping the support of μ constant. Other questions concern unimodularity and concavity of the speed v and the entropy h when seen as mappings $\mu \mapsto v(\mu)$ and $\mu \mapsto h(\mu)$. This question has been solved by F. Ledrappier and me for random walks on free groups, where we have shown that simple random walk is the fastest and entropy maximising random walk. The purpose of this talk is to give a short overview on this topic, to explain the technique of the proof briefly and to show that simple random walk is in general not the fastest random walk.

Matthias Hammer

Wed, 11:35
HS Weismann

Entrance laws for annihilating Brownian motions

Consider a system of particles moving independently on Brownian paths such that whenever two of them meet, the colliding pair annihilates instantly. The construction of such a system of annihilating Brownian motions (aBMs) is straightforward as long as we start with a finite number of particles, but is more involved for infinitely many particles. In particular, if we let the set of starting points become increasingly dense in the real line it is not obvious whether the resulting systems of aBMs converge and what the possible limit points (entrance laws) are.
In this talk, we will see that aBMs arise as the interface model of the continuous-space voter model. This link allows us to provide a full classification of entrance laws for aBMs. We also present some illustrating examples showing how different entrance laws can be obtained via finite approximations. Finally, we discuss a generalization to the infinite rate symbiotic branching model, of which the voter model is a special case.

Joint work with: Marcel Ortgiese • Florian Völlering

Thomas Hotz
TU Ilmenau

Thu, 17:20
HS II Geolog.

Analysing Markov chains using random measures

Let $X_t, t \in \mathbf{N}_0$ be a time-discrete, irreducible, positively recurrent and aperiodic Markov chain on a countable state space S with invariant distribution μ.
We are interested in determining $\alpha = \int f \, \mathrm{d}\mu$ for given $f \in \mathcal{L}^2(S, \mu)$.
By the ergodic theorem, $F_T = \frac{1}{T} \sum_{t=1}^{T} \to \alpha$ in quadratic mean for $T \to \infty$ if $X_0 \sim \mu$; this allows to determine α using a single, long simulation run of the Markov chain.
We generalise this approach by considering a sequence $\gamma_t, t \in \mathbf{N}_0$ of probability measures on S, computing $G_T = \frac{1}{T} \sum_{t=1}^{T} f \, \mathrm{d}\gamma_t$.
In the talk, we give conditions which guarantee $\mathbf{E}\, F_T = \mathbf{E}\, G_T = \alpha$ while $\mathbf{Var}\, G_T \leq \mathbf{Var}\, F_T$, i.e. G_T also converges to α in quadratic mean, never slower but usually much faster than F_T.
The new measure-based approach provides much freedom to tailor the simulation to the problem at hand, e.g. when considering rare events.
In fact, it can be seen as bridging the gap between two extreme special cases: simulating a single run (or multiple runs) of the Markov chain X as well as a deterministic, numerical approach which is often infeasible as it requires unbounded memory.
Simulations of concrete examples demonstrate the superiority of the measure-based approach over these extremes as well as its versatility.

Joint work with: Armin Zimmermann

Asgar Jamneshan
University of Konstanz

Tue, 11:40
HS Weismann

An extension of Markov kernels and disintegration

It is well-known that a conditional distribution of a random variable ξ possesses a regular representation in terms of a Markov kernel whenever ξ takes values in a standard Borel space. We establish a correspondence between Markov kernels and stable measure spaces, a notion which will be introduced in detail, which suggests a representation of a conditional distribution of a random variable with values in an arbitrary measurable space. As will be shown, this result extends in a measure-theoretic way the standard Borel case. As a corollary, we obtain a disintegration in the setting of general probability spaces. Applications are discussed.

References:

[1] A. Jamneshan, M. Kupper and M. Streckfuß (2017). Measures and integrals in conditional set theory. Preprint, available online at arxiv.org:1701.02661.

Joint work with: Michael Kupper • Martin Streckfuß

Monique Jeanblanc
LaMME

Thu, 10:45
HS Weismann

Thin-decomposition of random times and applications

We show that any random time can be decomposed as $\tau = \tau_1 \wedge \tau_2$ and $\tau_1 \vee \tau_2 = \infty$ where τ_1 is thin (i.e., stopping times, where $\mathbb{F}$ is a reference filtration) and τ_2 is thick, i.e., its graph is contained in a countable union of graphs of $\mathbb{F}$-stopping times.
We show that hypothesis H' is satisfied if and only if τ_1 satisfies H' and in that case we exhibit the semimartingale martingales in the filtration $\mathbb{F}$ progressively enlarged with τ.
We illustrate our setting by considering the various models of Coculescu, Jiao, Schmidt.

Joint work with: Anna Aksamit • Tahir Choulli

Achim Klenke
Universität Mainz

Tue, 14:25
HS Weismann

Infinite rate symbiotic branching on the real line: The tired frogs model

Consider a population of infinitesimally small frogs on the real line. Initially the frogs on the positive half-line are dormant while those on the negative half-line are awake and move according to the heat flow. At the interface, the incoming wake frogs try to wake up the dormant frogs and succeed with a probability proportional to their amount among the total amount of involved frogs at the specific site. Otherwise, the incoming frogs also fall asleep. This frog model is a special case of the infinite rate symbiotic branching process on the real line with different motion speeds for the two types.
We construct this frog model as the limit of approximating processes and compute the structure of jumps. We show that our frog model can be described by a stochastic partial differential equation on the real line with a jump type noise.

Joint work with: Leonid Mytnik

Martin Larsson
ETH Zurich

Thu, 14:50
HS Weismann

Generators of measure-valued jump-diffusions

Measure-valued jump-diffusions are useful as tractable approximations of large but finite stochastic systems, for instance large sets of equity returns. As in the finite-dimensional case, one can define

an associated operator that reflects the dynamics of the system. We show that, in full analogy with the finite-dimensional case, such operators are of Levy type expressed using a notion of derivative that is well-known from the superprocess literature. Examples falling into this framework include large population limits of particle systems with mean-field interaction, as well as measure-valued polynomial diffusions such as Fleming-Viot processes. The latter class encompasses a broad range of specifications that retain computational tractability. We also discuss further applications such as optimal control of measure-valued jump-diffusions.

Joint work with: Sara Svaluto-Ferro

Tibor Mach
Institute of Information Theory and Automation, Prague

Fri, 09:00
HS Weismann

Mean-field dual of the cooperative branching process

We assume that Λ is a countable lattice with a prescribed geometry and consider a Markov process X with values on $\{0,1\}^\Lambda$ with the following dynamics:

1. At a certain rate each two neighbouring occupied sites produce an offspring on an empty site adjacent to (at least) one of them. This we call the cooperative branching.
2. At another rate occupied sites become empty. This we call death.

We specifically interested in the limit of the processes which are dual to X on a complete graph. We call this limit the mean-field dual process as it is dual to a mean-field equation of the process X. We show that there in fact exists a duality between this process and a certain probability-measure valued function. This function (and by extension the mean-field dual process) has connections to recursive tree processes studies by Aldous and Bandyopadhyay. The cooperative branching process is based on the work of Sturm and Swart.

References:

[1] D. Aldous and A. Bandyopadhyay. A survey of max-type recursive distributional equations. *Annals of Applied Probability* (2005), 1047–1110.
[2] A. Sturm and J.M. Swart. A particle system with cooperative branching and coalescence. *Ann. Appl. Probab.* 25(3) (2015), 1616–1649.

Joint work with: Anja Sturm • Jan M. Swart

Martin Maiwald
Institute of Mathematical Stochastics, University Münster

Tue, 14:00
HS Weismann

On entrance boundaries and quasi-processes

The notion of a quasi-process stems from classical potential theory. It was introduced by Weil [2] as a generalisation of
its discrete version also called approximative Markov chain, studied by Hunt [1]. Although the concept might not be very familiar nowadays it is intricately related to several current developments in probability. For instance it is related to the theory of Markov extensions of real self-similar Markov processes and the theory of interlacements.
In the talk, we introduce this concept and explain its connections to so called entrance families. These will be used to define a topology for quasi-processes and a Martin entrance boundary of the state space. As a result we provide a Choquet-type representation on the basis of extremal quasi-processes.
Our approach is robust in several respects and we essentially only require a Feller-type condition for the underlying Markov process. The work is a continuation of considerations started by S. Dereich and L. Döring.

References:

[1] Hunt, G. A. Markoff chains and Martin boundaries. Illinois J. Math. 4 (1960), no. 3, 313–340.
[2] M. Weil: "Quasi-processus." Séminaire de Probabités IV, pp. 216–239, (1970)

Joint work with: Steffen Dereich

Ester Mariucci
Humboldt University

Tue, 15:15
HS Weismann

Wasserstein and total variation distance between marginals of Lévy processes

We present upper bounds for the Wasserstein distance of order p between the marginals of Lévy processes, including Gaussian approximations for jumps of infinite activity. Using the convolution structure, we further derive upper bounds for the total variation distance between the marginals of Lévy processes. Lévy processes form the prototype of continuous-time processes with a continuous diffusion and a jump part. In applications, there is a high interest to disentangle these parts based on discrete observations. While Aït-Sahalia and Jacod among many others propose an asymptotically (as the observation distances become smaller) consistent test on the presence of jumps for general semimartingale models, Neumann and Reiß argue that, already inside the class of α-stable processes with $\alpha \in (0, 2]$, no uniformly consistent test exists. The subtle, but important, difference is the uniformity over the class of processes. Mathematically, the difference is that on the Skorokhod path space $D([0, T])$ α-stable processes, $\alpha \in (0, 2)$, induce laws singular to that of Brownian motion ($\alpha = 2$), while their respective marginals at $t_k = kT/n$, $k = 0, \dots, n$ for n fixed, have equivalent laws, which even converge in total variation distance as $\alpha \to 2$ to those of Brownian motion. It is our aim here to shed some light on the geometry of the marginal laws of one-dimensional Lévy processes X_1, X_2 and to quantify the distance of the marginal laws non-asymptotically as a function of the respective Lévy characteristics (b_1, σ_1^2, ν_1), (b_2, σ_2^2, ν_2).
More precisely, we shall be able to quantify the rate of convergence for marginals of general Lévy processes in terms of the p-Wasserstein distances. A particular care has been put in understanding the behavior of the small jumps: we derive a Gaussian approximation of the small jump part exploiting the fine analysis by Rio of the approximation error in Wasserstein distance for the central limit theorem.
Furthermore, we present bounds on the total variation distance, which for statistical purposes, especially testing, is particularly meaningful. Our main idea is to use the convolutional structure of the laws to transfer bounds from Wasserstein to total variation distance. This strategy is implemented for Lévy processes with a non-zero Gaussian component (but without any restriction on the Lévy measures, which can be infinite, and even with infinite variation). Connections to other metrics like Zolotarev and Toscani–Fourier distances are also established. The theory is illustrated by concrete examples and an application to statistical lower bounds. In particular this allows to make the original proof by Jacod and Reiß for volatility estimation under high activity jumps simpler and much more transparent.

References:

[1] E. Mariucci, M. Reiß (2017). Wasserstein and total variation distance between marginals of Lévy processes. ArXiv:1710.02715.
[2] Y. Aït-Sahalia, J. Jacod (2009). Testing for jumps in a discretely observed process. *The Annals of Statistics* 37, 184–222.
[3] J. Jacod, M. Reiß (2014). A remark on the rates of convergence for integrated volatility estimation in the presence of jumps. *The Annals of Statistics* 42, 1131–1144.
[4] M. H. Neumann, M. Reiß (2009). Nonparametric estimation for Lévy processes from low-frequency observations. *Bernoulli* 15, 223–248.
[5] E. Rio (2009). Upper bounds for minimal distances in the central limit. *Ann. Inst. Henri Poincaré Probab. Stat.* 45, 802–817.

Joint work with: Markus Reiß

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Maxime Morariu-Patrichi
Imperial College London

Thu, 11:10
HS Weismann

Hybrid marked point processes: characterisation, existence and uniqueness

Suppose that one wishes to model the price of a stock and the submission times of buy and sell orders for that stock. A buy order can possibly move the price up and precipitate more sell orders in response. In return, lower prices will more likely induce new buy orders. How can one statistically describe this coupling between the buy/sell orders and the state of the stock market? To address modelling problems of this type, we introduce the class of *hybrid marked point processes* [1], which incorporate a state process $(X_t)_{t\geq 0}$ that interacts with a marked point process $N_{\mathcal{E}}$. The state process $(X_t)_{t\geq 0}$ and the marks of $N_{\mathcal{E}}$ take values in $\mathcal{X}$ and $\mathcal{E}$, respectively, where both $\mathcal{X}$ and $\mathcal{E}$ are Polish spaces. W hile $(X_t)_{t\geq 0}$ represents the state of a system (e.g., the stock price), we interpret $N_{\mathcal{E}}$ as a sequence of random events $E_n \in \mathcal{E}$, $n \geq 0$, occurring at discrete random times $T_n \in (0,\infty]$. Therefore, each element $e \in \mathcal{E}$ is to be thought of as a type of event (e.g., buy or sell order).
A particular example of a hybrid marked point process is a *state-dependent Hawkes process*, where events can exhibit self- or cross-excitation effects, like in classical Hawkes processes [2], but these effects can now also depend on the state process. Events of type A will precipitate events of type B only when they move the state process to some critical region, say. More precisely, denoting by $\mathcal{F}$ the filtration generated by $(X_t)_{t\geq 0}$ and $N_{\mathcal{E}}$, the $\mathcal{F}$-intensity process $(\lambda_{\mathcal{E}}(t,e))_{t\geq 0}$ of events of type $e \in \mathcal{E}$ is given by

$$\lambda_{\mathcal{E}}(t,e) = \nu(e) + \int_{[0,t)} \int_{\mathcal{E}} k(t-s, e', X_{s+}, e) N_{\mathcal{E}}(ds, de'),$$

where $\nu : \mathcal{E} \to [0,\infty)$ and $k : (0,\infty) \times \mathcal{E} \times \mathcal{X} \times \mathcal{E} \to [0,\infty)$ are measurable functions. In parallel, as each event occurs, the state process transitions to a new value according to transition probabilities $\phi : \mathcal{X} \times \mathcal{E} \times \mathcal{X} \to [0,\infty)$ that vary with the event type. At each event time T_n of $N_{\mathcal{E}}$ with mark E_n, we have that

$$P(X_{T_n+} \in dx \,|\, \sigma(E_n) \vee \mathcal{F}_{T_n-}) = \phi(x \,|\, E_n, X_{T_n-}) \mu_{\mathcal{X}}(dx),$$

where $\mu_{\mathcal{X}}$ is a fixed reference measure on $\mathcal{X}$. We prove that the joint process $((X_t)_{t\geq 0}, N_{\mathcal{E}})$ can be viewed as one single marked point process N with marks in $\mathcal{E}\times\mathcal{X}$ and $\mathcal{F}$-intensity process $(\lambda(t,e,x))_{t\geq 0}$, $e \in \mathcal{E}$, $x \in \mathcal{X}$, given by

$$\lambda(t,e,x) = \phi(x \,|\, e, X_t) \lambda_{\mathcal{E}}(t,e).$$

The generalisation from state-dependent Hawkes processes to hybrid marked point processes is made by letting $\lambda_{\mathcal{E}}(t,e) = \eta(e \,|\, N_{t-})$, where N_{t-} denotes the strict past of N at time t and η is a measurable functional.
Our main result in [1] addresses the existence of non-explosive hybrid marked point processes by studying the well-known Poisson-driven SDE

$$N(dt, de, dx) = M(dt, de, dx, (0, \psi(e, x \,|\, N_{t-}))],$$

where M is a given Poisson random measure on $[0,\infty) \times \mathcal{E} \times \mathcal{X} \times [0,\infty)$ and ψ is a measurable functional. The strong existence and uniqueness results in [3] rely on a Lipschitz condition that ψ fails to satisfy when it corresponds to a hybrid marked point process, i.e., when it is of the form $\psi(e, x \,|\, N_{t-}) = \phi(x \,|\, e, X_t)\eta(e \,|\, N_{t-})$. This motivates us to propose a natural pathwise construction that instead requires only sublinear behaviour of the intensity functional ψ and, thus, applies beyond hybrid marked point processes. Using a domination argument combined to a Poisson embedding lemma, we are able to verify that this construction yields indeed a solution. As we restrict the space of solutions to non-explosive marked point processes, we also manage to prove uniqueness without any specific assumptions on ψ.

References:
[1] Morariu-Patrichi, M. and Pakkanen, M. S. (2017). Hybrid marked point processes: characterisation, existence and uniqueness. Preprint, available at http://arxiv.org/abs/1707.06970.
[2] Laub, P. J., Taimre, T., and Pollett, P. K. (2015). Hawkes processes. Preprint, available at http://arxiv.org/abs/1507.02822.
[3] Massoulié, L. (1998). Stability results for a general class of interacting point processes dynamics, and applications. *Stochastic Processes and their Applications*, 75(1):1–30.

Joint work with: Mikko S. Pakkanen

Jan Nagel
TU Eindhoven

Wed, 14:50
HS Weismann

The speed of biased random walk among random conductances

We consider a random walk on the d-dimensional lattice in the random conductance model. Each edge of the lattice is assigned randomly a conductance and for a fixed realization of this environment, the random walker crosses an edge with a probability proportional to the conductivity of the edge. This model is one of the prime examples of a reversible process in an inhomogeneous medium. When we introduce a bias to the right, the process satisfies a law of large numbers with a nonzero effective speed. We are interested in properties of the speed as a function of the bias. In particular, we discuss monotonicity of the speed, that is, whether it is an increasing function in the strength of the bias. We show that uniform ellipticity is not enough to guarantee monotonicity and prove strict monotonicity in the low-disorder regime.

Joint work with: Noam Berger • Nina Gantert

Max Nendel

Thu, 17:20
HS Weismann

A semigroup approach to nonlinear Lévy processes

We study the relation between Lévy processes under nonlinear expectations, nonlinear semigroups and fully nonlinear PDEs. First, we establish a one-to-one relation between nonlinear Lévy processes and nonlinear Markovian convolution semigroups. Second, we provide a condition on a family of infinitesimal generators $(A_\lambda)_{\lambda\in\Lambda}$ of linear Lévy processes which guarantees the existence of a nonlinear Lévy processes such that the corresponding nonlinear Markovian convolution semigroup is a viscosity solution of the fully nonlinear PDE $\partial_t u = \sup_{\lambda\in\Lambda} A_\lambda u$. The results are illustrated with several examples.

Joint work with: Robert Denk • Michael Kupper

Peter Parczewski
Mannheim University

Thu, 15:15
HS Weismann

Discretizing Malliavin calculus

Suppose B is a Brownian motion and B^n is an approximating sequence of rescaled random walks on the same probability space converging to B pointwise in probability. Based on this approximation, we provide necessary and sufficient conditions for weak and strong L^2-convergence of basic operators in Malliavin calculus. In particular we obtain the convergence of a discretized Malliavin derivative and a discrete Skorokhod integral to their continuous counterparts. The limits do not depend on the distribution of the discrete time noise. Therefore, the results can be regarded as some kind of invariance principle for Malliavin calculus.
Given a sequence $(X^n)_{n\in\mathbb{N}}$ of random variables which admit a chaos decomposition in terms of discrete multiple Wiener integrals with respect to B^n, we derive necessary and sufficient conditions for strong L^2-convergence to a $\sigma(B)$-measurable random variable X via convergence of the discrete chaos coefficients of X^n to the continuous chaos coefficients of X.

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In contrast to semimartingale and filtration approaches for limit theorems for stochastic integrals, we make use of characterizations in terms of the S-transform and a discrete time version.
With these tools at hand, all our convergence results can be obtained in a surprisingly simple way by computing suitable $L^2(\Omega, \sigma(B^n), P)$-inner products and their limits as n tends to infinity.

Joint work with: Christian Bender

Guglielmo Pelino
University of Padova - Department of Mathematics

Thu, 16:55
HS II Geolog.

Convergence, Fluctuations and Large Deviations for finite state Mean Field Games via the Master Equation

Mean Field Games were introduced as limit models for symmetric non-zero-sum non-cooperative N-player dynamic games when the number N of players tends to infinity.
While a wide range of different classes of Mean Field Games has been considered up to now, here we focus on finite time horizon problems with continuous time dynamics under fully symmetric cost structure and complete information, where the position of each agent belongs to a finite state space $\Sigma = \{1, \dots, d\}$. We show the convergence to a limiting dynamics given by a finite state Mean Field Game system made of two coupled forward-backward ODEs.
The convergence of Nash equilibria for the N-player game to solutions of the Mean Field Game, when the number of players goes to infinity, turns out to be a difficult problem.
While the limits of N-player Nash equilibria in open-loop strategies can be completely characterized, the convergence problem for Nash equilibria in feedback form is more difficult. A result in this direction is given in [4] in our finite state setting, via the infinitesimal generator, but only if the time horizon is small.
A breakthrough was achieved by Cardaliaguet et al. [1] through the use of the Master Equation, in the continuous state space case. Their convergence argument relies on having a regular solution to the Master Equation, which in the diffusion case is a kind of infinite dimensional transport equation on the space of probability measures. Then the crucial ingredient for proving the convergence consists in a coupling argument, in a similar fashion to the propagation of chaos property for uncontrolled systems. Such coupling, in which independent copies of the limit process are compared to their prelimit counterparts, ultimately allows to get the desired convergence of the value functions of the N-player game to the solution of the Master Equation.
In this work, we focus on the convergence of feedback Nash equilibria in the finite state space scenario, in which players control their transition rates from state to state. The unique feedback Nash equilibrium for the N-player game is provided by the HJB system of Nd^N coupled ODE's Following the approach of [1], we show the convergence of the value functions of the N-player game to the solution U of the Master Equation

$$\begin{cases} -\frac{\partial U}{\partial t} + H(x, \Delta^x U) - \int_\Sigma D^m U(t, x, m, y) \cdot \alpha^*(y, \Delta^y U(t, y, m)) dm(y) = F(x, m), \\ U(T, x, m) = G(x, m), \quad (x, m) \in \Sigma \times P(\Sigma), \quad t \in [0, T], \end{cases} \tag{M}$$

where H is the Hamiltonian and α^* its unique minimizer, representing the optimal control, and F and G are the running and terminal costs which depend on the measure (that takes the place of the empirical measure for N finite) and $\Delta^y U$ denotes the finite difference of the function U.
The argument provides also the convergence of the feedback Nash equilibria and a propagation of chaos property for the associated optimal trajectories. The coupling technique necessary for the proof is the main motivation for writing the dynamics of the N players as a stochastic differential equation driven by Poisson Random measures, as in [2].
The well posedness and regularity of solution to the Master Equation is also investigated. It is a first order PDE stated in $P(\Sigma)$, the simplex of probability measures in $\mathbb{R}^d$, and thus a precise definition of the derivative $D^m U$ in such space must be given. Under the monotonicity assumptions of Lasry and

Lions, we solve (M) using the method developed in [1]: we show that the Mean Field Game system can be seen as the characteristic curves of (M) and linearize it around its solution.
Then we also study the empirical measure process of the N-player optimal trajectories. Indeed, the convergence obtained allows to get a Central Limit Theorem and a Large Deviation Principle for the asymptotic behavior, as N tends to infinity, of such processes. The key point for proving these results is to compare the prelimit optimal trajectories with the ones in which each player chooses the control induced by the Master Equation. The fluctuations are then found by analyzing the associated infinitesimal generator, while the Large Deviation properties are derived using a result in [3].

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Joint work with: Alekos Cecchin

Viet Son Pham
Technical University of Munich

Wed, 17:45
HS Weismann

Causal CARMA processes on the plane

We introduce causal CARMA processes on the plane extending the class of CARMA processes in time. This is accomplished by using a multi-parameter state-space representation driven by a Lévy basis. Our process differs fundamentally from the isotropic CARMA random field of Brockwell and Matsuda. We characterize the existence of the process and examine some of its features including the second-order structure and path properties. In particular, we investigate the sampling behavior and formulate conditions for the model to be a spatial ARMA process when sampled on an equidistant lattice. Furthermore we present a parameter estimator for the autoregressive case and analyze its asymptotic properties. Although we work only on $\mathbb{R}^2$, all results can be generalized to $\mathbb{R}^d$ in a straight-forward manner.

References:

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[2] P. J. Brockwell, Y. Matsuda (2017). Continuous autoregressive moving average random fields on $\mathbb{R}^n$. *J. R. Stat. Soc. Ser. B Stat. Methodol.* 79(3), 833–857
[3] V. S. Pham, C. Chong (2016). Volterra-type Ornstein–Uhlenbeck processes in space and time. *Submitted.*

Joint work with: Claudia Klüppelberg

Helmut Pitters
TU Dresden

Wed, 14:25
HS Weismann

Lifting preferential attachment trees yields beta coalescents

We consider preferential attachment trees which are specific scale-free trees. Starting with a preferential attachment tree of size n we show that repeatedly applying a so-called lifting yields a continuous-time Markov chain on preferential attachment trees. Each such tree induces a partition of $[n] = \{1, ..., n\}$ by placing labels in the same block if and only if they are attached to the same node in the tree. Our main result is that this Markov chain on preferential attachment trees induces a partition valued

process which is equal in distribution (up to a random time-change) to a beta n-coalescent, that is the restriction to $[n]$ of the multiple merger coalescent whose Λ measure is a beta distribution.

Neofytos Rodosthenous
Queen Mary University of London

Wed, 17:20
HS Weismann

Optimal stopping of one-dimensional diffusions with generalised drift

We consider the problem of optimally stopping a one-dimensional diffusion with generalised drift over an infinite horizon. We develop a complete characterisation of the problem's value function and optimal stopping strategy in terms of a variational inequality. We then solve the special case that arises when the state process is a skew geometric Brownian motion and the reward function is the one of financial call option. We show that the optimal stopping strategy can take several qualitatively different forms, depending on parameter values.

Joint work with: Mihail Zervos

Uwe Schmock
TU Wien

Tue, 17:55
HS Weismann

Geometry of Distribution-Constrained Optimal Stopping Problems

We adapt ideas and concepts developed in optimal transport (and its martingale variant) to give a geometric description of optimal stopping times of Brownian motion subject to the constraint that the distribution of the stopping time is a given probability. The methods work for a large class of cost processes. (At a minimum we need the cost process to be measurable and adapted. Continuity assumptions can be used to guarantee existence of solutions.) We find that for many of the cost processes one can come up with, the solution is given by the first hitting time of a barrier in a suitable phase space. As a by-product we recover classical solutions of the inverse first passage time problem / Shiryaev's problem.

Joint work with: Mathias Beiglböck • Manuel Eder • Christiane Elgert

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Nikolaus Schweizer

Fri, 10:55
HS Weismann

Approximation of geometrically ergodic Metropolis-Hastings algorithms

In this paper, we provide explicit, non-asymptotic perturbation bounds for Metropolis-Hastings algorithms when the likelihood in the acceptance probability is subject to an approximation error. This type of approximation error may arise when the likelihood of the target density is intractable. A prominent example is the Monte Carlo within Metropolis algorithm (MCWM) for latent variable models. We focus on settings where the associated unperturbed chain is geometrically ergodic (but not necessarily uniformly ergodic). Our bounds on the difference between the n-th step distributions of the perturbed and the unperturbed chains require two inputs: First, we need to control the error made in approximating the likelihood, at least in the center of the state-space. Second, we need to verify a stability condition on the perturbed chain, either by proving a Lyapunov-type condition, or by restricting the perturbed chain to the center of the state space.

Joint work with: Felipe Medina-Aguayo • Daniel Rudolf

Apostolos Sideris
TU Dresden

Thu, 12:00
HS Weismann

Exponential functionals of Markov additive processes

We consider the stochastic integral $\int_0^t e^{\xi_{s-}} d\eta_s$, where (ξ, η) is a Markov additive process (MAP) whose phase transitions are described by a Markov chain with finite state space. We study the convergence

of the integral for $t \to \infty$ following Erickson and Maller [1] and expanding their work to the MAP setting. In particular we make use of recent results by Alsmeyer and Buckmann [2] on the convergence of Markov modulated perpetuities which can be interpreted as the discrete time analogon of the above integral.

References:

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[2] G. Alsmeyer, F. Buckmann (2017) *Stability of perpetuities in Markovian environment*, Journal of Difference Equations and Applications 43, pp. 699–740.

Joint work with: Anita Behme

Renato Soares dos Santos

Fri, 09:25
HS Weismann

The parabolic Anderson model with renormalized inverse-square Poisson potential

Consider the heat equation with a multiplicative random potential obtained by superposing translations of kernels of the form $K(x) = \theta|x|^{-p}$ over the points of a standard Poisson point process in $\mathbb{R}^d$. The problem is ill-posed in general, but can be made rigorous when $d/2 < p < d$ with a renormalization procedure proposed by Chen and Kulik. In a series of papers, Chen and co-authors studied existence and large time asymptotics of the solution through its Feynman–Kac representation. Their work left open the critical case $d = 3$, $p = 2$ and $\theta = 1/16$, which we address.

Joint work with: Peter Nelson

Tobias Sohr
Universität Hamburg

Wed, 16:55
HS Weismann

A Solution Technique for Long Term Average Impulse Control Problems for Levy Processes

Impulse control problems deal with the question how to find an optimal payoff for a controlled continuous time process in the class of impulse control strategies. These problems occur in many fields ranging from biology to financial mathematics or economics.
In the case that the underlying process is a one-dimensional diffusion and the criterion is ergodic, there are recent results allowing to solve the problem (semi-)explicitly. Motivated by continuous inventory models, it has been shown that under general conditions an optimal strategy of the following type, herein called $(s, \mathcal{S})$ type, exists: Wait until the process exceeds a given boundary $\mathcal{S}$ and then shift back to an lower boundary s. [1] The aim of this talk is to present generalizations of these results to underlying processes with jumps and to discuss further applications.
Starting from a verification theorem in a general Markovian setting, we show that for an underlying Levy process an optimal strategy of $(s, \mathcal{S})$ type exists whenever the reward function is concave. This strategy consists of shifting back as soon as the process enters the stopping set of a related stopping problem, which is known to have an interval as stopping set. [2]
Applications of this theorem include fairly explicit formulas for the boundaries in some special cases including diffusions, phase-type jumps, and spectrally one-sided processes. Furthermore, mean field impulse control problems and problems with a restriction to the average number of controls per time interval are possible areas to apply the aforementioned approach.

References:

[1] K. Helmes, R. Stockbridge, C. Zhu. Continuous Inventory Models of Diffusion Type: Long-term Average Cost Criterion. *The Annals of Applied Probability* 27, 1831–1885

[2] M. Beibel. (1998). Generalized parking problems for Lévy processes. *Sequential Analysis* 17, 151–171

Joint work with: Sören Christensen

Jan-Henrik Steg
Bielefeld University

Tue, 12:05
HS Weismann

Symmetric Equilibria in Stochastic Timing Games

We construct subgame-perfect equilibria with mixed strategies for symmetric stochastic timing games with arbitrary strategic incentives. The strategies are qualitatively different for local first- or second-mover advantages, which we analyse in turn. When there is a local second-mover advantage, the players may conduct a war of attrition with stopping rates that we characterize in terms of the Snell envelope from the general theory of optimal stopping, which is very general but provides a clear interpretation. With a local first-mover advantage, stopping typically results from preemption and is abrupt. Equilibria may differ in the degree of preemption, precisely at which points it is triggered. We provide an algorithm to characterize where preemption is inevitable and to establish the existence of corresponding payoff-maximal symmetric equilibria.

Michaela Szölgyenyi
ETH Zürich

Tue, 17:30
HS Weismann

On Euler-type schemes for SDEs with discontinuous drift

Stochastic differential equations with irregular (non-globally Lipschitz) coefficients are a very active topic of research. We study equations, where we relax the global Lipschitz condition on the drift coefficient to allow for discontinuities on a set of positive reach.
We study strong convergence of an Euler-type scheme, which uses adaptive step-sizing for a better resolution close to the discontinuity.
We obtain a numerical method which has – up to logarithmic terms – strong convergence order $1/2$ with respect to the average computational cost.

Joint work with: Andreas Neuenkirch • Lukasz Szpruch

Jonas M. Tölle
Universität Augsburg

Tue, 11:15
HS Weismann

The set of sub-σ-algebras is a compact metric space.

We propose a sequential topology on the collection of sub-σ-algebras included in a (separable) probability space $(\Omega, \mathcal{F}, \mathbb{P})$. We prove strong compactness of the conditional expectations viewed as L^2-projection operators.
We establish the compactness of the space of sub-σ-algebras via an application of Tychonoff's theorem to a bundle space construction of L^2-subspaces. We prove that any abstract limit point in this space can be uniquely related to a sub-Markovian L^2-projection - that is - the conditional expectation w.r.t. some σ-algebra. The proposed topology preserves independence and is compatible with join and meet operations. Previous related results can be found e.g. in [1].
We shall discuss some probabilistic as well as functional analytic consequences of our result. In particular, we provide conditions for an abstract martingale convergence theorem which solves an open problem proposed in [2].

References:

[1] Z. Artstein (2001). Compact convergence of σ-fields and relaxed conditional expectation. *Probability Theory and Related Fields* 120(3), 369–394.

[2] M. Tsukada (1983). Convergence of closed convex sets and σ-fields. *Probability Theory and Related Fields* 62(1), 137–146.

Joint work with: Patrick Beissner

Florian Völlering

Tue, 14:50
HS Weismann

Wasserstein-eigenmetrics of Markov chains

Coarse Ricci curvature, introduced by Yann Ollivier, measures how a Markov transition kernel contracts distances in a (possibly discrete) metric space. This geometric interpretation of the action of a Markov chain is particularly useful if there is a positive uniform lower bound on the curvature. Typically the metric structure of the space is assumed to be given. Instead we will look at the question of the existence of special metrics for which the state space of a Markov chain is uniformly curved with respect to the coarse Ricci curvature.
On compact spaces there exist uniformly curved pseudo-metrics, which act as eigenfuctions for a super-linear Wasserstein operator. In a parallel to the Perron–Frobenius theorem for matrices, the existence of true pseudo-metrics as eigenfuction corresponds to a reducibility property, where the states which cannot be distinguished under such a pseudo-metric can be projected away to obtain an autonomous Markovian subchain of the original chain.
I will show examples to illustrate these ideas.

Robert Wardenga
TU Dresden

Thu, 16:55
HS Weismann

Affine Processes with Stochastic Discontinuities

Motivated by the observation, that asset prices may exhibit jumps of random height at priorly fixed dates such as board meetings, we study affine processes beyond the common assumption of stochastic continuity. We restrict ourselves to the study of $d-$dimensional semimartingales X with state space $D \in \mathbb{R}^d$ on a filtered probability space $\left(\Omega, (\mathcal{F}_t)_{t\geq 0}, \mathcal{F}, \mathbb{P}\right)$ and define X to be *affine* if there exist $\mathbb{C}$ and $\mathbb{C}^d-$valued deterministic functions $\phi(s,t,u)$ and $\psi(s,t,u)$, respectively, such that

$$\mathbb{E}\left[e^{\langle u, X_t\rangle}\middle|\mathcal{F}_s\right] = \exp\left(\phi(s,t,u) + \langle \psi(s,t,u), X_s\rangle\right)$$

holds for all $u \in i\mathbb{R}^d$,$0 \leq s \leq t$ and $x \in D$. Under fairly general assumptions ϕ and ψ can be completely characterized as càdlàg solutions of a certain abstract measure differential equation, with a driver that is of Lévy–Khintchine form in between discontinuities. On the other hand we prove existence of such affine semimartingales given a set of admissible parameters requiring only integrability in time. Our findings generalize well known results on affine processes to semimartingales with singular continuous and discontinuous characteristics.
We apply our results presenting a new affine term structure framework that incorporates models with stochastic discontinuities.

Joint work with: Martin Keller-Ressel • Thorsten Schmidt

Philip Weißmann
University of Mannheim

Wed, 16:30
HS Weismann

Lévy processes conditioned to avoid an interval

We consider an oscillating Lévy process ξ such that the ascending and descending ladder height processes have finite means. The aim is to construct the process ξ to avoid an interval $[a, b]$ in a meaningful way, although it could be that

$$T_{[a,b]} := \inf\{t \geq 0 : \xi_t \in [a,b]\} < +\infty$$

almost surely. The strategy is like in several examples of Lévy processes conditioned to avoid a Borel set, like the process conditioned to stay positive (Silverstein [3], Chaumont and Doney [1]) or the process conditioned to avoid zero (Panti [2]).
Namely we want to find a harmonic function h for the process killed on entering $[a,b]$ and show that the corresponding h-transform equals

$$\mathbb{P}_x^{\updownarrow}(\Lambda) := \lim_{q \searrow 0} \mathbb{P}_x(\Lambda, t < e_q | e_q < T_{[a,b]})$$

for a $\mathcal{F}_t$-measurable set Λ and e_q being an exponential distributed random variable with parameter $q > 0$. The idea of how this harmonic function looks is based on stochastic potential theory. But it turns out that this function is the analogue to the harmonic function Vysotsky [4] found for a random walk killed on entering a bounded interval

References:

[1] L. Chaumont, R. A. Doney (2005). On Lévy processes conditioned to stay positive. *Electron. J. Probab.* 10(28), 948–961
[2] H. Panti (2016). On Lévy processes conditioned avoid zero. ArXiv1304.3191v30
[3] M. L. Silverstein (1980). Classification of coharmonic and coinvariant functions for a Lévy process. *Ann. Probab.* 8, 539–575
[4] V. Vysotsky (2015). Limit theorems for random walks that avoid bounded sets, with applications to the largest gap problem. *Stoch. Process. Appl.* 125, 1886–1910.

Gundelinde Wiegel
Graz University of Technology

Wed, 15:15
HS Weismann

Lyapunov exponents on trees

We consider a symmetric nearest neighbour random walk on an infinite regular tree moving in random potential. The potentials represent a random risk of dying for the random walk at each vertex. A measurement for the riskiness of moving in this random medium is provided by the Lyapunov exponents. They observe the long time behaviour of the probability of reaching a certain vertex after starting at a fixed vertex. There are two different ways of treating the random potentials in this observation: the annealed (or averaged) and the quenched approach.
We will see that here we can directly relate these two approaches to each other.

Section 8: Time series

Suhasini Subba Rao
Texas A&M University, College Station, Texas 77845

Thu, 11:35
HS Anatomie

Linear Regression with Time Series Regressors

In several diverse applications, from the neurosciences to econometrics, it is of interest to model the influence observed regressors have on a response of interest.
In many of these applications, the regressors have a meaningful ordering and are usually a long time series. The problem of linear regression, where the number of regressors n is of the same order or magnitudes larger than the number of responses p has received considerable attention.
However, most of these approaches place a sparsity assumption on regressor coefficients. When the regressors are a time series, the sparse assumption can be unrealistic with no intuitive interpretation. In this talk we consider the problem of linear regression with time series regressors, but work under the assumption that the regressor coefficients are absolutely summable.
We propose a computationally efficient method for estimating the regression parameters, that avoids matrix inversion. We show that the parameter estimators are consistent and derive a central limit theorem The proposed estimation scheme, leads to a simple method for estimating the variance of the parameter estimators. Though consistent the parameter estimators are noisy, thus we describe a post-processing step to reduce the noise in the estimators.

Joint work with: Raanju Sundararajan

Boris Aleksandrov
Helmut Schmidt University

Fri, 09:25
SR Phys. 0008

Parameter estimation and diagnostic tests for INMA(1) processes

The INMA(1) model for count time series, an integer-valued counterpart to the usual moving-average model of order 1, was introduced by Al-Osh & Alzaid (1988) and McKenzie (1988). During the last years, it gained increasing interest for applications. For instance, it was used by Cossette et al. (2011) to model the number of claims in the area of insurance, and Zhang et al. (2015) applied the model in the area of reinsurance. Furthermore, Hu et al. (2017) point out application areas where the claim numbers may exhibit overdispersion. While stochastic properties of this model, in particular for the special case of the Poisson INMA(1) model, have been comprehensively studied in the literature, only little is known about statistical inference concerning this model.
We start with a central limit theorem for Poisson INMA(1) processes, which allows to explicitly derive the asymptotic distribution of moment and frequency related statistics. In particular, we consider the asymptotic distribution (including bias correction) for diverse moment estimators, for the index of dispersion, and for the autocorrelation function. We apply these results for constructing confidence intervals for model parameters, and for deriving hypothesis tests to check the marginal distribution (e.g., with respect to the Poisson's equidispersion property) as well as the autocorrelation function (to diagnose the moving average structure). We also show simulation results for INMA(1) time series with different parameters to demonstrate the finite-sample performance of the asymptotic approximations for the above mentioned statistics.

References:

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[4] L. Zhang, X. Hu, B. Duan (2015). Optimal reinsurance under adjustment coefficient measure in a discrete risk model based on Poisson MA(1) process. *Scandinavian Actuarial Journal* 5, 455–467
[5] X. Hu, L. Zhang, W. Sun (2017). Risk model based on the first-order integer-valued moving average process with compound Poisson distributed innovations. *Scandinavian Actuarial Journal*, in press.
[6] C. H. Weiß (2008). Serial dependence and regression of Poisson INARMA models. *Journal of Statistical Planning and Inference* 138(10), 2975–2990.

Joint work with: Christian H. Weiß

Carina Beering
Technische Universität Braunschweig

Tue, 11:15
SR Phys. 0008

Bootstrapping characteristic functions under local stationarity

We propose a kernel-type estimator for the local characteristic function of locally stationary processes introduced by Dahlhaus in 1997. Under weak moment conditions, we provide a functional central limit theorem for the local empirical characteristic function process, which we are able to generalize further. Since in some cases asymptotic confidence intervals cannot be computed due to unknown parameters, we use the block bootstrap proposed in Dowla et al. in 2013 to generate a bootstrap estimator for the local CF. Subsequently, we show consistency for this method. Finally, we illustrate the finite sample behaviour of the procedure in a small simulation study for time-varying α-stable distributions for $\alpha \in (1, 2)$.

References:

[1] Dahlhaus, R. (1997): Fitting time series models to nonstationary processes. *The Annals of Statistics* 25, 1–37
[2] Dowla, A. et al. (2013). Local block bootstrap inference for trending time series. *Metrika* 76, 733–764

Joint work with: Carsten Jentsch • Anne Leucht • Marco Meyer

Annika Betken

Tue, 11:40
SR Phys. 0008

Change-point tests for LMSV time series

We consider hypothesis tests for the identification of structural changes in long memory stochastic volatility (LMSV) time series. A general change-point problem, including various alternative hypotheses such as changes in location, in volatility, and in the tail index, is discussed. To avoid the estimation of unknown parameters in practice, an application of self-normalized CUSUM- and Wilcoxon-type test statistics is proposed. Under the hypothesis of stationarity, the limiting behavior of the considered test statistics is derived. For this purpose, a limit theorem for the two-parameter empirical process of subordinated LMSV time series has been proved. Since the theory of empirical processes also applies to many other fields in non-parametric statistics, the empirical process limit theorem is of particular and independent interest.

References:

[1] A. Betken, R. Kulik: Testing for Change in Stochastic Volatility with Long Range Dependence. arXiv:1706.06351

Joint work with: Rafal Kulik

Monika Bours
RWTH Aachen

Wed, 17:20
SR Phys. 0008

Large-sample approximations for high-dimensional variance-covariance matrices of factor models

In this talk we consider high dimensional vector time series $\mathbf{Y}_{n1}, \ldots, \mathbf{Y}_{nn}$ with a factor model structure

$$\mathbf{Y}_{ni} \;=\; \mathbf{B}\,\mathbf{F}_i + \boldsymbol{\varepsilon}_i, \qquad i = 1, \ldots, n,$$

where the vector $\mathbf{F}_i$ contains all factors at time i, for $i = 1, \ldots, n$. It is assumed that the number of factors is allowed to go to infinity. The matrix $\mathbf{B}$ contains the corresponding factor loadings and $\boldsymbol{\varepsilon}_i$ is the error component.
Factor models are widely used in various areas including psychometrics, marketing, finance as well as natural sciences and technology. For example, factor models are a key tool for financial risk analysis and macroeconomic forecasting of indicators such as the GDP (Gross Domestic Product) and inflation. Since large datasets are becoming increasingly available in many disciplines the analysis of high-dimensional time series has become an highly active area. The estimation of high-dimensional variance-covariance matrices is of particular interest, but often only an intermediate step, since interest focuses on the behaviour of functions of the sample variance-covariance matrix, especially bilinear forms which naturally arise when studying projection type statistics.
We establish new results on distributional approximations for bilinear functions of sample variance-covariance matrices in terms of Brownian motions. In the high dimensional setting, where also the dimension is allowed to go to infinity, these approximations by Gaussian processes hold true without any constraints on the dimension, the sample size or their ratio. Our results are valid for uniformly ℓ_1-bounded projection vectors which arise either naturally or by construction in many statistical problems like change-point analysis, sparse financial portfolio selection and shrinkage estimation.

Joint work with: Ansgar Matthias Steland

Alexander Braumann
TU Braunschweig

Tue, 12:05
SR Phys. 0008

Bootstrap methods for vector autoregression estimators in generalized dynamic factor models

We consider bootstrap methods for the parameters of vector autoregressive models for a static factor process, which is an unobserved part of a generalized dynamic factor model as proposed in Forni et al. 2000, Forni and Lippi 2001. In such models the panel of wide-sense stationary time series can be large. The idiosyncratic components are weakly dependent in their cross-sectional and time dimensions. The static factors, which are modelled by a vector autoregressive system, need to be estimated before estimating the autoregressive parameters.
We derive the asymptotic distribution of the autoregressive parameter estimates and analyse under which circumstances the autoregressive parameter estimates are asymptotically biased and what influences this bias. This is an extention of the univariate case presented in Shintani and Guo 2016. Bootstrap methods are discussed which account for that asymptotic bias. Their asymptotic validity is shown using the asymptotic framework of Bai 2003, Goncalves and Perron 2014 and results from Goncalves and Perron 2016.

Joint work with: Jens-Peter Kreiß

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 8: Time series

Axel Bücher
Ruhr-Universität Bochum

Tue, 17:55
SR Phys. 0008

On a pseudo-maximum likelihood estimator for the extremal index

The extremes of a stationary time series typically occur in clusters. A primary measure for this phenomenon is the extremal index, representing the reciprocal of the expected cluster size. Both a disjoint and a sliding blocks estimator for the extremal index, essentially due to Northrop (2015) [An efficient semiparametric maxima estimator of the extremal index. Extremes 18, 585–603], are analyzed in detail. In contrast to many competitors, the estimators only depend on the choice of one parameter sequence. We derive an asymptotic expansion, prove asymptotic normality and show consistency of an estimator for the asymptotic variance. Explicit calculations in certain models and a finite-sample Monte Carlo simulation study reveal that the sliding blocks estimator outperforms other blocks estimators, and that it is competitive to runs- and interexceedance estimators in various models. The methods are applied to a variety of financial time series.

Joint work with: Betina Berghaus

Jürgen Franke

Tue, 14:25
SR Phys. 0008

Bootstrapping functional autoregressions

Functional autoregressions (FAR) are among the most popular models for time series of functional data in a Hilbert space $\mathcal{H}$, e.g. of curves in some L^2-space. The simplest case of order 1, which by change of Hilbert space also includes higher order models, follows the recursion:

$$X_{t+1} = \Psi(X_t) + \varepsilon_{t+1},$$

where the innovations ε_t are i.i.d. random variables in $\mathcal{H}$. FARs are frequently used for forecasting or tests, e.g. for changes in the structure of the data generating process, compare, e.g., Horváth and Kokoszka (2010). In many practical applications, resampling methods are used for calculating approximate prediction intervals or critical values for tests. However, the theoretical basis for those methods is still rather incomplete.
We consider the residual-based, also called naive, bootstrap where the bootstrap data are generated by

$$X^*_{t+1} = \hat{\Psi}_n(X^*_t) + \varepsilon^*_{t+1},$$

where $\hat{\Psi}_n$ is an estimate of Ψ and $\varepsilon^*_1, \dots, \varepsilon^*_n$ are i.i.d., conditional on the original data, with distribution given by the empirical distribution of the centered sample residuals $X_t - \hat{\Psi}_n(X_{t-1})$, $t = 1, \dots, n$. This resampling method is quite popular and works very well in the scalar and multivariate case. For functional data, this resampling method has already been investigated for functional linear regression models by González-Manteiga and Martínez-Calvo (2011), but for autoregressions, the situation is more complicated such that we have to follow a different strategy for proving the asymptotic validity of the residual-based bootstrap which combines ideas from the scalar autoregressive case as in Kreiss and Franke (1992) with a careful analysis of the unavoidable misspecification of the estimate $\hat{\Psi}_n$.
In this talk, we discuss the validity of this bootstrap in a rather strong sense, starting from the convergence of the empirical distribution of the sample residuals to the true distribution of the innovations which can be shown using the strong consistency result of Bosq (2010) for the estimate $\hat{\Psi}_n$ of the autoregressive operator Ψ.
In the second part of the talk, we extend these results to nonlinear functional autoregressions where Ψ is no longer a linear operator, but can be estimated by kernel smoothers as proposed by Ferraty et al. (2012).

References:

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Joint work with: Euna Nyarige • Johannes Krebs

Alexander Heinemann

Fri, 09:00
SR Phys. 0008

A Justification of Conditional Confidence Intervals

To quantify uncertainty around point estimates of conditional objects such as conditional means or variances, parameter uncertainty has to be taken into account. Attempts to incorporate parameter uncertainty are typically based on the unrealistic assumption of observing two independent processes, where one is used for parameter estimation, and the other for conditioning upon. Such unrealistic foundation raises the question whether these intervals are theoretically justified in a realistic setting.
This paper presents an asymptotic justification for this type of intervals that does not require such an unrealistic assumption, but relies on a sample-split approach instead. By showing that our sample-split intervals coincide asymptotically with the standard intervals, we provide a novel, and realistic, justification for confidence intervals of conditional objects. The analysis is carried out for a general class of Markov chains nesting various time series models.

Joint work with: Eric Beutner • Stephan Smeekes

Johannes Heiny
Aarhus University

Wed, 14:00
SR Phys. 0008

A comparison of high-dimensional sample covariance and correlation matrices of a heavy-tailed time series

In Principal Component Analysis one studies the sample covariance or sample correlation matrix, both of which often lead to the same result.
In this talk, we first analyze the joint distributional convergence of the largest eigenvalues of the sample covariance matrix of a p-dimensional heavy-tailed time series when p converges to infinity together with the sample size n. Assuming a regular variation condition with tail index $\alpha < 4$, we employ a large deviations approach to show that the extreme eigenvalues are essentially determined by the extreme order statistics from an array of iid random variables. The asymptotic behavior of the extreme eigenvalues is then derived routinely from classical extreme value theory. The resulting approximations are strikingly simple considering the high dimension of the problem at hand.
Then we compare the behavior of the eigenvalues of the sample covariance and sample correlation matrices and argue that the latter seems more robust, in particular in the case of infinite fourth moment.
We show that the largest and smallest eigenvalues of a sample correlation matrix stemming from n independent observations of a p-dimensional time series with iid components converge almost surely to $(1+\sqrt{\gamma})^2$ and $(1-\sqrt{\gamma})^2$, respectively, as $n \to \infty$, if $p/n \to \gamma \in (0,1]$ and the truncated variance of the entry distribution is "almost slowly varying", a condition we describe via moment properties of self-normalized sums. Moreover, the empirical spectral distributions of these sample correlation matrices converge weakly, with probability 1, to the Marchenko–Pastur law.

Joint work with: Thomas Mikosch

Shaikh Tanvir Hossain
University of Mannheim

Tue, 14:00
SR Phys. 0008

Modeling and Prediction of Dynamic Networks using binary autoregressive time series processes

Suppose a time series of networks is identified by their adjacency matrices $A_1, \dots, A_T$, where $A_t = (a_{ij;t})_{i,j=1,\dots,N}$ with $a_{ij;t} \in \{0,1\}$ and $a_{ij,t} = 1$ indicating that there is a directed edge pointing from vertex i to vertex j at time t. To model the joint dynamics of the edges, we propose to use multivariate binary time series processes. For this purpose, we adopt the class of Discrete AutoRegressive Moving-Average (DARMA) models introduced for univariate categorical data by Jacobs and Lewis (1983). Recent extensions of these models allow the application to vector-valued data and to model negative autocorrelations by a simple modification. The resulting model class is flexible enough to capture very general autocorrelations driving the dynamic network structure. For the purely autoregressive case, Yule-Walker-type equations hold that allow in principle an explicit estimation of all model parameters. However, as the dimension of the adjacency matrices grows quadratically with the number of vertices, we shall make use of Lasso-penalization techniques to estimate sparse models. For this purpose, we adopt the approach of Basu and Michailidis (2015), who established consistent estimation for high-dimensional vector autoregressive models under sparsity. Our modeling approach is suitable for prediction of single and joint edge probabilities in dynamic networks. We illustrate our method by simulations and for real data.

References:

[1] S. Basu, G. Michailidis (2015). *Regularized Estimation in Sparse High-dimensional Time Series Models*. *The Annals of Statistics* 43, No. 4, 1535–1567.
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Joint work with: Carsten Jentsch • Lena Reichmann

Anja Janssen
KTH Royal Institute of Technology

Wed, 11:35
SR Phys. 0008

Regularly varying time series and max-stable processes

In this talk, we will discuss some connections between stationary multivariate regularly varying time series and the class of max-stable processes in discrete time. We focus on the extremal aspects of both processes which can be expressed in terms of a limiting process that is known as the (spectral) tail process, which describes the conditional behavior of the process before and after an extremal event at a given time. We explore how the stationarity of the processes is reflected in the extremal behavior and how it is for example possible to construct an underlying stationary max-stable process for a given spectral tail process.
The talk is based on the preprint "Spectral tail processes and max-stable approximations of multivariate regularly varying time series" available at https://arxiv.org/abs/1708.07019.

Kevin Kokot
Ruhr-Universität Bochum

Tue, 14:50
SR Phys. 0008

Functional data analysis in the Banach space of continuous functions

Functional data analysis is typically conducted within the L^2-Hilbert space framework. There is by now a fully developed statistical toolbox allowing for the principled application of the functional data machinery to real-world problems, often based on dimension reduction techniques such as functional principal component analysis. At the same time, there have recently been a number of publications

that sidestep dimension reduction steps and focus on a fully functional L^2-methodology. In this talk, we go one step further and develop data analysis methodology for functional time series in the space of all continuous functions. The work is motivated by the fact that objects with rather different shapes may still have a small L^2-distance and are therefore identified as similar when using an L^2-metric. However, in applications it is often desirable to use metrics reflecting the visualization of the curves in the statistical analysis. The methodological contributions are focused on developing change-point tests. Particular interest is put on relevant differences; that is, on not trying to test for exact equality, but rather for pre-specified deviations under the null hypothesis.

References:

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Joint work with: Holger Dette • Alexander Aue

Jonas Krampe
TU Braunschweig

Wed, 18:10
SR Phys. 0008

Time Series Modeling on Dynamic Networks

We consider multivariate time series on dynamic networks with a fixed number of vertices. Each component of the time series is assigned to a vertex of the underlying network. The dependency of the various components of the time series is modeled dynamically by means of the edges.
We make use of a multivariate doubly stochastic time series framework, that is we assume linear processes for which the coefficient matrices are stochastic processes themselves. We explicitly allow for dependence in the dynamics of the coefficient matrices, including of course an i.i.d. structure as is typically assumed in random coefficients models. In the paper asymptotic normality of statistics like the sample mean is investigated. Furthermore, autoregressive moving average models are defined in this framework. Estimators of the parameters are discussed for various parametrizations of such network autoregressive models and how this can be used to forecast such a process. Some interesting features of these processes are shown in simulations and the finite sample behavior of the forecast approach is investigated.

Chong Liang
KIT

Wed, 15:15
SR Phys. 0008

Determination of Vector Error Correction Models in High Dimensions

We provide a shrinkage type methodology which allows for simultaneous model selection and estimation of vector error correction models (VECM) when the dimension is large and can increase with sample size. Model determination is treated as a joint selection problem of cointegrating rank and autoregressive lags under respective practically valid sparsity assumptions. We show consistency of the selection mechanism by the resulting Lasso-VECM estimator under very general assumptions on dimension, rank and error terms. Moreover, with computational complexity of a linear programming problem only, the procedure remains computationally tractable in high dimensions. We demonstrate the effectiveness of the proposed approach by a simulation study and an empirical application to recent CDS data after the financial crisis.

Joint work with: Melanie Schienle

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 8: Time series

Nils Mause
RWTH Aachen University

Tue, 17:30
SR Phys. 0008

Inference on the mean of high-dimensional random vectors in a multiple sample setting

A common problem in statistical research is that of comparing the mean vectors of two or more populations. For example, in finance one often is interested in a comparison of portfolios in terms of their expected returns. Classically, when the dimension d of the data is smaller than the sample size N, the Hotelling's T^2 test can be used to address this problem. However, nowadays large datasets consisting of a huge amount of variables are getting more and more common, and thus one needs to deal with 'large d, small N' situations where the data dimension exceeds the sample size and the precision matrix, the inverse of the pooled sample variance-covariance matrix, may no longer exist.
One possible solution to this problem was developed by Bai and Saranadasa in [1], where they proposed using the test statistic $T_{BS} = \|\overline{X}_1 - \overline{X}_2\|_2^2 - \tau \mathrm{tr}(S)$, consisting of the sample means $\overline{X}_j$ of two populations $j = 1, 2$ and the trace of the pooled sample variance-covariance matrix S scaled by some $\tau > 0$. Under the null hypothesis of equal means they have shown the asymptotic normality of the test statistic T_{BS} as long as the dimension d increases at the same rate as the sample size N, i.e. $\frac{d}{N} \to c > 0$.
Within the high-dimensional framework where not only the sample size shall go to infinity but also the dimension $d = d_N$ is allowed to grow with the sample size N we propose a new method of proof for the asymptotic null distribution of a rescaled version of the test statistic T_{BS} which does not rely on any assumption on the ratio of dimension and sample size, and thus also holds for $d_N \gg N$.
This is joint work with Ansgar Steland from the Institute of Statistics, RWTH Aachen University, Germany. It was supported by the German Research Foundation / Deutsche Forschungsgemeinschaft (DFG) [grant number STE 1034/11-1].

References:

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Joint work with: Ansgar Matthias Steland

Simone Maxand

Wed, 11:10
SR Phys. 0008

Identification of independent structural shocks in the presence of multiple Gaussian components

Several recently developed identification techniques for structural VAR models are based on the assumption of non-Gaussianity. So-called independence based identification provides unique structural shocks (up to scaling and ordering) under the assumption of at most one Gaussian component. While non-Gaussianity of certain interesting shocks, e.g., a monetary policy shock, appears rather natural, not all macroeconomic shocks in the system might show this clear difference from Gaussianity. We generalize identifiability by noting that even in the presence of multiple Gaussian shocks the non-Gaussian ones are still unique. Consequently, independence based identification allows to uniquely determine the (non-Gaussian) shocks of interest irrespective of the distribution of the remaining system. In an illustrative macroeconomic model the identified structural shocks confirm the results of previous studies on the early millennium slowdown. Furthermore, extending the time horizon provides full identification under the non-Gaussianity assumption.

13th German Probability and Statistics Days
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Section 8: Time series

Marco Meyer
Helmut-Schmidt-Universität Hamburg

Wed, 17:45
SR Phys. 0008

Frequency domain hybrid bootstrap for spectral means

For time series the class of spectral mean statistics (also called integrated periodograms) includes many important statistics such as sample autocovariances and autocorrelations, as well as smoothed spectral density estimators, among other things. Existing methods for bootstrapping these estimators have a very limited range. Essentially, these procedures cover the case of univariate, linear time series with independent innovations, and some even require the time series to be Gaussian.
We propose a new, hybrid bootstrap method in the frequency domain which is consistent for a much wider range of stationary processes. It uses existing methods to replicate the dominant part of the distribution of interest, and introduces a new concept of convolved subsampling to correct for those parts of the variance that cannot be mimicked by classical procedures. We show consistency for this hybrid procedure for a general class of time series, ranging clearly beyond linear processes, and for general spectral mean statistics. This yields, among other things, a method to consistently bootstrap sample autocovariances. The performance of this procedure is illustrated via simulations.

Joint work with: Efstathios Paparoditis • Jens-Peter Kreiß

Vytaute Pilipauskaite
Aarhus University

Wed, 16:55
SR Phys. 0008

Testing for long memory in panel random-coefficient AR(1) data

It is well-known that random-coefficient AR(1) process can have long memory depending on the index β, which controls the shape of the distribution of autoregressive coefficient at unity. We discuss estimation of β from panel data comprising N random-coefficient AR(1) series, each of length T. Our proposed estimator for β is a version of the tail index estimator of Goldie and Smith (1987) applied to sample lag 1 autocorrelations of individual time series. Its asymptotic normality is derived under certain conditions on N, T and some parameters of our statistical model. Based on this result, we construct a statistical procedure to test if the panel random-coefficient AR(1) data exhibit long memory. A simulation study illustrates finite-sample performance of the introduced estimator and testing procedure.

Joint work with: Remigijus Leipus • Anne Philippe • Donatas Surgailis

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Daniel Constantin Rademacher
Technische Universität Carolo-Wilhelmina zu Braunschweig

Tue, 15:15
SR Phys. 0008

Periodogram of Functional Time Series and Related Quantities

Consider a stationary and centered functional time series taking values in a separable Hilbert space.
In a recent paper Cerovecki and Hörmann (2017) show asymptotic normality of the functional discrete Fourier transform under relatively mild assumptions.
The limiting covariance operator can be seen as an infinite dimensional extension of the well known spectral density matrix of a multivariate time series and is therefore called *spectral density operator*.
On this basis we draw inference about this operator by considering the tensor product of the functional discrete Fourier transform with itself, the so-called *periodogram operator*.
By construction, many properties of the periodogram matrix extend to the periodogram operator and it can be seen that it is an asymptotically unbiased but not consistent estimator for the spectral density operator.
Moreover, we study in detail the periodogram operator of a linear process under suitable summability conditions, i.e. we derive an explicit formula for the periodogram operator and determine its asymptotic covariance structure. In order to achieve consistency we introduce so called *integrated periodogram*

operators and investigate such estimators in case of a linear process. In particular we study their asymptotic behavior.

References:

[1] C. Cerovecki, S. Hörmann (2017). On the CLT for discrete Fourier transforms of functional time series. *Journal of Multivariate Analysis*, Vol. 154, 282–295

Joint work with: Jens-Peter Kreiß • Efstathios Paparoditis

Lena Reichmann

Wed, 10:45
SR Phys. 0008

Generalized binary time series models

The serial dependence of categorical data is commonly described using Markovian models. As a result of their flexibility, they can suffer from a huge number of parameters if the state space or the model order becomes large. To address the problem of a large number of model parameters in the univariate case, a more parsimonious and nicely interpretable class of Discrete AutoRegressive Moving-Average (NDARMA) models has been introduced in the literature. For binary data, we propose two model extensions. First, we allow for negative model coefficients to allow also for negative autocorrelations, which is not possible using NDARMA models. Second, we consider the vector-valued case that is suitable e.g. for dynamic network modeling. In this case, the effect of Markov models having a huge number of parameters becomes even more pronounced. Both extensions are simple and maintain the nice interpretability and the autoregressive moving-average structure leading to a new generalized NDARMA model class. We provide sufficient stationarity conditions and derive the stationary solution of the model equations. For the purely autoregressive case, we prove Yule-Walker-type equations that facilitate the task of parameter estimation in these models to some large extent. Further, we discuss mixing properties of these models. For illustration, we study the estimation performance in these models by simulations and apply our model to quarterly OECD recession data from G7 countries.

Joint work with: Carsten Jentsch

Mario Philipp Rothfelder
Tilburg University

Wed, 14:50
SR Phys. 0008

Long-Run Precision Matrix Estimation for High-Dimensional Linear Processes

This paper proposes a novel estimator for estimating the inverse of the long-run covariance matrix (also known as long-run precision matrix) of a high-dimensional linear time series. The estimator minimizes the (weighted) ℓ_1-penalized Bregman-divergence of the negative log-determinant of a symmetric positive definite matrix which allows for the usage of the graphical LASSO algorithm to solve the underlying optimization problem. It is shown that the proposed (adaptive) LASSO-type estimator is consistent in the Frobenius-norm and that the spatial dimension N of the underlying process is allowed to grow at a rate such that $N^2/T \to 0$ as $T \to \infty$. An extensive Monte Carlo study is utilized to assess the small sample properties of the proposed estimator and it is found that the estimator performs reasonably well in a variety of different settings.

Stefan Richter
Heidelberg University

Wed, 16:30
SR Phys. 0008

Towards a general theory for non-linear locally stationary processes

In this talk some general theory is presented for locally stationary processes based on the stationary approximation and the stationary derivative. Strong laws of large numbers, central limit theorems as well as deterministic and stochastic bias expansions are proved for processes obeying an expansion in

terms of the stationary approximation and derivative. It is shown that this applies to some general nonlinear non-stationary Markov-models.
The results are applied to derive the asymptotic properties of localized maximum likelihood estimates of parameter curves in such models. In this setting, we also obtain results on adaptive bandwidth selection via cross validation and results about simultaneous inference.

Joint work with: Rainer Dahlhaus • Wei Biao Wu

Ansgar Matthias Steland
RWTH Aachen

Wed, 14:25
SR Phys. 0008

Inference for High-Dimensional Time Series Based on Bilinear Forms of Covariance Matrices with Applications to Shrinkage

For a high-dimensional vector time series, whose coordinates are linear processes, inference on elements of the covariance matrix can be based on bilinear forms of the sample variance-covariance matrix, which also arise when studying variances and covariances of projections onto lower dimensional subspaces. We show that such a bilinear form and even a growing number, L_n, of them can be approximated by a Brownian motion, without any constraint the dimension, d_n, or the number, L_n. The relevant asymptotic variances and covariances of the bilinear forms can be estimated consistently, even uniform in the dimension.
Those results allow to construct statistical procedures, e.g. confidence intervals for the trace functional and change-point tests. We also establish large sample approximations for shrinkage estimators of the covariance matrix in the sense of Ledoit and Wolf.

References:

[1] A. Steland, R. v. Sachs (2017). Large sample approximations for variance-covariance matrices of high-dimensional time series, *Bernoulli*, 23 (4A), 2299–2329.
[2] A. Steland, R. v. Sachs (2017). Asymptotics for high-dimensional covariance matrices and quadratic forms with applications to the trace functional and shrinkage.*Stochastic Processes and Their Applications*, accepted.

Joint work with: Rainer v. Sachs

Christian H. Weiß
Helmut-Schmidt University

Wed, 12:00
SR Phys. 0008

On Eigenvalues of the Transition Matrix of some Count-Data Markov Chains

For certain types of stationary count-data Markov chains, we derive the complete set of eigenvalues of the corresponding transition matrix. Although we also refer to some countably infinite Markov chains below, our main interest is in the finite case, because there, the knowledge about the eigenvalues is particularly important for practice. A possible application refers to the Perron–Frobenius theorem, which allows to quantify the speed of convergence of the h-step-ahead forecasting distribution towards the marginal distribution based on the "second-largest" eigenvalue of the transition matrix. Another application concerns the Pearson's χ^2-statistic, the asymptotic distribution of which might be expressed by using the complete set of eigenvalues of the transition matrix.
Motivated by these applications, we analyze the eigenstructure of some count-data Markov chains. Our main focus is on so-called CLAR(1) models, which are characterized by having a linear conditional mean. We derive a lower bound for their second largest eigenvalue, which often (but not always) even equals this eigenvalue. In particular, a method for the calculation of the complete set of eigenvalues is presented, which relies on the computation of higher-order conditional (factorial) moments. The method is exemplified for several specific cases of CLAR(1) models (especially such having a finite range). The obtained results give important insights into the eigenstructure of CLAR(1) models for counts, and have consequences on, e.g., the determination of a reasonable forecasting horizon, where

non-trivial forecasts (i.e., differing from those obtained from the stationary marginal distribution) are possible.

References:

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13th German Probability and Statistics Days
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Section 9: Computational statistics and data analysis

Section 9: Computational statistics and data analysis

Thordis L. Thorarinsdottir
Norwegian Computing Center

Wed, 11:35
HS Anatomie

On developing general and efficient inference algorithms for complicated hierarchical models

A common problem in spatial statistics consists of estimating the marginal distribution of a phenomena at any location within a region. The (usually two or three) parameters of the marginal distribution are then assumed to depend on a set of covariates and, potentially, a spatially structured random effect. In addition, it is often of interest to incorporate a model averaging component to assess model uncertainty in the effect of the proposed covariates. We discuss how inference for such models can be performed in a Bayesian setting in a general and an efficient manner without the need for user-specified tuning parameters in the Bayesian inference algorithm. This is demonstrated in two applications where the three-parameter generalized extreme value (GEV) distribution with latent Gaussian fields is used for spatial modelling of extreme hourly precipitation and for regional flood frequency analysis in Norway.

Carlos Enrique Améndola Cerón
Technische Universität Berlin

Thu, 11:35
SR Geologie

Learning Mixtures of Gaussians via Method of Moments

Following up on Karl Pearson's introduction of the method of moments to recover the parameters of a mixture of two univariate Gaussians, we ask in general if the model parameters of a mixture of k Gaussians in dimension n can be identified from all the moments up to certain order d.
Computationally, the method matches the mixture density moments to sample moments, leading to a polynomial system of equations in the unknown parameters. For instance, in Pearson's case where $n = 1$ and $k = 2$, the system corresponding to the first $d = 5$ moments in the means μ_1, μ_2, standard deviations σ_1, σ_2 and mixture weights α_1, α_2 is:

$$\begin{aligned}
\alpha_1\mu_1 + \alpha_2\mu_2 &= m_1\\
\alpha_1(\mu_1^2 + \sigma_1^2) + \alpha_2(\mu_2^2 + \sigma_2^2) &= m_2\\
\alpha_1(\mu_1^3 + 3\mu_1\sigma_1^2) + \alpha_2(\mu_2^3 + 3\mu_2\sigma_2^2) &= m_3\\
\alpha_1(\mu_1^4 + 6\mu_1^2\sigma_1^2 + 3\sigma_1^4) + \alpha_2(\mu_2^4 + 6\mu_2^2\sigma_2^2 + 3\sigma_2^4) &= m_4\\
\alpha_1(\mu_1^5 + 10\mu_1^3\sigma_1^2 + 15\mu_1\sigma_1^4) + \alpha_2(\mu_2^5 + 10\mu_2^3\sigma_2^2 + 15\mu_2\sigma_2^4) &= m_5.
\end{aligned}$$

One may ask then if the resulting systems have an infinite number of solutions, finitely many solutions or a unique solution up to label swapping; for general enough or for special values of the moments m_i. These scenarios correspond to different degrees of identifiability. For the above system, the generic number of solutions is 9, as found by Pearson.
Among recent results with collaborators is that for $n = 1$, considering the first $d = 3k - 1$ moments will yield generically a finite number of Gaussian mixture densities with the same matching moments. In contrast, the system of 19 polynomial equations in 19 unknowns of all moments up to order $d = 3$ for a mixture of $k = 2$ Gaussians in dimension $n = 3$ will have generically infinitely many solutions and thus the method of moments will fail in this case.

We draw parallels between this approach and related work that considers tensor decomposition methods for special kinds of Gaussian mixture submodels, under assumptions such as spherical covariance. Further, using results from algebraic geometry, we classify all cases where method of moments would fail under the homoscedastic Gaussian mixture model where the common covariance matrix is known.

References:

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Jone Ascorbebeitia Bilbatua

Thu, 17:45
SR Geologie

Testing for conditional dependence between domestic indexes using nonparametric copulas

It is well known that the comovements between portfolios are time-varying. The interest is to detect in which level the comovements variation between domestic indexes can be explained by some global risk factors. Concretely, we will study the dependence of Euro Stoxx. Moreover, we are interested in measures of dependence beyond linear Pearsons correlation. This coefficient suits for normal variables, but not for variables with more complicated distributions such as financial variables. To overcome this fact, we propose the use of copulas to analyze the relation between domestic European indexes, conditional to the Euro Stoxx. The use of copulas allows us to model the dependence better than with elliptic distributions. We estimate conditional copulas using nonparametric methods to obtain the joint probability distribution function between indexes and we pay special attention on the asymptotic properties of the nonparametric estimator. We consider also an alternative estimator and we analyze it with the purpose of improving the estimators properties. Then we make a discussion of both estimators. Moreover, we focus on the bandwidth choice of the conditional copula estimator and its sensitivity via a simulation study. This conditional copula method allows us to relate daily data with monthly data in a very simple manner, and therefore to relate stock indexes with macroeconomic variables such as inflation or GDP. We will measure the dependence and the conditional dependence using the Kendall's tau. We provide a statistic to test the significance of tau and its empirical distribution using jacknife.

Joint work with: Eva Ferreira Garcia • Susan Orbe Mandaluniz

Sándor Baran

Thu, 15:15
SR Geologie

Combining predictive distributions for calibration of ensemble forecasts for precipitation accumulation

Statistical post-processing techniques are now widely used to correct systematic biases and errors in calibration of ensemble forecasts obtained from multiple runs of numerical weather prediction models. A standard approach is the ensemble model output statistics (EMOS) method, where the forecast distribution is given by a single parametric law with parameters depending on the ensemble members. Choosing an appropriate parametric family for the weather variable of interest is a critical, however, often non-trivial task, and has been the focus of much recent research. We assess the merits of combining predictive distributions from censored and shifted gamma [1] and censored generalized extreme value [2] EMOS models for precipitation accumulation using the state of the art forecast combination

methods. In two case studies with precipitation forecasts from two ensemble prediction systems we investigate the performance of the (spread-adjusted) linear pool, the beta transformed linear pool, and a recently introduced Bayesian calibration approach [3] and we also propose a computationally efficient ?plug-in' approach to determining combination weights in the linear pool that is specific to post-processing applications.

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Joint work with: Sebastian Lerch

Florian Dumpert
University of Bayreuth

Thu, 16:30
SR Geologie

Consistency and Robustness Properties of Predictors Based on Locally Learned SVMs

Support Vector Machines (SVMs) play an important role in many areas of science. In the past two decades, much research has been conducted on the statistical and computational properties of support vector machines and related kernel methods. On the one hand, the consistency and robustness of the method are of interest. On the other hand, from a mathematical point of view, there is an interest in a method that can deal with many observations and many features. Since SVMs require a lot of computing power and storage capacity, various possibilities for processing large data sets have been proposed. One of them, called regionalization, divides the space of declaring variables into possibly overlapping domains and defines the function to predict output by the formation of locally learned support vector machines. Another advantage of regionalization: If the generating distribution in different regions of the input space has different characteristics, learning only one "global" SVM may lead to an imprecise estimate. Locally trained predictors can overcome this problem. It is possible to show that a locally learned predictor holds consistency and robustness results under assumptions that can be checked by the user of this method. We will look at these consistency and robustness properties, such as bounds for the maxbias or the influence function for predictors based on locally learned support vector machines.

Joint work with: Andreas Christmann

Axel Gandy
Imperial College London

Thu, 16:55
SR Geologie

Implementing Monte Carlo Tests with p-value Buckets

Software packages usually report the results of statistical tests using p-values. Users often interpret these by comparing them to standard thresholds, e.g. 0.1 %, 1 % and 5 %, which is sometimes reinforced by a star rating (***, **, *). In this article, we consider an arbitrary statistical test whose p-value p is not available explicitly, but can be approximated by Monte Carlo samples, e.g. by bootstrap or permutation tests. The standard implementation of such tests usually draws a fixed number of samples to approximate p. However, the probability that the exact and the approximated p-value lie on different sides of a threshold (the resampling risk) can be high, particularly for p-values close to a

threshold. We present a method to overcome this. We consider a finite set of user-specified intervals which cover [0,1] and which can be overlapping. We call these p-value buckets. We present algorithms that, with arbitrarily high probability, return a p-value bucket containing p. We prove that for both a bounded resampling risk and a finite runtime, overlapping buckets need to be employed, and that our methods both bound the resampling risk and guarantee a finite runtime for such overlapping buckets. To interpret decisions with overlapping buckets, we propose an extension of the star rating system. We demonstrate that our methods are suitable for use in standard software, including for low p-values occurring in multiple testing settings, and that they can be computationally more efficient than standard implementations.

Joint work with: Georg Hahn • Dong Ding

Claudio Heinrich

Thu, 12:00
SR Geologie

Statistical postprocessing of sea surface temperature forecasts

Numerical weather prediction (NWP) models predict future weather by approximating solutions to the (deterministic) partial differential equations that govern the dynamics in atmosphere and oceans.
These models oftentimes exhibit systematical bias and miscalibration and therefore require statistical postprocessing based on training data.
We consider NWP forecasts for sea surface temperature on the entire globe issued by the Norwegian Climate Prediction Model NorCPM.
Challenges for statistical postprocessing of sea surface temperature are, among others, strong seasonality effects, trends in the bias caused by global warming, and a nonstationary error correlation.
We compare various alternatives for both bias correction and calibration, demonstrating that, despite the high dimensional nature of the problem and relatively few observations, principal component analysis can be used to approximate the full error covariance matrix.

Joint work with: Alex Lenkoski • Thordis L. Thorarinsdottir

Martin Keller-Ressel
TU Dresden

Thu, 10:45
SR Geologie

Distance Multivariance - a new dependence measure for multiple random vectors

'Distance multivariance' and 'total distance multivariance' are new measures for the dependence of $n \geq 2$ random vectors. These measures extend distance covariance (introduced by Szekely, Rizzo and Bakirov) from pairs of random vectors to n-tuplets of random vectors. We show that total distance multivariance is able to detect the independence of n random variables and to distinguish it from the weaker condition of pairwise independence. Moreover, we show that distance multivariance has a simple finite-sample representation in terms of the distance matrices of the sample points, where distance is measured by a continuous negative definite function. Based on our theoretical results, we propose a test for independence of multiple random vectors which is consistent against all alternatives.

Joint work with: Björn Böttcher • Rene Schilling

Karsten Keller

Thu, 18:10
SR Geologie

Change-point detection using the conditional entropy of ordinal patterns

The talk discusses change-point detection using only the ordinal structure of a time series. A statistic based on the conditional entropy of ordinal patterns characterizing the local up and down in a time series is introduced and investigated. This statistic requires only minimal a priori information on given data and shows good performance in numerical experiments. We give some theoretical background and illustrate the proposed method by examples.

Joint work with: Anton M. Unakafov

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 9: Computational statistics and data analysis

Bernhard Klar
Institut für Stochastik, Karlsruher Institut für Technologie

Thu, 14:00
SR Geologie

Focusing on regions of interest in forecast evaluation

Often, interest in forecast evaluation focuses on certain regions of the whole potential range of the outcome, and forecasts should mainly be ranked according to their performance within these regions. A prime example is risk management, which relies on forecasts of risk measures such as the value-at-risk or the expected shortfall and hence requires appropriate loss distribution forecasts in the tails. Further examples include weather forecasts with a focus on extreme conditions, or forecasts of environmental variables such as ozone with a focus on concentration levels with adverse health effects.
We show how weighted scoring rules can be used to this end, and in particular that they allow to rank several potentially misspecified forecasts objectively with the region of interest in mind. This is demonstrated in various simulation scenarios.
We introduce desirable properties of weighted scoring rules and present general construction principles based on conditional densities or distributions and on scoring rules for probability forecasts.
In our empirical application to log-return time series all forecasts seem to be slightly misspecified, as is often unavoidable in practice, and no method performs best overall. However, using weighted scoring functions the best method for predicting losses can be identified, which is hence the method of choice for the purpose of risk management.

Joint work with: Hajo Holzmann

Sebastian Lerch

Thu, 14:50
SR Geologie

Similarity-based semilocal estimation of post-processing models

Weather forecasts are typically given in the form of forecast ensembles obtained from multiple runs of numerical weather prediction models with varying initial conditions and model physics. Such ensemble predictions tend to be biased and underdispersive and thus require statistical post-processing. In the ensemble model output statistics approach, a probabilistic forecast is given by a single parametric distribution with parameters depending on the ensemble members. We propose two semilocal methods for estimating the model parameters where the training data for a specific observation station are augmented with corresponding forecast cases from stations with similar characteristics. Similarities between stations are determined by using either distance functions or clustering based on various features of the climatology, forecast errors and locations of the observation stations. In a case study on wind speed over Europe, the proposed similarity-based semilocal models show improvements in predictive performance compared with standard regional and local estimation methods. They further allow for estimating complex models without numerical stability issues and are computationally more efficient than local parameter estimation.

Joint work with: Sandor Baran

Eckhard Liebscher

Thu, 11:10
SR Geologie

Parametric classes of star-shaped distributions

In the talk we consider a d-dimensional random vector X having the density

$$\varphi_{g,h,\mu,\Sigma}(x) = \left(C_0 \det(\Sigma)\right)^{-1} \; g\left(h(\Sigma^{-1}(x-\mu))\right) \text{ for } x \in \mathbb{R}^d.$$

We call the distribution of X a *continuous star-shaped distribution*. Function $h : \mathbb{R}^d \to [0, +\infty)$ is assumed to be homogeneous of order 1 and determines the contour sets of the density.
Alternatively, function $h = h_K$ can be introduced as the Minkowski functional of a star body K, see papers Richter (2014), Liebscher and Richter (2016) for a detailed introduction to the class of

continuous star-shaped distributions. The generator function $g : \mathbb{R} \to [0, +\infty)$ is chosen such that $\int_0^\infty r^{d-1} g(r) dr = 1$. $\mu \in \mathbb{R}^d$ is the location parameter and the diagonal matrix $\Sigma = \text{diag}(\sigma_1, \ldots, \sigma_d)$ contains the scale parameters of the distribution.
We introduce parametric classes of star-shaped distribution based on the spherical (polar) transformation of the distribution. For this purpose, functions g and h are appropriately parametrized. Properties of the distribution classes such as the convexity or non-convexity of the contours are studied. In view of statistical applications the identifiability of a given class is an important issue. We discuss sufficient conditions for the identifiability and show that the proposed classes are identifiable.
In the last part, we deal with the maximum-likelihood estimation for the whole distribution and for function h separately. Further the asymptotic normality of the estimators is discussed.

References:

[1] Liebscher, E.; Richter, W.-D. (2016). Estimation of star-shaped distributions. *Risks*, special issue "Selected Papers from the 10th Tartu Conference on Multivariate Statistics" **4**, 1–37.
[2] Richter, W.-D. (2014). Geometric disintegration and star-shaped distributions. *Journal of Statistical Distributions and Applications* **2014**, 1–20.

Joint work with: Wolf-Dieter Richter

Annette Möller
Clausthal University of Technology

Thu, 14:25
SR Geologie

Spatially adaptive Bayesian estimation for Probabilistic Temperature Forecasts

Weather forecasting today is based on deterministic numerical weather prediction (NWP) models. To represent model uncertainty, ensembles of NWP forecasts are employed, obtained by running the NWP model multiple times, each time with a different set of model conditions. However, forecast ensembles often exhibit systematic biases and dispersion errors. To improve the ensemble forecast skill and obtain reliable forecasts, statistical postprocessing models have been developed and applied with great success. To account for dependencies in space, this work proposes a spatially adaptive extension of the state-of-the-art Ensemble Model Output Statistics (EMOS) model. The new approach, named Markovian EMOS (MEMOS), introduces a Markovian dependence structure on the model parameters by employing Gaussian Markov random fields. For fitting the MEMOS model in a Bayesian fashion the recently developed Integrated Nested Laplace Approximation (INLA) approach is utilized, allowing for fast and accurate approximation of the posterior distributions of the parameters. To obtain physically coherent forecasts the basic MEMOS model is provided with an additional spatial dependence structure induced by the Ensemble Copula Coupling (ECC) approach, which makes explicit use of the rank order structure of the raw ensemble.
The method is applied to 24-h temperature forecasts of the European Center for Medium-Range Weather Forecasts (ECMWF) over Germany, where it outperforms standard univariate EMOS variants in terms of several verification scores. When testing for equal forecast accuracy with the Diebold–Mariano test, it can be shown that this improvement is indeed statistically meaningful.

Joint work with: Thordis L. Thorarinsdottir • Alex Lenkoski • Tilmann Gneiting

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Sebastian Olivier Schneider
Max Planck Institute for Research on Collective Goods

Thu, 17:20
SR Geologie

Non-parametrically Interpolating Utility Points to Establish Smoothed Differentiable Utility Functions With an Application to Risk Preferences of a Sample From Bogota

We present a novel way to interpolate utility functions between utility points using a non-parametric, global smoothing approach to account for possible measurement errors.

For experimentally elicited utility points, this method may jointly establish both smoothed differentiable utility functions and smoothed derivatives, which, taken together, allows for experimental elicitation of differentiable, non-parametric utility functions with their derivatives.
We apply this method with experimental data from a sample of poor individuals in Bogota to infer individual preferences with respect to decision making under risk including corresponding measures of intensities.
Functions assigning a utility to a monetary amount play an important role in economics, especially in the study of decision making under risk.
For example, risk aversion–the preference to avoid risk–and prudence–the preference to accept a mean-zero lottery at a state of higher wealth instead of at a state of lower wealth–are defined as a negative second and positive third derivative of the utility function in the expected utility framework.
Corresponding intensity measures can be defined as ratios of the second and third derivative over the first and second derivative of the utility function (Pratt, 1964; Kimball 1990).
Although it is now widely accepted that preferences cannot be inferred from behavior but have to be elicited experimentally, convincing procedures that yield the required differentiable utility functions are still missing.
For experimentally elicited utility points (e.g. using the trade-off method, Wakker and Deneffe, 1996), utility between these points is either linearly interpolated or a parameter of a parametric function is estimated using non-linear least squares estimation.
Whereas linear interpolation cannot account for measurement errors (and almost never results in a continuos function), parametric functions often imply a certain preference by definition. Therefore, a more flexible approach that may account for measurement errors is needed. We develop such an approach building on P-spline regression as introduced by Eilers and Marx (1996).
As B-spline regression, P-spline regression directly yields estimates for derivatives of smoothed functions.
However, there is no need to care for neither the amount of knots nor their placement. This is achieved with an excessive number of equidistantly placed B-spline functions, where a penalty term impedes unnecessary fluctuations. This penalty consists of the squared mth-order difference of regression coefficients, corresponding to penalizing changes in the mth derivative.
We determine the weight of this penalty using exhaustive permuted leave-k-out cross validation (Aldrin, 2006) to improve prediction quality and account for possibly correlated observations (Arlot and Celisse, 2010).
We set an individual, data-driven minimum for the weight of the penalty to impede overfitting possibly resulting from approximately equal distance of utility points, i.e. sparse or no information per B-spline.
Furthermore, we introduce an objective, data-driven way to jointly penalize multiple orders, resulting in jointly smoothing different derivatives of the utility function, required to consistently estimate different preferences jointly.
Lastly, we suggest a way to incorporate value constraints in P-spline regression, such that e.g. the utility of a monetary amount of 0 is fixed to cero, which is commonly assumed.
A monotonicity constraint is incorporated following Bollaerts et al. (2006).
In our application building on maximally 9 experimentally elicited utility points per individual and more than 500 individuals from Bogota, we find comparable results to earlier studies with respect to classification of individuals as prudent and risk averse.

References:

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[2] Arlot, S., and A. Celisse (2010). A survey of cross-validation procedures for model selection. *Statistics Surveys* 4: 40–79
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Joint work with: Marcela Ibanez • Gerhard Riener

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 10: Nonparametric and asymptotic statistics

Section 10: Nonparametric and asymptotic statistics

Fabienne Comte
Université Paris Descartes

Tue, 11:15
HS Anatomie

Nonparametric regression function estimation with non compactly supported bases

In this talk, I will describe the specific properties of Laguerre and Hermite bases, and analyze how they have been used for density estimation, with direct and noisy observation.
Then I will focus on nonparametric regression model and explain how most results about adaptive nonparametric least squares estimation, usually restricted to compact supports, can be generalized to non compactly supported bases. The proofs of the risk bounds of the estimators rely on a matrix Bernstein inequality by Tropp. The results also apply to dependent models such as autoregressive models or discretely observed diffusion processes. They can be extended to other (implicit) regression problems, such as survival function estimation in presence of interval censoring.
The presentation borrows from a series of papers in collaboration with D. Belomestny (Duisburg-Essen University), V. Genon-Catalot (Université Paris Descartes) and G. Mabon.

Viktor Bengs
Philipps University Marburg

Wed, 16:55
HS Phys.-Prak.

Construction of asymptotic confidence bands for the jump curve in bivariate regression problems

We construct uniform and pointwise asymptotic confidence bands for the single edge in an otherwise smooth image function based on the rotational difference kernel method by Qiu (1997). Using methods from M-estimation, we show uniform consistency of the estimators of location and slope of the edge function and develop a uniform linearization of the contrast process which is uniform in this bivariate parameter. The uniform confidence bands then rely on a Gaussian approximation of the score process together with anti-concentration results for suprema of Gaussian processes from Chernozhukov et al. (2014), while pointwise bands are based on asymptotic normality.

References:

[1] P. Qiu (1997). Nonparametric estimation of jump surface. *Sankhyā: The Indian Journal of Statistics, Series A*, 268–294
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Joint work with: Hajo Holzmann • Matthias Eulert

Marc Ditzhaus

Wed, 11:35
HS Phys.-Prak.

The power of big data sparse signal detection tests on nonparametric detection boundaries

In the literature weak and sparse (or dense) signals within high dimensional data or Big Data are well studied concerning detection, feature selection and estimation of the number of signals. In this talk we

focus on the quality of detection tests for signals. Since the pioneering work of Donoho and Jin (2004) it was shown in the literature for different (mainly) parametric models that the detection boundary of the log-likelihood ratio test and Tukey's higher criticism test coincide asymptotically. In contrast to this it is less known about the behavior of tests on the detection boundary, especially for the higher criticism test. We fill this gap in great detail with the analysis on the detection boundary. We give general tools to handle the log-likelihood ratio and higher criticism statistics. To illustrate our results we apply them to a nonparametric model and get a nonparametric detection boundary for it. In particular, it results that the higher criticism test has no power on the nonparametric detection boundary while the log-likelihood ratio test has nontrivial power there.

References:

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Joint work with: Arnold Janssen

Manuela Dorn
Universität Bayreuth

Wed, 14:50
HS Phys.-Prak.

A Test of exogeneity in the functional linear regression model

Models containing endogenous control variables often occur in econometrics, natural sciences and other disciplines. They usually require more complex estimation methods. If the endogeneity remains unnoticed it may lead to inconsistent estimates. In multivariate statistics several methods for testing exogeneity are known yet.
We focus on the functional linear regression model

$$Y = \int_0^1 \beta(t)X(t)dt + \sigma U,$$

where the slope parameter β belongs to the Sobolev space of periodic functions. Assuming an optimal linear instrument for the endogenous control variable X exists, Johannes (2016) provides an instrument variable estimator which is consistent even in the endogenous case, whereas the least-squares estimator proposed in Cardot and Johannes (2010), for the exogenous case, is inconsistent here. Based on the idea of the Hausman test, we use the behavior of those estimators to introduce a test for exogeneity. However, some modifications on the test statistic are necessary, as a direct analogue of the one used in the original Hausman test is not applicable in the functional context. Finally, the finite-sample performance of the test is checked by a small simulation study.

References:

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[2] H. Cardot, J. Johannes (2010). *Thresholding projection estimators in functional linear models*, J. of Multivariate Anal., 101(2): 395–408
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Joint work with: Melanie Birke • Carsten Jentsch

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 10: Nonparametric and asymptotic statistics

Holger Drees
University of Hamburg

Thu, 17:45
HS Phys.-Prak.

Tail empirical processes in nonparametric boundary regression

Consider a nonparametric boundary regression model

$$Y_i = g(i/n) + \varepsilon_i, \quad 1 \le i \le n,$$

with iid non-positive errors ε_i whose cdf satisfies

$$F(x) = c|x|^\alpha + o(|x|^{-\alpha}),$$

as $x \uparrow 0$, for some $c, \alpha > 0$. If the regression function g belongs to some Hölder class, it can be estimated at any point $x \in (0,1)$ by $\hat{g}_n(x) = p_x(x)$ for the polynomial p_x of suitable order which minimizes $\int_{x-h_n}^{x+h_n} p_x(t)\,dt$ under the constraint $p_x(i/n) \ge Y_i$ for all $i/n \in [x-h_n, x+h_n]$. Here $h_n \to 0$ denotes a suitably chosen sequence of bandwidths; see Jirak et al. (2014) and Drees et al. (2017+) for details. We are mainly interested in the irregular case $\alpha \le 2$ when the estimator converges at a faster rate than in classical nonparametric mean regression with regular error distributions.
To construct tests of the above model assumption on F or some hypotheses on α, tail empirical processes based on the residuals $\hat{\varepsilon}_{n,i} = Y_i - \hat{g}_n(i/n)$ for $i/n \in [h_n, 1-h_n]$ are a useful tool. However, it turns out that for the most extreme observations these processes behave quite differently from the analogous tail empirical processes based on the true errors, which bedevils their application to testing problems considerably.

References:

[1] H. Drees, N. Neumeyer, L. Selk (2017+). Estimation and hypotheses testing in boundary regression models. To appear in *Bernoulli*
[2] M. Jirak, A. Meister, M. Reiss (2014). Adaptive estimation in nonparametric regression with one-sided errors. *Annals of Statistics* 42(5), 1970–2002

Claudio Durastanti
Ruhr-Universität Bochum

Thu, 17:20
HS Phys.-Prak.

On high-frequency limits of U-statistics in Besov spaces over compact manifolds

In this talk, quantitative bounds in high-frequency central limit theorems are derived for Poisson based U-statistics of arbitrary degree built by means of wavelet coefficients over compact Riemannian manifolds. The wavelets considered here are the so-called needlets, characterized by strong concentration properties in both spatial and harmonic domains and by an exact reconstruction formula. We consider U-statistics $U_j(t)$ of arbitrary order, where $j \ge 0$ is the so-called resolution level of the wavelets and $t > 0$ can be viewed as the time. They are based on a Poisson random measure on a general compact manifold $\mathcal{M}$ of arbitrary dimension d with an absolutely continuous control measure based on a density assumed to live in a given Besov space $B^s_{r,q}$, effective at measuring regularity properties of functions. Under this assumption, we provide a fine analysis of the asymptotic behavior of $U_j(t)$ in terms of the regularity of the density of the control measure. To our knowledge, these are the first results of this type in this framework and refine considerably not only the study of the asymptotics of such objects, but also the quantitative bounds one can obtain, explicitly exhibiting the relationship between speed of convergence and regularity of the control measure.
More in details, we compute upper bounds on the Wasserstein distance between the given U-statistic and a standard normal distribution, in terms of the dimension d of the manifold $\mathcal{M}$, the expected number of observations at the time t R_t, the scale parameter of the needlet frame B, the resolution level j, as well as the Besov regularity parameter s of the density function f. A central tool in the proof of our main results is the so-called Stein–Malliavin method for Poisson point processes, following Lachieze-Rey and Peccati (2013).

Joint work with: Solesne Bourguin

13th German Probability and Statistics Days
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Section 10: Nonparametric and asymptotic statistics

Céline Duval
Université Paris Descartes - MAP5

Thu, 11:10
HS Phys.-Prak.

Adaptive procedure for Fourier density estimation

We introduce a new procedure to attain adaptivity for Fourier density estimators. This adaptive procedure applies for a wide range of inverse problems and its main advantage is its simplicity making it numerically fast and stable. We illustrate it on two classical examples: deconvolution and decompounding (i.e. nonparametric estimation of the jump density of a compound Poisson process from n increments). For this latter example, we give an adaptive optimal estimator and provide an upper bound that is valid simultaneously for sampling rates Δ that can vanish, $\Delta := \Delta_n \to 0$, can be fixed, $\Delta_n \to \Delta_0 > 0$ and even can get large $\Delta_n \to \infty$. This last result is new and presents interest on its own.

Joint work with: Johanna Kappus

Benedikt Funke
FH Aachen

Fri, 10:30
HS Phys.-Prak.

Nonparametric Testing on Discontinuities of Probability Densities Using Truncated Asymmetric Kernels

Discontinuity in density functions is of economic importance and interest. For instance, in studies on regression discontinuity designs, discontinuity in the density of a running variable suggests violation of the no-manipulation assumption. In line with this notion, estimation and testing procedures on discontinuity in densities with positive support are developed. The proposed approach is built on splitting the asymmetric, gamma kernel into two parts at a prespecified cutoffthat is suspected to be a discontinuity point and constructing two truncated kernels. The jump-size magnitude of the density at the cutoff can be estimated nonparametrically by two kernels and a multiplicative bias correction method. The estimator is easy to implement, and its convergence properties are delivered by various approximation techniques on incomplete gamma functions. Based on the jump-size estimator, two versions of test statistics for the null of continuity at a given cutoff are also proposed. Moreover, estimation theory of the entire density in the presence of a dis- continuity point is explored. Monte Carlo simulations confirm nice finite-sample properties of the jump-size estimator and the test statistics.

Joint work with: Masayuki Hirukawa

Mirko Alexander Jakubzik
Technische Universität Dortmund

Fri, 10:55
HS Phys.-Prak.

Applications of a minimum distance estimator for specific self-exciting point processes

Applications of a minimum distance estimator for specific self-exciting point processes
In this contribution based on a paper by Kopperschmidt and Stute published in 2013 we study minimum distance estimation for self-exciting point processes.
The abstract definition of those processes is a consequence of the analysis relying heavily on the Doob–Meyer decomposition (Ethier and Kurtz 1986): In a semi-parametric modelling approach we invoke the compensator of a counting process given by said decomposition to predict its qualitative behaviour.
The introduced minimum distance estimator yields consistent and asymptotically gaussian distributed estimates for the parametric part of the predictor. While the main results concerning these asymptotic properties are due to Kopperschmidt and Stute, we augment the range of applications by discussing models convenient for practical usage, e.g. the class of shifted birth processes: We derive formulae to explicitly compute the covariance matrix of the minimum distance estimator and establish the corresponding confidence sets.

Furthermore prediction intervalls for the underlying counting process are deduced from these confidence sets and debated in view of real data obtained through a civil engineering experiment that took place at TU Dortmund University (Szugat et al. 2016).
Finally we give an outlook for upcoming results including the implementation of damage accumulation as an extension to the given models and discuss the numerical issues we are facing throughout simulation and application.

References:

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Arnold Janssen

Fri, 09:00
HS Phys.-Prak.

On the consistency of false rejection proportion of adaptive multiple tests

The pioneer multiple test of Benjamini and Hochberg (1995) with up to date more than 42000 citations is a basic tool in high dimensional data analysis, for instance in genomics when a huge amount of tests are carried out simultaneously for the same data set. Their test and also improved data dependent adaptive tests of Storey, Taylor and Sigmund (2004) control the so called FDR, see also Heesen and Janssen (2016) for more general adaptive procedures. The FDR is the expectation of the ratio of the number of false rejections and all rejections. Although the FDR can be controlled by some given level α the "false discovery proportion" (FDP) may have stochastic fluctuations.

In this talk we discuss the consistency for general adaptive multiple tests. We present finite sample and asymptotic results in order to bound deviations of the FDP from the present FDR level.

References:

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Joint work with: Marc Ditzhaus

Jan Johannes
Ruprecht-Karls-Universität Heidelberg

Thu, 12:00
HS Phys.-Prak.

Data-driven Estimation by Aggregation based on a penalised contrast criterion

We consider the non-parametric estimation of a function f based on an orthogonal series approach. Given a family of orthogonal series estimators $\{\hat{f}_m, m \in \mathcal{M}\}$ of f indexed by a dimension parameter m belonging to a pre-specified collection $\mathcal{M}$ the selection of a dimension parameter $\hat{m} \in \mathcal{M}$ as a minimiser of a penalised contrast criterion leads in many cases to an optimal estimator $\hat{f}_{\hat{m}}$ in an oracle or minimax sense. In this work we propose a fully data-driven aggregation of the series estimators, $\hat{f}_{\hat{w}} = \sum_{m\in\mathcal{M}} \hat{w}_m \hat{f}_m$, which shares the optimality properties of the estimator $\hat{f}_{\hat{m}}$. The construction of the random weights $\{\hat{w}_m, m \in \mathcal{M}\}$ is inspired by the recent work of Johannes, Simoni and Schenk [2015] where a fully data-driven Bayes estimator in an indirect sequence space model with hierarchical prior is constructed. Notably, the construction of the random weights allows to caracterise the estimator $\hat{f}_{\hat{m}}$ as a

limit case of the data-driven aggregation strategy. As illustration we consider non-parametric regression with random design and non-parametric density estimation and we discuss its potential extension to deconvolution models as well as non-parametric inverse regression.

Alexander Kreiß
Heidelberg University

Wed, 12:00
HS Phys.-Prak.

Nonparametric inference for continuous-time event counting and link-based dynamic network models

A flexible approach for modeling both dynamic event counting and dynamic link-based networks based on counting processes is proposed, and estimation in these models is studied. We consider nonparametric likelihood based estimation of parameter functions via kernel smoothing. The asymptotic behavior of these estimators is rigorously analyzed by allowing the number of nodes to tend to infinity. The finite sample performance of the estimators is illustrated through an empirical analysis of bike share data. This work is available on arxiv: https://arxiv.org/abs/1705.03830

Joint work with: Enno Mammen • Wolfgang Polonik

Martin Kroll
ENSAE-ParisTech CREST

Thu, 14:00
HS Phys.-Prak.

On minimax optimal and adaptive estimation of linear functionals in inverse Gaussian sequence space models

We consider the inverse Gaussian sequence space model with unknown multiplication operator, that is, we observe

$$X_j = \lambda_j \theta_j + \varepsilon \xi_j,$$

and

$$Y_j = \lambda_j + \sigma \eta_j$$

for $j \in \mathbb{N}$ where $(\xi_j)_{j\in\mathbb{N}}$, $(\eta_j)_{j\in\mathbb{N}}$ are independent standard Gaussian random variables. Our aim is not to reconstruct the solution $\theta = (\theta_j)_{j\in\mathbb{N}}$ itself but the value of a linear functional $\ell(\theta)$ of the solution. In our setup the optimal rate depends on two different noise levels, namely the noise level ε concerning the observation of the transformed solution, and the noise level σ concerning the noisy observation of the sequence $\lambda = (\lambda_j)_{j\in\mathbb{N}}$. First, we consider this nonparametric estimation problem from a minimax point of view and obtain upper and lower bounds under smoothness assumptions on the unknown solution and the multiplication operator. Second, we discuss an approach to adaptive estimation of $\ell(\theta)$ via a method combining model selection with the Goldenshluger-Lepski method.

Joint work with: Cristina Butucea • Jan Johannes

Dominik Liebl
Universität Bonn

Thu, 14:25
HS Phys.-Prak.

On the Optimal Reconstruction of Partially Observed Functional Data

We propose a new reconstruction operator that aims to recover the missing parts of a function given the observed parts. This new operator belongs to a new, very large class of functional operators which includes the classical regression operators as a special case. We show the optimality of our reconstruction operator and demonstrate that the usually considered regression operators generally cannot be optimal reconstruction operators.
Our estimation theory allows for autocorrelated functional data and considers the practically relevant situation in which each of the *n* functions is observed at *m* discretization points. We derive rates of

consistency for our nonparametric estimation procedures using a double asymptotic ($n \to \infty, m \to \infty$). For data situations, as in our real data application where m is considerably smaller than n, we show that our functional principal components based estimator can provide better rates of convergence than any conventional nonparametric smoothing method.

Joint work with: Alois Kneip

Xavier Loizeau
Universität Heidelberg

Thu, 10:45
HS Phys.-Prak.

A family of adaptive Bayesian methods for statistical ill-posed inverse problems

Consider an infinite dimensional parameter space Θ and a linear operator λ mapping Θ to itself. Given a family of sample distributions $(\mathbb{P}^{\varepsilon}_{\theta})_{\theta\in\Theta}$, with noise level ε, we consider the estimation of θ° in Θ while observing Y^{ε} from $\mathbb{P}^{\varepsilon}_{\lambda\theta^{\circ}}$ using a Bayesian point of view.
Studying the asymptotic as ε tends to 0, we first introduce the notion of oracle optimal concentration over a family of prior distributions which does not rely on a comparison to a frequentist oracle optimal convergence rate.
Considering a statistical ill-posed inverse problem, a family of sieve prior distributions is then introduced. It is indexed by a tuning parameter which has to be chosen. We show that Bayesian oracle optimality is achieved if the tuning parameter is chosen optimally, which requiers knowledge of the true parameter. Hence, a hierarchical approach is used to construct a fully data driven prior from this family.
Facing the difficulty to justify the choice of a particular prior in the non-parametric context, we then study a non informative prior obtained by iteration of the posterior. This procedure generates a family of posterior distributions, giving more and more weight to the observations while the prior information fades away. We show that, interestingly, each element of the family conserves the oracle optimality property and that, as the number of iteration tends to infinite, the posterior distribution degenerates to the so called model selection frequentist estimator, providing a new proof for its optimality.
Three examples are used all along the presentation; namely, the inverse Gaussian sequence space model, the circular deconvolution and the real line deconvolution. We can see in those three examples that the estimate given by the posterior mean optimally aggregates so called projection estimators and does not require to split the sample.

Enno Mammen
Heidelberg University

Wed, 10:45
HS Phys.-Prak.

Nonparametric estimation of locally stationary Hawkes processes

In this talk we consider multivariate Hawkes processes with baseline hazard and kernel functions that depend on time. This defines a class of locally stationary processes. We discuss estimation of the time-dependent baseline hazard and kernel functions based on a localized criterion. Theory on stationary Hawkes processes is extended to develop asymptotic theory for the estimator in the locally stationary model.

Alexander Meier
OvGU Magdeburg

Thu, 16:30
HS Phys.-Prak.

Bayesian nonparametric analysis of multivariate time series

While there is an increasing amount of literature about Bayesian time series analysis, only few non-parametric approaches to multivariate time series exist.
Many methods rely on Whittle's likelihood, involving the second order structure of a stationary time series by means of its *spectral density matrix* $\mathbf{f}$.
The latter is often modeled in terms of the Cholesky decomposition to ensure positive definiteness.

However, asymptotic properties under these priors such as posterior consistency or posterior contraction rates are not known.
A different idea is to model **f** by means of random measures.
This is in line with [1], who model the normalized spectral density of a univariate time series with a Dirichlet process mixture of beta densities.
We use a similar approach, with matrix-valued mixture weights induced by a *completely random matrix-valued measure* [2, 3].
We use a class of infinitely divisible matrix Gamma distributions [4] for this purpose.
While the procedure performs well in practice, we also establish *posterior consistency* and derive posterior *contraction rates*.

References:

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[3] J. B. Robertson, M. Rosenberg, et al. (1968). The decomposition of matrix-valued measures. *The Michigan Mathematical Journal*, 15(3), 353-–368
[4] V. Perez-Abreu and R. Stelzer (2014). Infinitely divisible multivariate and matrix Gamma distributions. *Journal of Multivariate Analysis*, 130, 155–175

Joint work with: Claudia Kirch • Renate Meyer

Fabian Mies

Thu, 16:55
HS Phys.-Prak.

Nonparametric Gaussian Inference for Stable Processes

Jump processes driven by α-stable Levy processes impose inferential difficulties as their increments are heavy-tailed and the intensity of jumps is infinite. We consider the estimation of the functional drift and diffusion coefficients from high-frequency observations of a stochastic differential equation. By transforming the increments suitably prior to a regression, the variance of the emerging quantities may be bounded while allowing for identification of drift and diffusion in the limit. The findings are applied to obtain a comprehensive treatment of the asymptotics of a nonparametric kernel estimator, covering asymptotic normality and consistency of subsampling approximations, and of a parametric volatility estimator for the Ornstein–Uhlenbeck process. The proposed approach also suggests a semiparametric estimator for the index of stability α.

Joint work with: Ansgar Matthias Steland

Nestor Parolya
Leibniz University Hannover

Wed, 17:45
HS Phys.-Prak.

Testing for Independence of Large Dimensional Vectors

In this paper new tests for the independence of two high-dimensional vectors are investigated.
We consider the case where the dimension of the vectors increases with the sample size and propose multivariate analysis of variance-type statistics for the hypothesis of a block diagonal covariance matrix. The asymptotic properties of the new test statistics are investigated under the null hypothesis and the alternative hypothesis using random matrix theory. For this purpose we study the weak convergence of linear spectral statistics of central and (conditionally) non-central Fisher matrices.
In particular, a central limit theorem for linear spectral statistics of large dimensional (conditionally) non-central Fisher matrices is derived which is then used to analyse the power of the tests under the alternative.
The theoretical results are illustrated by means of a simulation study where we also compare the new tests with several alternative, in particular with the commonly used corrected likelihood ratio test. It is

demonstrated that the latter test does not keep its nominal level, if the dimension of one sub-vector is relatively small compared to the dimension of the other sub-vector. On the other hand the tests proposed in this paper provide a reasonable approximation of the nominal level in such situations. Moreover, we observe that one of the proposed tests is most powerful under a variety of correlation scenarios.

Joint work with: Holger Dette • Taras Bodnar

Markus Pauly
Ulm University

Wed, 14:25
HS Phys.-Prak.

Nonparametric Procedures for Factorial Designs: Treatment Effects and Testing Hypotheses

Most existing tests for nonparametric factorial designs are based on ranks and hypotheses are formulated in terms of distribution functions. However, especially in heterogeneous settings, null hypotheses formulated in terms of parameters or effect measures and corresponding confidence intervals would be of more interest.
In this talk, we explain that the effect measures, underlying existing rank-based procedures, may either lead to possibly paradox results or/and depend on sample sizes (except in the case of completely balanced designs). Moreover, we point out that this undesirable property may particularly cause problems in interpretation of effects but also for inference.
Thus, we propagate to work with unweighted nonparametric effect measures that can be motivated from so-called pseudo-ranks. We then introduce novel test procedures that are suitable for testing hypotheses formulated in these effects in general nonparametric factorial designs and analyze their large and small sample properties theoretically and in simulations. We note that the R-package ranked performing the computations in general univariate factorial designs can be downloaded from CRAN.

References:

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Katharina Proksch
University of Göttingen

Thu, 15:15
HS Phys.-Prak.

Multiscale scanning in inverse problems

We propose a multiscale scanning method to determine active components of a quantity f w.r.t. a dictionary $\mathcal{U}$ from observations Y in an inverse regression model $Y = Tf + \xi$ with linear operator T and general random error ξ. To this end, we provide uniform confidence statements for the coefficients $\langle \varphi, f \rangle$, $\varphi \in \mathcal{U}$, under the assumption that $(T^*)^{-1}(\mathcal{U})$ is of wavelet-type. Based on this we obtain a multiple test that allows to identify the active components of $\mathcal{U}$, i.e. $\langle f, \varphi \rangle \neq 0$, $\varphi \in \mathcal{U}$, at controlled, family-wise error rate. Our results rely on a Gaussian approximation of the underlying multiscale statistic with a novel scale penalty adapted to the ill-posedness of the problem. The scale penalty furthermore ensures convergence of the statistic's distribution towards a Gumbel limit under reasonable assumptions. We show that our method obeys an oracle optimality, i.e. it attains the same asymptotic power as a single-scale testing procedure at the correct scale.
We illustrate the potential of the method as an inferential tool for imaging.
As a particular application we discuss super-resolution microscopy and analyze experimental STED data to locate single DNA origami.

Joint work with: Frank Werner • Axel Munk

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 10: Nonparametric and asymptotic statistics

Paavo Sattler
Ulm University

Wed, 14:00
HS Phys.-Prak.

Inference For High-Dimensional Split-Plot-Designs: A Unified Approach for Small to Large Numbers of Factor Levels

Statisticians increasingly face the problem to reconsider the adaptability of classical inference techniques. In particular, diverse types of high-dimensional data structures are observed in various research areas; disclosing the boundaries of conventional multivariate data analysis.
Such situations occur, e.g., frequently in life sciences whenever it is easier or cheaper to repeatedly generate a large number d of observations per subject than recruiting many, say N, subjects.
In this paper, we discuss inference procedures for such situations in general heteroscedastic split-plot designs with a independent groups of repeated measurements. These will, e.g., be able to answer questions about the occurrence of certain time, group and interactions effects or about particular profiles.
The test procedures are based on standardized quadratic forms involving suitably symmetrized U-statistics-type estimators which are robust against an increasing number of dimensions d and/or groups a, while N,d and even a increasing completely independent.
We then discuss its limit distributions in a general asymptotic framework and additionally propose improved small sample approximations. Moreover, subsampling-type estimators were developed and used for less computation time. Finally, its small sample performance is investigated in simulations and the applicability is illustrated by a real data analysis.

Joint work with: Markus Pauly

Lukas Steinberger
University of Freiburg

Wed, 11:10
HS Phys.-Prak.

Minimax rate optimal estimation of linear functionals under differential privacy

One of the many new challenges for statistical inference in the information age is the increasing concern of data privacy protection. Over the last few decades, the problem of constructing privacy preserving data release mechanisms has produced a vast literature in computer science. However, from a statistical inference perspective the topic has received much less attention. A few notable examples are Duchi et al. [2], Wasserman and Zhou [6] and Smith [4, 5]. In this talk, we focus on the notion of (local) differential privacy (Dwork et al. [3]) to guarantee data confidentiality and study its impact on statistical inference in a rigorous, decision theoretic, minimax framework. In this setup, the objective is not only to come up with an optimal estimation procedure, but also with a privatization mechanism that best facilitates subsequent estimation while respecting the required privacy provisions.
In particular, we extend the general and elegant theory of Donoho and Liu [1] on minimax rates of estimation of linear functionals over convex parameter spaces to the case where the statistician has only access to a privatized version of the original sample. We find that the minimax rates of convergence in the privatized and the non-privatized case can differ quite substantially, but the difference highly depends on the concrete estimation problem at hand. More formally, while Donoho and Liu [1] characterize the minimax rates of convergence by the Hellinger modulus of continuity of the functional to be estimated, we find that the minimax rates of differentially private estimation are determined by the total variation modulus of continuity.

References:

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Joint work with: Angelika Rohde

Maximilian Wechsung
Friedrich Schiller University Jena

Thu, 14:50
HS Phys.-Prak.

Nonparametric Estimation in Poisson Autoregression

We consider Poisson regression models for count data. Let us observe a time series of counts that, conditionally on the past, are Poisson distributed with certain intensites. The time series of intensities is unobservable and we impose an autoregressive scheme on it. In the literature some consideration has been given to parametric models, e.g. of the linear or log linear type. In these cases $\sqrt{n}$-consistency of the partial maximum likelihood estimator has been established.
We intend to consider a nonparametric autoregressive model for the intensity process and do not want to restrict ourselves to parametric classes of link functions. In order to obtain a suitable estimation equation a contractive condition has to be imposed on the true link function. We analyze the rate of convergence of a nonparametric least squares estimator proposed by Meister and Kreiß (2016). We prove uniform mixing of the univariate count process and use the derived properties to apply some classical tools from empirical process theory in our asymptotic analysis. As always in these problems the size of the class of admissible functions determines the rate of convergence.

Frank Werner
Max Planck Institute for biophysical Chemistry

Thu, 11:35
HS Phys.-Prak.

Empirical Risk Minimization as Parameter Choice Rule for General Linear Regularization Methods

We consider a posteriori parameter choice rules for filter based linear regularization methods in the statistical inverse problem setting. In particular, we investigate the choice of the regularization parameter by minimizing an unbiased estimate of the predictive risk. This parameter choice rule and its usage are well-known in the literature, but oracle inequalities and optimality results in this general setting are unknown.
We prove a (generalized) oracle inequality, which relates the direct risk with the minimal prediction risk. From this oracle inequality, we are then able to conclude that the filter based regularization methods with the investigated parameter choice rule achieve minimax convergence rates with respect to the mean integrated squared error.
Finally, we also present numerical simulations, which support the order optimality of the method and the quality of the parameter choice in finite sample situations.

Joint work with: Housen Li

13th German Probability and Statistics Days
Freiburger Stochastik-Tage, February 27–March 2, 2018
Section 10: Nonparametric and asymptotic statistics

Heiko Werner
Philipps-Universität Marburg

Wed, 16:30
HS Phys.-Prak.

Adaptive estimation in sup-norm for semiparametric conditional location-scale mixtures

Suppose that the conditional density of Y given X is a semiparametric location-scale mixture of two symmetric densities, one of which is known up to unknown scale, the other being unkown with additional unkown location. We discuss identification in such a model, and provide an estimator for the location, scale and mixing proportion functions. We analyze their rate of convergence in sup-norm, and propose an adaptive version of the estimator.

Semiparametric mixtures have recently been studied in various papers, see e.g. (2,3). (2) studied a conditional two-component location mixture model in a symmetric density. They proposed an estimator and derived its pointwise, non-adaptive rate of convergence.
In this paper we consider a related problem. Suppose that the conditional density of Y given $X = x$ is given by

$$g(y|x) = p(x)\, f_x(y - \mu(x)) + \frac{1 - p(x)}{\sigma(x)}\, f_0\big(y/\sigma(x)\big),$$

where $p(x) \in (0, 1)$ is a smooth weight function, $\mu(x)$ a smooth location and $\sigma(x)$ a smooth scale function, f_0 a fixed, known symmetric density and f_x an unkown symmetric density depending smoothly on x.
We discuss identification of $\theta(x) = \big(p(x), \mu(x), \sigma(x), f_x\big)$, and propose a smoothed minimum-contrast estimators for these functions. The rate of convergence of the resulting estimators is analyzed in the sup-norm, it turns out to be the usual nonparametric rate in sup-norm for $p(x), \mu(x)$ and $\sigma(x)$. We also propose an adaptive version of the estimator based on the Lepski-scheme. The main technical tool is a version of the Bernstein-inequality for U-statistics from [1].

References:

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Joint work with: Hajo Holzmann • Pierre Vandekerkhove

Tino Werner
Carl von Ossietzky Universität

Wed, 17:20
HS Phys.-Prak.

Asymptotic linear expansion of regularized M-estimators

Modern data analysis frequently requires working with high-dimensional data where the number of predictors is extremely large and often exceeds the number of observations by far. Due to the practical impossibility to reasonably interpret so many coefficients, empirical risk minimization is replaced by structural risk minimization invoking a penalty term that encourages sparsity of the predicted parameter. Popular linear models following this concept include the Lasso, the elastic net or the adaptive Lasso. The estimators for the coefficients can be regarded as functionals, more precisely as regularized M-functionals.
Such M-functionals are highly non-linear. But in fact, if the functional satisfies some regularity properties which in our case will be compact differentiability, then an infinite-dimensional Delta-method provides an asymptotic linear expansion in terms of influence curves up to some error term depending on the

number of observations. The influence curve is a well-known tool of robust statistics that quantifies the influence of a single observation on the estimator.
For a suitably consistent starting estimator, this linearization replaces solving optimization problems by evaluating these influence curves at the given data points. We show under which conditions the asymptotic linear expansion is valid. Furthermore, we provide concrete examples of machine learning algorithms that fit into this framework.

Tobias Zwingmann
Philipps-Universität Marburg

Fri, 09:25
HS Phys.-Prak.

Weak convergence of quantile and expectile processes under general assumptions

We show weak convergence of quantile and expectile processes to Gaussian limit processes in the space of bounded functions endowed with an appropriate semimetric which is based on the concepts of epi- and hypo convergence as introduced in Buecher et al. (2014). We impose assumptions for which it is known that weak convergence with respect to the supremum norm or the Skorodhod metric generally fails to hold. For expectiles, we only require a distribution with finite second moment but no further smoothness properties of distribution function, for quantiles, the distribution is assumed to be absolutely continuous with a version of its Lebesgue density which is strictly positive and has left- and right-sided limits. We also show consistency of the bootstrap for this mode of convergence.
Let F be a distribution function with finite second moment. We define μ_τ and $\mu_{\tau,n}$ to be the expectile and the empirical expectile, respectively, of F with level $\tau \in [0,1]$.
Recently Holzmann and Klar (2017) showed that the sequence of processes of centred and normalized empirical expectiles $\tau \mapsto \sqrt{n}\big(\widehat{\mu}_{\tau,n} - \mu_\tau\big)$ converges weakly in $\big(\mathcal{C}[\tau_l,\tau_u], \|\cdot\|\big)$, $0 < \tau_l < \tau_u < 1$, to a Gaussian process with continuous sample paths, assumed that F is continuous in a neighbourhood of $[\tau_l,\tau_u]$. They also investigated the convergence of $\sqrt{n}\big(\widehat{\mu}_{\tau_0,n} - \mu_{\tau_0}\big)$ in case of F having point mass in μ_{τ_0} and were able to show weak convergence of this random variable to $\sigma_1\, W\, 1(W>0) + \sigma_2\, W\, 1(W<0)$. Here $W \sim \mathcal{N}(0,\sigma)$, $\sigma, \sigma_1, \sigma_2 > 0$ and $1(\cdot)$ is the indicator function.
In the latter case, the typical path of the empirical expectile process seems to evolve a jump around μ_{τ_0}, as indicated by the mixture representation of the above limit variable. Thus a potential limit process is likely to be discontinuous. Since convergence of a continuous function to a discontinuous one is not possible in the sup-norm, we used a semi-metric introduced by Buecher et al. (2014), which they showed can deal with such problems. Using this metric, we are able to show process convergence of the empirical process (in the expectile and quantile case) under rather general assumptions.

References:

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Joint work with: Hajo Holzmann

Section 11: Statistics of stochastic processes

Victor Panaretos
EPFL

Wed, 17:20
HS Anatomie

Nearly Blind Deconvolution of Gaussian Processes

Functional data analyses typically proceed by smoothing, followed by functional PCA. This paradigm implicitly assumes that rough variation is due to nuisance noise. Nevertheless, relevant functional features such as time-localised or short scale fluctuations may indeed be rough relative to the global scale, but still smooth at shorter scales. These may be confounded with the global smooth components of variation by the smoothing and PCA, potentially distorting the parsimony and interpretability of the analysis. We investigate how both smooth and rough variations can be recovered on the basis of discretely observed functional data. Assuming that a functional datum arises as the sum of two uncorrelated components, one smooth and one rough, we develop identifiability conditions for the recovery of the two corresponding covariance operators. In the Gaussian case, this would correspond to a sort of blind deconvolution problem. The key requirement is that the the superposed covariances possess complementary forms of parsimony: one smooth and low rank (large scale), and the other banded and potentially high rank (small scale). Under these conditions, we show that the recovery problem is reducible to a low rank matrix completion problem, and exploit this to construct consistent estimators of the two covariances. (Based on joint work with Marie-Hélène Descary.)

Cathrine Aeckerle

Thu, 17:45
SR Phys. 0008

Concentration inequalities for diffusion processes and their application to adaptive drift estimation in sup-norm loss, Part I

We derive concentration inequalities for general (additive) functionals and the local time process of scalar diffusion processes. Our approach substantially relies on combining the device of martingale approximation and moment bounds which are obtained by the generic chaining method. As a concrete statistical application, we consider the question of estimating the drift function for a large class of ergodic diffusion processes. The unknown drift is supposed to belong to a nonparametric class of smooth functions of unknown order. We suggest a fully data-driven procedure which allows for rate-optimal drift estimation (with respect to sup-norm risk) and, at the same time, yields an asymptotically efficient estimator of the invariant density of the diffusion.

Joint work with: Claudia Strauch

David Berger
Ulm University

Thu, 11:35
SR Phys. 0008

Central Limit Theorems for the Autocovariance of a Moving Average Random Field

Let L be a Lévy basis on $\mathbb{R}^d$ for $d \geq 1$ and $f : \mathbb{R}^d \to \mathbb{R}$ measurable. Consider the moving average random field

$$X_t = \int_{\mathbb{R}^d} f(t-u)\, dL(u),\ t \in \mathbb{R}^d.$$

We first show that X is well-defined if $f \in L^{p,\infty}(\mathbb{R}^d) \cap L^2(\mathbb{R}^d)$ and $\mathbb{E}(|L((0,1)^d)|^p) < \infty$ for $p \in (0,1)$, for $p \in (1,2)$ if $f \in L^{p,\infty}(\mathbb{R}^d) \cap L^2(\mathbb{R}^d)$, $\mathbb{E}(|L((0,1)^d)|^p) < \infty$ and $\mathbb{E}L((0,1)^d) = 0$ or if f decays exponentially and $\mathbb{E}\log^+(|L((0,1)^d)|)^d < \infty$.
Then, when f and L satisfy some integrability conditions, we derive a central limit theorem for the sample mean and sample autocovariance

$$\gamma_n^*(h) = \frac{1}{|\Gamma_n|} \sum_{t \in \Gamma_n} X_t X_{t+h},$$

where $\Gamma_n \subset \mathbb{Z}^d$, $n \in \mathbb{N}$, is a sequence of subsets which satisfies some conditions.
We consider both cases when (Γ_n) is deterministic or random.

References:

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Carsten Chong
École Polytechnique Fédérale de Lausanne

Thu, 12:00
SR Phys. 0008

Volatility estimation for stochastic PDEs

High-frequency volatility estimation for processes like semimartingales or stationary moving averages based on realized power variations are well studied in the literature. By contrast, apart from the situation of deterministic volatility, there is no systematic work on estimating the stochastic volatility process of tempo-spatial processes such as stochastic PDEs. In this talk, we discuss laws of large numbers and central limit theorems for the realized power variations of stochastic PDEs and related processes. In particular, we show that their asymptotic behavior heavily depends on whether the underlying equation is, for example, of parabolic or hyperbolic type.

Reinhard Hoepfner
Institut fuer Mathematik, Universitaet Mainz

Thu, 16:55
SR Phys. 0008

LAMN in a class of parametric models for null recurrent diffusions

We study statistical models for one-dimensional diffusions which are recurrent null. A first parameter in the drift is the principal one, and determines regular varying rates of convergence for the score and the information process. A finite number of other parameters, of secondary importance, introduces additional flexibility for the modelization of the drift, and does not perturb the null recurrent behaviour.

Under time-continuous observation we obtain local asymptotic mixed normality (LAMN), state a local asymptotic minimax bound, and specify asymptotically optimal estimators.

References:

[1] R. Höpfner (2014). *Asymptotic statistics*, deGruyter
[2] R. Höpfner, Yu. Kutoyants (2003). On a problem of statistical inference in null recurrent diffusions. *Statist. Inference Stoch. Proc.* 6(1), 25–42

Joint work with: Carina Zeller

Jan Kallsen
Christian-Albrechts-Universität zu Kiel

Thu, 14:00
SR Phys. 0008

Ornstein–Uhlenbeck Equivalents of Polynomial Processes

The talk is devoted to filtering of and statistical inference on partially observed polynomial processes in discrete and continuous time. These problems are known to allow for an explicit solution for the simpler class of linear Gaussian state space models. The key insight underlying the present piece of research is that for any polynomial process one can find an explicit linear Gaussian model sharing its first two moments. This opens the door to deriving optimal linear filters for such processes, which in turn can be applied to parameter estimation.

Joint work with: Matthias Lenga

Mehmet Madensoy
University of Mannheim

Fri, 10:30
SR Phys. 0008

Change point inference on volatility in noisy Itō semimartingales

This work is concerned with tests on structural breaks in the spot volatility process of a general Itō semimartingale based on discrete observations contaminated with i.i.d. microstructure noise. We construct a consistent test building up on infill asymptotic results for certain functionals of spectral spot volatility estimates. A weak limit theorem is established under the null hypothesis relying on extreme value theory which allows for the construction of confidence intervals. A simulation study illustrates the finite-sample performance of the method and efficiency gains compared to a skip-sampling approach.

Joint work with: Markus Bibinger

Ole Martin
Christian-Albrechts-Universität zu Kiel

Fri, 10:55
SR Phys. 0008

Asymptotics of bipower variations based on asynchronous observations

In high-frequency statistics one usually deals with sums of functionals of increments of stochastic processes, whose asymptotics are of interest when the mesh of the observation times tends to zero. As a generalization of the famous Hayashi-Yoshida estimator for the quadratic covariation of two continuous semimartingales $X^{(1)}$ and $X^{(2)}$ based on asynchronous and exogenous observations introduced in [1] we investigate functionals of the form

$$\sum_{i,j:t_{i,n}^{(1)}\wedge t_{j,n}^{(2)}\leq T} f\big(X^{(1)}_{t_{i,n}^{(1)}} - X^{(1)}_{t_{i-1,n}^{(1)}}, X^{(2)}_{t_{j,n}^{(2)}} - X^{(2)}_{t_{j-1,n}^{(2)}}\big) 1_{\{(t_{i-1,n}^{(1)}, t_{i,n}^{(1)}]\cap(t_{j-1,n}^{(2)}, t_{j,n}^{(2)}]\neq\emptyset\}} \tag{1}$$

where $t_{i,n}^{(l)}$, $l = 1, 2$, are increasing stopping times and f denotes a function $f : \mathbb{R}^2 \to \mathbb{R}$. We will study these functionals for general semimartingales $X^{(1)}$, $X^{(2)}$ including jumps and general, possibly endogenous, observation schemes. In the setting of synchronous observation times the asymptotics of

(1) are well understood; compare e.g. Chapter 3 in [2]. We will see that in the setting of asynchronous observation times the class of functions f for which (1) converges is much smaller than the class of functions for which we have convergence in the synchronous setting. Based on the observation that in the asynchronous setting convergence not only depends on the function f but also on the nature of the observation scheme we investigate additional conditions on the observation times to widen the class of functions for which convergence is obtained. Statistical applications based on these functionals include the estimation of the quadratic covariation and testing for common jumps.

References:

[1] T. Hayashi, N. Yoshida (2005). On covariance estimation of non-synchronously observed diffusion processes. *Bernoulli* 11(2), 359-–379
[2] J. Jacod, P. Protter (2012). *Discretization of Processes*, Springer-Verlag

Joint work with: Mathias Vetter

Christian Palmes
TU Dortmund

Thu, 14:25
SR Phys. 0008

Inference on the Trend of a High-Frequency Observed Lévy Jump Process

In this talk, a pointwise nonparametric kernel based estimator for the drift function in a Lévy driven jump diffusion model is proposed. Under ergodicity and stationarity of the underlying process X, we derive asymptotic properties as consistency and asymptotic normality of the estimator. In addition, we propose a consistent estimator of the asymptotic variance. Moreover, we show that this approach is robust under microstructure noise by using the pre-averaging approach proposed in Podolskij and Vetter (2006). Finally, a simulation study is given that satisfactorily validates our theoretical results from a numerical finite sample point of view.

Joint work with: Benedikt Funke

Viktor Schulmann
TU Dortmund

Thu, 15:15
SR Phys. 0008

Estimation of stopping times for some stopped Lévy processes on hypergroups

Let $X = (X_t)_{t\geq 0}$ be a known Markov process and T an unknown random time with a smooth Lebesgue density and independent of X. We present an estimator for the density of T based on i.i.d. samples of X_T. For a Brownian motion X or, more generally, a Lévy process on $\mathbb{R}$ such an estimator was given in [1] and [2] using the Mellin and Laplace transforms. Applying their techniques we study this problem for Bessel processes or, more generally, Lévy processes on certain noncompact commutative hypergroups. We calculate the convergence rates of our estimators, which turn out to be optimal in the minimax sense.

References:

[1] D. Belomestny, J. Schoenmakers (2016). Statistical inference for time-changed Lévy processes via Mellin transform approach. *Stochastic Processes and their Applications* 126, 2092–1222.
[2] D. Belomestny, J. Schoenmakers (2015). Statistical Skorohod embedding problem: Optimality and asymptotic normality. *Statistics & Probability Letters* 104, 169–180.

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Section 11: Statistics of stochastic processes

Radomyra Shevchenko
Technische Universität Dortmund

Thu, 17:20
SR Phys. 0008

Drift Estimation for Fractional Ornstein Uhlenbeck Processes With Periodic Structure

In recent years there has been a lot of research on the topic of stochastic differential equations driven by the fractional Brownian motion and thus often exhibiting long-range dependence. We will consider one class of such equations, namely the fractional Ornstein–Uhlenbeck processes with periodic mean given by the equation

$$dX_t = (L(t) - \alpha X_t)\, dt + \sigma dB_t^H,$$

where α is a nonzero real number, L is a bounded periodic function and B^H is the fractional Brownian motion with the Hurst parameter $H \in (\frac{1}{2}, \frac{3}{4})$. In the ergodic setting Dehling et al. in [1] have constructed a consistent and asymptotically normal joint parametric estimator of the mean and α for the case $L \equiv \sum_{i=1}^{p} \mu_i \phi_i$ with known functions ϕ_i. Based on this result we will construct a new estimator for the drift function under different conditions. Furthermore, we will motivate and explain this construction as well as discuss the asymptotic properties of the new estimator.

References:

[1] H. Dehling, B. Franke and J.H.C. Woerner (2016). Estimating drift parameters in a fractional Ornstein Uhlenbeck process with periodic mean. *Statistical Inference for Stochastic Processes* 20, 1–14

Claudia Strauch
Universität Mannheim

Thu, 18:10
SR Phys. 0008

Concentration inequalities for diffusion processes and their application to adaptive drift estimation in sup-norm loss, Part II

We derive concentration inequalities for general (additive) functionals and the local time process of scalar diffusion processes. Our approach substantially relies on combining the device of martingale approximation and moment bounds which are obtained by the generic chaining method. As a concrete statistical application, we consider the question of estimating the drift function for a large class of ergodic diffusion processes. The unknown drift is supposed to belong to a nonparametric class of smooth functions of unknown order. We suggest a fully data-driven procedure which allows for rate-optimal drift estimation (with respect to sup-norm risk) and, at the same time, yields an asymptotically efficient estimator of the invariant density of the diffusion.

Joint work with: Cathrine Aeckerle

Adrian Theopold

Thu, 14:50
SR Phys. 0008

Estimation of the Jump Activity Index in the Presence of Random Observation Times

We propose an estimator for the jump-activity index of a pure-Jump Semimartingale where the underlying process driving the jump component is a "locally-stable" process. Our estimator works in a setting of random but exogenous observation times.
The method employs an empirical characteristic function approach whose limit is dependent on the unknown observation scheme. To bypass this problem we use a limiting sequence of points towards zero at which we evaluate the characteristic function such that the influence of the observation scheme becomes negligible.

The estimator itself extends a recently proposed one (Todorov 2015) from a setting of equidistant spaced observation points. His method has a significantly smaller variance in comparison to estimators based solely on power variations. Furthermore, due to "self-normalization", the variance only depends on the jump activity but not on other components of the observed process. We have similar findings in our setting though the variance is now dependent on the observation scheme.

References:

[1] V.Todorov (2015). Jump Activity Estimation for Pure-jump Semimartingales via Self-normalized Statistics. *The Annals of Statistics* Vol. 43, No.4, 1831–1864

Joint work with: Mathias Vetter

Bezirgen Veliyev
Aarhus University

Thu, 11:10
SR Phys. 0008

The realized empirical distribution function of stochastic variance with application to goodness-of-fit testing

We propose an estimator of the empirical distribution function (EDF) of the latent spot variance of the log-price of a financial asset. We show that over a fixed time span, as inferred from noisy high-frequency data, our realized EDF (or REDF) is consistent as the mesh of the observation grid goes to zero. In a double-asymptotic framework, with time also increasing to infinity, the REDF converges to the marginal distribution of volatility, assuming it exists. We exploit this to construct new nonparametric goodness-of-fit tests for stochastic volatility models. We examine our framework in a Monte Carlo study. The REDF is found to be accurate over the entire support of the volatility distribution. This leads to goodness-of-fit tests that are both correctly sized and powerful against common alternatives. We apply the developed tools to equity tick-by-tick data for ten sector-wide exchange-traded funds.

Joint work with: Kim Christensen • Martin Thyrsgaard

Mathias Vetter
Christian-Albrechts-Universität zu Kiel

Thu, 10:45
SR Phys. 0008

A universal approach to estimate the conditional variance in semimartingale limit theorems

The typical central limit theorems in high-frequency asymptotics for semimartingales are results on stable convergence to a mixed normal limit with an unknown conditional variance. Estimating this conditional variance usually is a hard task, in particular when the underlying process contains jumps. For this reason, several authors (Mykland and Zhang, 2017; Christensen, Podolskij, Thamrongrat, Veliyev, 2017) have recently discussed methods to automatically estimate the conditional variance, i.e. they build a consistent estimator from the original statistics, possibly computed at various different time scales. These methods work in several situations, but are always restricted to the case of continuous paths. The aim of this talk is to present a new method to consistently estimate the conditional variance which works regardless of whether the underlying process is continuous or not. We will discuss the case of power variations in detail and give insight to the heuristics behind the approach.

Section 12: Statistical methodology

Aad van der Vaart
Leiden University

Tue, 14:00
HS Anatomie

On Bayesian uncertainty quantification

We give an overview of theoretical results that justify or not the use of a posterior distribution of an high- or infinite-dimensional parameter as a method for uncertainty quantification. The posterior distribution is the conditional distribution of the parameter given the data when the parameter is thought of as having been generated by a prior. For the non-Bayesian it is just a random distribution over the parameter space, whose spread could be used to form the equivalent of a confidence set. We shall see that in the nonparametric situation this is only justified if the prior does not oversmooth the true parameter. Furthermore, if the smoothness of the prior is chosen dependent on the data (adaptation), then uncertainty quantification is correct for a large set of, but not all true parameters.

Dennis Dobler
Vrije Universiteit Amsterdam

Tue, 17:30
SR Geologie

Asymptotics of a non-Markov state transition probability estimator with applications to the expected length of stay

In right-censored multi-state models without the Markov assumption, the well-known Aalen-Johansen estimator ceases to estimate the state transition probabilities consistently. Therefore, an alternative estimator had been proposed in [1] which is based on an artificial competing risks model. In this talk, based on [2], we discuss the convergence in distribution of this estimator in a càdlàg function space with an increasing sample size and provide detailed formulas for the asymptotic covariance function. In a next step, the estimator is applied to derive confidence intervals for the expected length of stay in a specific state. The methods are illustrated with the examination of a historical two-sample liver cirrhosis data-set for which the Aalen–Johansen estimator produces a completely different result.

References:

[1] A. C. Titman (2015). Transition Probability Estimates for Non-Markov Multi-State Models. *Biometrics*, 71(4), 1034–1041
[2] D. Dobler, A. C. Titman (2017). Weak convergence of a non-Markov transition probability estimator under right-censoring with applications to expected lengths of stay. *Preprint*, arXiv:1704.03304v1

Joint work with: Andrew C. Titman

Dominic Edelmann

Tue, 11:15
SR Geologie

The Distance Standard Deviation

The distance standard deviation, which arises in distance correlation analysis of multivariate data, is studied as a measure of spread. New representations for the distance standard deviation are obtained in terms of Gini's mean difference and in terms of the moments of spacings of order statistics. Inequalities for the distance variance are derived, proving that the distance standard deviation is bounded above by the classical standard deviation and by Gini's mean difference. Further, it is shown that the distance standard deviation satisfies the axiomatic properties of a measure of spread. Explicit closed-form

expressions for the distance variance are obtained for a broad class of parametric distributions. The asymptotic distribution of the sample distance variance is derived.

Joint work with: Donald Richards • Daniel Vogel

Tobias Fissler
Imperial College London

Wed, 15:15
SR Geologie

Order-Sensitivity and Equivariance of Scoring Functions

From the cradle to the grave, human life is full of decisions. Due to the inherent nature of time, decisions have to be made today, but at the same time, they are supposed to account for unknown and uncertain future events. Therefore, it is best practice to base the decisions on forecasts for these unknown future events.
In order to compare and rank competing forecasts, it is common to utilize loss or scoring functions. These are functions of the form $S(x, y)$ such that, if the forecast x is issued and the observation y materializes, one obtains the *penalty* $S(x, y)$.
To encourage truthful and honest forecasts, it is widely accepted that scoring functions ought to be *strictly consistent* in the sense that the expected score $\mathbf{E}_F S(x, Y)$ is minimized by the correctly specified functional of interest. Examples are the squared loss $S(x, y) = (x - y)^2$ for the mean or the absolute loss $S(x, y) = |x - y|$ for the median. If a functional possesses a strictly consistent scoring function, it is called *elicitable*. Besides its benefits in the context of forecast comparison, elicitability also opens the way to M-estimation and regression.
If a functional is elicitable, there is usually a whole class of strictly consistent scoring functions. To provide guidance in the choice which of the many scoring functions to take, we establish further quality criteria of scoring functions.
While strict consistency provides the possibility to compare forecasts only with the correctly specified forecast, *order-sensitivity* also establishes a ranking of possibly misspecified forecasts, respecting their specific order. This amounts to monotonicity properties of the expected score as a function $x \mapsto \mathbf{E}_F S(x, Y)$ besides the mere requirement to have a global minimum at the correctly specified forecast.
On the other hand, many functionals such as risk measures show equi- or invariance properties with respect to certain transformations. Equivariance properties of scoring functions such as translation invariance or positive homogeneity respect these simultaneous transformations of forecasts and observations. Consequently, forecast ranking in terms of such scoring functions is invariant by those transformations, e.g. a simultaneous change of the units of measurement.
We illustrate the results considering various functionals of applied interest such as the pairs (mean, variance) or (Value at Risk, Expected Shortfall).

Joint work with: Johanna F. Ziegel

Hanna Gruber
TU Braunschweig

Wed, 14:25
SR Geologie

First-order autoregressive processes with irregular innovations

We consider a time-varying first-order autoregressive model with irregular innovations. To estimate the parameter function, we use a quasi-maximum likelihood method. A precise control of these estimators demands an analysis of extremes of certain weakly dependent processes, a delicate probabilistic problem. Based on our analysis, upper and matching lower bounds are derived for appropriate functional smoothness classes, showing the optimality of our estimators. Unlike to the regular case, the minimax rates depend both on the smoothness and an additional shape parameter, characterising our irregular distributions.

Joint work with: Moritz Jirak

Tue, 14:50
SR Geologie

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Section 12: Statistical methodology

Claudia Kirch

Multiscale change point detection based on moving sums

The detection of multiple change points in time series is of great practical importance in a wide range of applications. In this talk we present an approach for the location problem based on moving sum statistics which are a computationally cheap very intuitive approach to the problem, that also provide a nice visual tool. Eichinger and Kirch (Bernoulli, 2016+) prove consistency of corresponding change point estimators as well as their asymptotic limit distribution.
Additionally, this allows us to derive bootstrap confidence intervals for the change points.
In many practical situations, however, a single bandwidth is not sufficient to detect all change points. Instead a multiscale method based on a combination of the information from several bandwidths is needed. Using an information criteria approach in the combination step we prove consistency of the multiscale procedure. The theoretic results are confirmed by a small simulation study.

Joint work with: Haeran Cho

Dominik Poß

Tue, 12:05
SR Geologie

Generalized functional linear models with points of impact

A generalized functional linear regression model with points of impact is assumed. In the classical generalized functional linear regression model, scalar responses $Y_1, \dots, Y_n$ are connected to the inner product of functional predictors $X_1, \dots, X_n$ and an unknown coefficient function via a smooth link function. Additionally an unknown number of unknown specific locations ("points of impact") at which the functional predictor will have a further effect on the response are allowed. The focus lies on the estimation of these points of impact. Some asymptotical results for our estimators are given. The estimation procedure is then illustrated in the case of a (functional) logistic regression framework with points of impact where the dependend variable Y_i is binary.

Joint work with: Dominik Liebl

Kerstin Reckrühm
Otto-von-Guericke-Universität Magdeburg

Tue, 15:15
SR Geologie

Multiple Change Point Detection: A MOSUM Approach Based on Estimating Functions

Multiple change point detection is a current topic in research and captures problems in a wide range of fields, for example, finance, quality control, medicine or climate control.
The MOSUM (moving sum) procedure investigated by Eichinger and Kirch (2016+) is one of the basic approaches to detect multiple changes in the classical mean change model. The statistic is constructed by comparing the sample means of sub-samples of size G around each time point. Hence, a quite natural way for generalizing this procedure to several parameter change problems would be to use MOSUM Wald-type statistics based on differences of local estimators. However, especially in non-linear models, applying these statistics can lead to high computational effort and large numerical errors. To reduce the complexity in computation MOSUM statistics based on estimating functions, where only a global estimator of the parameter has to be computed, are considered. After constructing an appropriate MOSUM test statistic we examine its asymptotic behavior under the null hypothesis and alternatives as well as statistical properties of corresponding estimators.
Moreover, we investigate the behavior of MOSUM Wald-type statistics under i.i.d. assumptions and under some restrictions on the underlying estimating function. This enables us to compare the performance of these two MOSUM procedures in simulation examples.

Joint work with: Claudia Kirch

Tue, 11:40
SR Geologie

Frank Röttger
OVGU Magdeburg

D-optimal saturated designs for the Bradley-Terry paired comparison model

Optimal design theory for nonlinear regression studies amongst others local optimality on a given design space. We identify the Bradley-Terry paired comparison model with graph representations and prove for an arbitrary number of parameters, that every saturated D-optimal design is displayed as a path in the graph representation. Via this path property, we give a complete description of the optimality regions of saturated designs. Furthermore, we exemplify the unsaturated D-optimal designs with full support for 4 alternatives.

Joint work with: Thomas Kahle • Rainer Schwabe

Joseph Sakshaug

Wed, 14:50
SR Geologie

Bayesian Combining of Probability and Non-Probability Samples for Survey Error Reduction and Cost Savings

Sample surveys are frequently used in the social sciences to measure and describe large populations. While probability-based sample surveys are considered the standard by which valid population-based inferences can be made, there has been increased interest in the use of non-probability samples to study public opinion and human behavior, particularly through web surveys. This increased interest is driven by multiple factors such as costs which can be significant when recruiting a probability-based sample. A second factor is the popularity of the web as a survey platform which has led to increased adoption of online access panels that can deliver cheaper and timelier survey results compared to traditional probability-based surveys. However, online access panels are heavily criticized because they do not employ probability sampling methods to recruit panel members, and therefore the mathematical probability theories that underlie valid statistical inference cannot be applied. While non-probability-based surveys are not ideal for making population-based inferences, their attractive cost properties make them potentially useful as a supplement to traditional probability-based data collection.
In this paper, we examine this notion by combining probability and non-probability Web survey samples under a Bayesian framework. The Bayesian paradigm is well-suited for this situation as it permits the integration of multiple data sources, and a potential for increased precision in estimation. On the other hand, combining probability samples with non-probability samples that could be biased may offset gains in efficiency. Thus, there is likely to be a bias-precision tradeoff when combining probability- and non-probability samples. We examine this tradeoff using the German Internet Panel (GIP), a nationally-representative, probability-based web survey in combination with a set of non-probability-based web surveys that fielded a subset of the GIP questionnaire during the same time period. We apply the Bayesian combining framework to produce estimates of survey items and compare them to the probability-based estimates alone.
We examine the accuracy and precision of the resulting survey estimates to determine whether combining the probability and non-probability samples yields valid inferences relative to the probability survey alone. Furthermore, we examine the cost implications of the approach by using a mix of actual and hypothetical cost scenarios to demonstrate the amount of actual cost savings that would result from combining probability and non-probability samples relative to a probability-only sample.

Joint work with: Arkadiusz Wisniowski • Diego Perez-Ruiz • Annelies Blom

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Christina Stöhr

Wed, 14:00
SR Geologie

Asymptotic distribution of the stopping time in sequential change-point procedures based on U-Statistics

There are two different approaches in the context of change-point analysis. In the classical a-posteriori approach, a completely observed data set is available when starting the testing procedure. In the se-

quential change-point analysis we adapt tests for structural breaks after each observation while still controlling the type-1-error asymptotically. We propose a general framework of sequential testing procedures based on U-Statistics which, as an example, yields a robust sequential change-point procedure related to a Wilcoxon-type test statistic. The critical values can be obtained from the derived limit distribution under the null hypothesis and we show that the proposed tests have asymptotic power one. Sequential change point procedures naturally involve a certain detection delay as some data needs to be collected after the change to obtain statistical significance. The speed of detection is of particular importance for the sequential change-point analysis as, for example, monitoring patient or machine data requires an intervention as soon as possible after a structural break occurred. Therefore, we derive the asymptotic distribution of the corresponding stopping time. The performance of the testing procedures for finite sample sizes is assessed by a simulation study.

Joint work with: Claudia Kirch

Poster presentation

Eren Bas
Giresun University

Tue, 18:45
Get Together

Intuitionistic Fuzzy Regression Functions Approach for Forecasting

Fuzzy inference systems have been commonly used for time series forecasting in the literature. Adaptive network fuzzy inference system, fuzzy time series approaches and fuzzy regression functions approaches are popular among others. In recent years, intuitionistic fuzzy sets have been preferred in the fuzzy methods and new fuzzy inference systems have been proposed based on intuitionistic fuzzy sets. In this study, a new fuzzy regression functions approach is proposed based on intuitionistic fuzzy sets for forecasting purpose.
This new inference system is called as intuitionistic fuzzy regression functions (IFRF) approach. The intuitionistic fuzzy c-means method is used to fuzzification of the data set. To evaluate the performance of IFRF, the proposed method was applied to Australian Beer Consumption data (AUST) between 1957 Q2 and 1994 Q1. The results obtained from IFRF were compared with Winter's Multiplicative Exponential Smoothing (WMES), Seasonal Autoregressive Integrated Moving Average (SARIMA), Feed-Forward Artificial Neural Network (FF-ANN), Adaptive Network Fuzzy Inference System (ANFIS), Modified Adaptive Network Based Fuzzy Inference System (MANFIS) and Autoregressive Adaptive Network Fuzzy Inference System (AR-ANFIS) methods according to Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE) criteria. The proposed method has superior forecasting performance among all methods.

Joint work with: Ufuk Yolcu • Erol Egrioglu • Ali Zafer Dalar

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Markus Bibinger
Philipps-Universität Marburg

Tue, 18:45
Get Together

Volatility estimation for stochastic PDEs using high-frequency observations

We study the parameter estimation for parabolic, linear, second order, stochastic partial differential equations (SPDEs) observing a mild solution on a discrete grid in time and space. The SPDE model covers many interesting applications, we highlight its use for term structure models. A high-frequency regime is considered where the mesh of the grid in the time variable goes to zero. Focusing on volatility estimation, we provide an explicit and easy to implement method of moments estimator based on the squared increments of the process. The estimator is consistent and admits a central limit theorem. This is established moreover for the estimation of the integrated volatility in a semi-parametric framework. Starting from a representation of the solution as an infinite factor model and exploiting mixing properties of Gaussian time series, the theory considerably differs from the statistics for semi-martingales literature. The performance of the method is illustrated in a simulation study.

Joint work with: Mathias Trabs

Mustafa Çavuş
Anadolu University

Tue, 18:45
Get Together

Comparing performance of tests for ANOVA under heterocedasticity

There are numerous methods proposed for testing equality of group means under heteroscedasticity. Cochran, Welch-Aspin, Welch, Box, Scott-Smith, Marascuilo, Brown-Forsythe, Approximate F,

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Alexander-Govern, Generalized F, Modified Brown-Forsythe, Adjusted Welch, B2, Parametric Bootstrap test are the major methods. Although these methods are investigated under several circumcitances, literature needs further investigation to evaluate performance of those methods. In this study we consider effect of outlier(s), large group number, unbalanced design and small sample size. It is often the case that the type I error rates may be very different for the methods and that leads power of the test incomparable. To overcome this problem, a new performance criterion is proposed to evaluate performance of the tests. Monte-Carlo simulation study will be conducted to obtain performance of the tests.

References:

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[3] G. E. P. Box (1954). Some theorems on quadratic forms applied in the study of analysis of variance problems. *Annals of Mathematical Statistics* 25, 290–302
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[13] M. Cavus, B. Yazici, A. Sezer (2016). Robust methods to compare means under violation of normality with outliers. *German Probability and Statistics Days 2016 Abstract Book*, 191–192

Joint work with: Berna Yazici • Ahmet Sezer

Ganna Chekhanova
TU Bergakademie Freiberg

Tue, 18:45
Get Together

Solution methods for equations with random parameters

In the literature there can be found a lot of different methods for the solution of differential equations with random parameters. A part of these methods are proposed only by heuristic considerations and often it is not clear, in which cases these methods can be applied, how accurate are the results achieved by these methods and how sensitive they are with respect to only assumed parameters of the underlying stochastic model.
In the presented work we will report about some results related to the above mentioned questions.

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Carsten Chong
École Polytechnique Fédérale de Lausanne

Tue, 18:45
Get Together

Path properties of the solution to the stochastic heat equation with Lévy noise

We investigate the path properties of the solution to the stochastic heat equation with Lévy noise. When viewed as a stochastic process in time with values in an infinite-dimensional space, we establish the existence of a càdlàg modification of the solution in certain fractional Sobolev spaces. Furthermore, also the regularity of sections, for fixed time or fixed space, is analyzed. In both cases, we find critical values such that noises with a smaller Blumenthal-Getoor index typically lead to continuous sections, while noises with a larger Blumenthal-Getoor index typically lead to sections that are unbounded on any non-empty open subset.

Joint work with: Robert C. Dalang • Thomas Humeau

Thomas Delerue

Tue, 18:45
Get Together

Weak convergence of the solution to the stochastic heat equation driven by a pure jump Lévy white noise

Let $L = (L_u)_{u\in D}$ be a two-parameter Lévy sheet with $D = [0, T] \times [0, \pi] \subseteq \mathbb{R}^2_+$. Consider the random field L^ε consisting of the compensated sum of the jumps of L having size at most ε. Under suitable conditions on the sequence $\sigma^2(\varepsilon) = \mathrm{Var}(L^\varepsilon(1, 1))$, we show a functional central limit theorem for the random fields $(L^\varepsilon/\sigma(\varepsilon))_{\varepsilon>0}$ towards a Brownian sheet $W = (W_u)_{u\in D}$ in the Skorohod space $D([0, T] \times [0, \pi])$ as $\varepsilon \to 0$. This generalizes a result of S. Asmussen and J. Rosiński (see [1]) to two-parameter Lévy sheets.
We then consider the stochastic heat equation with Dirichlet boundary conditions driven by $\dot{L}^\varepsilon$ and $\dot{W}$, with mild solutions $X^\varepsilon = (X^\varepsilon_u)_{u\in D}$ and $X = (X_u)_{u\in D}$, respectively. These solutions are stochastic integrals of the heat kernel against the corresponding noise. We aim at showing that the aforementioned weak convergence induces the weak convergence of $X^\varepsilon/\sigma(\varepsilon)$ towards X in a suitable function space, namely the Skorohod space of $H_s([0, \pi])$-valued processes, where $H_s([0, \pi])$ is the fractional Sobolev space of order s, for some $s \in \mathbb{R}$ (see [2]). In simulation, X^ε could then be approximated by the simpler solution X.
A first step towards this objective is to show that, if now L, L^ε, W are one-parameter Lévy processes, then the weak convergence result in [1] induces convergence in distribution of the integral processes $(\int_0^t g(t - s)\,\mathrm{d}L^\varepsilon_s / \sigma(\varepsilon))_{t\geq 0}$ towards $(\int_0^t g(t - s)\,\mathrm{d}W_s)_{t\geq 0}$ in $D([0, \infty))$, for differentiable kernels $g : [0, \infty) \to \mathbb{R}$ with bounded $g' \in L^2([0, \infty))$.

References:

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Joint work with: Carsten Chong

Monika Doll

Tue, 18:45
Get Together

Tests on Asymmetry for Ordered Categorical Variables

Skewness is a well-established statistical concept for continuous and sometimes also discrete quantitative statistical variables. There is almost no literature concerning skewness for ordered categorical variables although this type of variables is common for behavioral, educational, and social sciences.
Suitable measures of skewness for ordered categorical variables have to be invariant with respect to the group of strictly increasing, continuous transformations. Therefore, they have to depend on

the corresponding maximal-invariants. Based on these maximal-invariants we propose a new class of skewness functionals, show that members of this class preserve a suitable ordering of skewness, derive the asymptotic distribution of the corresponding skewness statistic, and investigate the power behavior of the corresponding skewness tests for the null of symmetry against several alternatives. It will be shown that the power dominates the power of alternative skewness tests based on the third standardized moment, adapted Wilcoxon- and sign-tests, and a likelihood ratio test under order restrictions of probabilities.

Joint work with: Ingo Klein

Erol Egrioglu
Giresun University

Tue, 18:45
Get Together

Bootstrapped linear and nonlinear artificial neural network for time series forecasting

Time series forecasting is important task in the real life. Artificial neural networks are a useful tool for forecasting of nonlinear time series. In the real world, time series can contain both linear and nonlinear components. One of the approaches proposed to forecast these kinds of time series is linear and nonlinear artificial neural network (L&NL-ANN). The forecasts obtained from L&NL-ANN may change depending on time series samples but this variation is neglected in the literature. In this paper, bootstrapped linear and nonlinear artificial neural network (B-L&NL-ANN) is proposed. B-L&NL-ANN considers time series samples variation and it is possible to obtain standard errors, confidence intervals for forecasts and perform linearity and nonlinearity hypothesis tests. B-L&NL-ANN uses random subsampling bootstrap approach for probabilistic inference, particle swarm optimization for training of the network. The forecasts of B-L&NL-ANN are obtained as a central tendency measure of forecasts' bootstrap samplings. The proposed method is compared with other methods in the literature in a Monte Carlo Simulation study and real-world time series data analysis. The strong and weak sides of the proposed method are evaluated according to applications.

References:

[1] U. Yolcu, C.H. Aladag, E. Egrioglu (2013). A new linear & nonlinear artificial neural network model for time series forecasting. *Decision Support System Journals* **54**, 1340–1347.

Joint work with: Ufuk Yolcu • Eren Bas • Ozge Cagcag Yolcu • Ali Zafer Dalar

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Maurilio Gutzeit
OVGU Magdeburg (until Sept 2017: Universität Potsdam)

Tue, 18:45
Get Together

Testing the Equality in Distribution of Two Random Graphs

The study of networks leads to a wide range of high dimensional inference problems. In most practical scenarios, one needs to draw inference from a small population of large networks. The present paper studies hypothesis testing of graphs in this high-dimensional regime.
We consider the problem of testing between two populations of inhomogeneous random graphs de fined on the same set of vertices. We propose tests based on estimates of the Frobenius and operator norms of the difference between the population adjacency matrices. We show that the tests are uniformly consistent in both the "large graph, small sample" and "small graph, large sample" regimes. We further derive lower bounds on the minimax separation rate for the associated testing problems, and show that the constructed tests are near optimal.

Joint work with: Debarghya Ghoshdastidar • Alexandra Carpentier • Ulrike von Luxburg

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Kondakji Hakam

Tue, 18:45
Get Together

High-frequency expert opinions and power utility maximization in a market with Gaussian drift

We consider a continuous-time financial market with partial information on the drift and solve utility maximization problems which include expert opinions on the unobservable drift. Stock returns are driven by a Brownian motion and the drift depends on a factor process which is an Ornstein–Uhlenbeck process. Thus the drift is hidden and has to be estimated from observable quantities. If the investor only observes stock prices then the best estimate is the Kalman filter.
However, to improve the estimate, an investor may also rely on expert opinions providing
a noisy estimate of the current state of the drift. This reduces the variance of the filter and thus improves expected utility. That procedure can be seen as a continuous-time version of the classical Black-Litterman approach.
For the associated portfolio problem with logarithmic utility explicit solutions are available in the literature. In this talk we consider the case of power utility. Here, we apply dynamic programming techniques and solve the corresponding dynamic programming equation for the value function. Diffusion approximations for high-frequency discrete-time experts allow to simplify the problem and to derive more explicit solutions. Numerical results are presented.
We extend findings of a joint work with Dorothee Westphal and Jörn Sass.

Joint work with: Ralf Wunderlich • Gabih Abdelali

Martin Haubold

Tue, 18:45
Get Together

Semi-Static and Sparse Variance-Optimal Hedging

We consider hedging of a contingent claim by a 'semi-static' strategy composed of a dynamic position in one asset and static (buy-and-hold) positions in other assets.
We give general representations of the optimal strategy and the hedging error under the criterion of variance-optimality and provide tractable formulas using Fourier-integration in case of the Heston model. We also consider the problem of optimally selecting a sparse semi-static hedging strategy, i.e. a strategy which only uses a small subset of available hedging assets. The developed methods are illustrated in an extended numerical example where we compute a sparse semi-static hedge for a variance swap using European options as static hedging assets.

Joint work with: Paolo Di Tella • Martin Keller-Ressel

Wahid Khosrawi-Sardroudi
University of Freiburg

Tue, 18:45
Get Together

Polynomial Semimartingales

Polynomial Preserving Processes are Markov processes that allow for computation of moments up to arbitrary order in semi-closed form. For example they contain all affine processes satisfying a certain integrability condition. We extend this class to allow for stochastic discontinuities within a semimartingale framework. We establish a relation between the predictable characteristics and the polynomial property and discuss an extension to a non Markov setting.

Joint work with: Thorsten Schmidt

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Kateřina Koňasová
Charles University, Faculty of Mathematics and Physics

Tue, 18:45
Get Together

Stochastic reconstruction for inhomogeneous point processes

In stochastic geometry visualisation and simulation studies remain fundamental part of point pattern analysis. Visual inspection of our data provides a useful preliminary step towards understanding its properties. Next step consists of finding a suitable model for observed pattern. Then with estimated parameters the model is fitted to the data and tested. Once the model is chosen, we can start with simulations that can be used for a number of different aims, e.g. exploring the sampling variation of estimated summary characteristics. However, this approach demands a lot of probabilistic and statistical knowledge.
Stochastic reconstruction lets us generate point patterns with prescribed summary characteristic that are free of explicit model conditions. This algorithmic procedure has tradition in statistical physics, see [1]. Nowadays the method of stochastic reconstuction is of particular interest in biology and ecology. It can be used when monitoring forest ecosystems, see [4]. Of course, many other applications of this technique can be found in recent scientific papers, for example the quasi-plus sampling method by Tsceschel and Chiu in [3] or the model-free isotropy test by Wong and Chiu, see [5].
Up to this day only stationary patterns were reconstructed. In this case we have a large choice of different summary characteristics. In the inhomogeneous case the situation becomes more complex because we are not able to intuitively define their inhomogeneous counterparts. The inhomogeneous version is known for K and J-function. Unfortunately, it is not clear whether the known counterparts of J and K-function contain enough information for successful reconstruction of observed point pattern.
Our aim is to discuss the possibility of the extension of the stochastic reconstruction algorithm described in [2] for second-order intensity-reweighted stationary point processes using the direct method of minimizing the energy functional.

This work has been supported by the Charles University Grant Agency, project no. 472217.

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[3] A. Tscheschel, S. N. Chiu (2008) Quasi-plus sampling edge correction for spatial point patterns. *Computational Statistics & Data Analysis* 52(12), 5287–5295
[4] A. Lilleleht, A. Sims, A. Pommerening (2014). Spatial forest structure reconstruction as a strategy for mitigating edge-bias in circular monitoring plots. *Forest Ecology and Management* 316, 47–53
[5] K. Y. Wong, S. N. Chiu (2016). Isotropy test for spatial point processes using stochastic reconstruction. *Spatial Statistics* 15, 56–69

Joint work with: Jiří Dvořák

Linda Möstel

Tue, 18:45
Get Together

Confidence Intervals for Markov Transition and Generator Matrices, with Application to Credit Rating Migrations

Confidence intervals for the parameters of discrete- and continuous-time Markov chains are derived. Whereas point estimates in both, discrete- and continuous-time as well as for complete and partial observations are intensively discussed in the literature, interval estimates have only received scant attention so far. However, from a credit risk perspective, Markov chains play a crucial role in the modeling of rating migrations. In this respect, confidence intervals for the parameters of Markov chain models can provide valuable information on the stability of point estimates, and thus on the robustness

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of an important input factor for credit portfolio models, financial stress tests, the pricing of debt, or maturity-based probabilities of defaults as required by the new reporting standard IFRS 9 which will take affect in 2018. Therefore, we aim at describing appropriate methods for a discrete-time data setting, a continuous-time data setting with complete observations as well as a continuous-time data setting with partial observations. For each of the data scenarios both, analytic as well as resampling based approaches are outlined and we will depict, that our suggested confidence intervals show superior theoretical properties compared to the sparse existing methods.

Joint work with: Marius Pfeuffer • Matthias Fischer

Kevin Musielak
Universität Siegen

Tue, 18:45
Get Together

Symbols and Time Inhomogenous Processes

For different classes of stochastic processes (e.g. Lévy-, Feller-, and Itô-processes) we define the (probabilistic) symbol q via

$$q(x,\xi) := -\lim_{t \searrow 0} \frac{\mathbb{E}^x e^{i(X_t^\sigma - x)'\xi} - 1}{t}$$

for $\xi \in \mathbb{R}^d$ where $\sigma = \sigma_K^x$ is the first exit time from a compact neighborhood $K := K_x$ of x.
The symbol was used to define generalized Blumenthal-Getoor-indices to derive e.g. upper and lower bounds for the Hausdorff dimension of the range of the process, as well as for the Hölder continuity (from the right) and the γ-variation of the trajectories.
Until now, all considered classes of processes are Markovian semimartingales and homogenous in time. The canonical way to deal with time inhomogenous processes is to consider the space-time process $\tilde{X} := (X_s, s)_{s \geq 0}$ where X is a time homogenous process. This approach has a big disadvantage: All known generalized Blumenthal-Getoor-indices β fulfill $\beta(\tilde{X}) \geq 1$ and in many cases we only get quite bad bounds. In this talk, we want to give a first idea on how to generalize previous results for the time inhomogenous case in order to get better bounds in the future.

Joint work with: Alexander Schnurr

Alexander Nerlich
Ulm University

Tue, 18:45
Get Together

The strong Law of large Numbers and the central limit Theorem for abstract Cauchy Problems driven by random Measures

In this talk, we establish the SLLN as well as the CLT for a class of vector-valued stochastic processes $X : [0,\infty) \times \Omega \to V$ which arise as solutions of the stochastic differential inclusion

$$\eta(t,z) N_\Theta(dt \otimes z) \in dX(t) + \mathcal{A}X(t)dt,$$

where $(V, ||\cdot||_V)$ is a separable Banach space, $\mathcal{A}$ is a multi-valued, densely defined, m-accretive operator acting on V and N_Θ is the counting measure induced by a point process Θ.
The SLLN and the CLT will be proven not only for real-valued, but also for vector-valued functionals and the applicability of these theoretical results to the (weighted) p-Laplacian evolution equation (for "small" p) will be demonstrated.
Moreover, the class of functionals is sufficiently large to prove these results for X itself and for certain norms which are stronger than $||\cdot||_V$. Particularly, in the p-Laplacian case our results yield the SLLN and the CLT for the solution itself and all L^q-norms of the process, where $q \in [1,\infty)$.
The key assumption needed to achieve this, is that the nonlinear semigroup arising from the multi-valued operator $\mathcal{A}$ extincts in finite time. Of course, some distributional assumptions regarding the noise are also necessary.

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Takaaki Ohnishi
The University of Tokyo

Tue, 18:45
Get Together

Quantification of spatial collocation patterns of shops and facilities using the two-dimensional Kolmogorov-Smirnov statistic

We empirically investigate spatial distributions of shops and facilities (hereafter called establishments) observed in Japanese telephone directory (Yellow Pages) data on nationwide scale. This data contains comprehensive individual listings of about 7 million establishments (nearly all shops, firms, hospitals, schools, parks, etc). Name, address, latitude and longitude, phone number, and industrial sector of the establishment are also included. The industrial sector is divided into 39 categories. Each category is further divided into 735 subcategories. This allows us to study and discuss systematically geographic location patterns of establishments that are associated with various aspects of agglomeration.
Industry agglomeration is an universal property observed in most countries and at various spatial scales. The spatial agglomeration of industries has been traditionally measured by using cluster-based methods which is defined on a discrete definition of space. In these methods, space is divided into subunits, so the position of the boundaries and level of observation have an impact resulting in the modifiable areal unit problem. In order to avoid this problem, recent studies have applied distance-based methods which consider space as continuous. Although these methods allow an exact and unbiased analysis of the spatial concentration at all scales simultaneously, it is necessary to define the values of some parameters and the shape of the kernel function.
To overcome these disadvantages, we present the use of the two-dimensional Kolmogorov-Smirnov two sample test to quantify spatial collocation patterns of establishments. The Kolmogorov-Smirnov test computes the maximum difference between two cumulative distribution functions yields a P-value. The spatial difference between categories of establishments can be characterized by P-value, which is small if there is attraction and large otherwise. To identify characteristic collocation patterns of different types of establishment, we characterize subcategories by 735 dimensional vector whose elements consist of the Kolmogorov-Smirnov statistic. Then we perform a cluster analysis with Ward's method using Euclidean distance and classify subcategories into groups. The obtained dendrogram illustrates the hierarchical structure and defines groups at different levels. We show that obtained groups are different from category classification and help to characterize spatial distributions of establishments, implying that we can extract important spatial information of urban structure from geographic interaction between different types of establishment.

Joint work with: Takayuki Mizuno • Tsutomu Watanabe

Michael Schatz
ETH Zurich

Tue, 18:45
Get Together

Uniform integrability of a single jump local martingale with state-dependent characteristics.

Local martingales that are not uniformly integrable martingales have recently gained increased attention in the stochastic processes and mathematical finance literature, being linked to special cases in arbitrage pricing theory and to the occurrence of bubbles.
We present a deterministic necessary and sufficient criterion to determine whether a single jump local martingale is a uniformly integrable martingale. Our class of processes is based on a general, possibly explosive homogenous diffusion and a state dependent jump hazard rate and solves a stochastic differential equation of the form

$$dS_t = b(S_t)1_{\{t<\tau\}}dt + \sigma(S_t)1_{\{t<\tau\}}dW_t - \frac{b(S_t^-)}{h(S_t^-)}d1_{\{\tau\leq t\}},$$

for a random time τ with $\mathbf{P}\left[\tau = t|\mathcal{F}_t^-\right] = h(S_t^-)$, (partly) extending both results on homogeneous diffusions [1] and single jump processes with deterministic jump hazard [2]. The uniformly integrable

martingale property is investigated using the machinery of Feynman–Kac and an analysis of singular points of ODEs.
While to date, most of the research on local martingales that are not uniformly integrable martingales has been focused on deterministically bounded time, we provide natural examples of processes that live on a stochastically unbounded (yet finite) time window.

References:

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[2] M. Herdegen, S. Herrmann (forthcoming). Strict Local Martingales and Optimal Investment in a Black-Scholes Model with a Bubble. *Mathematical Finance*

Joint work with: Didier Sornette

Roman Schefzik
German Cancer Research Center (DKFZ)

Tue, 18:45
Get Together

Identifying differential distributions for single-cell RNA sequencing data comprising biological replicates

Major advances in technology in the current decade allow to sequence information from individual biological cells and thus offer a high resolution of cellular differences. Single cell sequencing facilitates fundamental insights into biology and was chosen as the method of the year 2013 by Nature Publishing Group. In particular, performing high-throughput ribonucleic acid (RNA) sequencing at the single-cell level (scRNA-seq) has enabled the quantification of cellular heterogeneity. However, it remains a challenge to account for the natural biological variation for the detection of differential gene expression, cellular heterogeneity and clustering in the scRNA-seq data. Thus, the design of appropriate statistical analysis methods for scRNA-seq data currently is of great interest and importance.
Recently developed tools are able to detect differences in gene expression distributions across conditions which are more involved than a shift in the mean. For instance, a current approach allows for a classification of genes with a differential distribution (DD) into categories that represent distinct DD patterns such as differential modality or differential proportion of cells within each component.
Our aim is to develop a statistical method that identifies DDs in the scenario in which the scRNA-seq data consist of read counts obtained by different biological replicates for each physiological condition. In such a case, the gene expression for each condition can first be represented by a mixture distribution, where each mixture component corresponds to a kernel density estimate fitted to the expression data of an individual biological replicate. Due to this strategy, the information given by the corresponding multiple biological replicates is aggregated for each condition separately. Then, the condition-specific distributions so obtained are checked for significant differences applying the L^2 Wasserstein distance and a permutation test. Our procedure is illustrated and evaluated using data from a recent scRNA-seq experiment.

Stefanie Schwaar
Technische Universität Kaiserslautern

Tue, 18:45
Get Together

Randomized weight function in change-point tests and estimators

In change-point analysis the point of interest is to decide if the observations follow one model or if there was at least one point in time, where the model has changed. This results in two subfields, the testing of a change and the estimation of the time of change. Here both parts are considered but with the restriction of testing and estimating for at most one change-point.
The well-known AMOC (at most one change) mean change model is based on the independent observations having one change in the mean. Based on the quasi-likelihood ratio test a test statistic with an asymptotic Gumbel distribution was derived for this model. As it is a well-known fact that

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the corresponding convergence rate is very slow, modifications of the test using a weight function were considered. Those tests and the corresponding estimators have a better performance. But no weight function performs uniformly better than the others (i.e. independent of the point in time the change occurs, e.g. early changes or changes in the middle). To overcome this problem, a randomized weight function is introduced. An analyse of the test statistic and estimator having a randomized weight function is given.

Sebastian Schwinn

Tue, 18:45
Get Together

Improving the performance of polling models using forced idle times

We consider polling models in the sense of Takagi [2]. These models are multiple queue, cyclic service systems which are served by one server. In our case, the feature of the server is that it may be forced to wait idly for new messages at an empty queue instead of switching to the next station. We propose four different wait-and-see strategies that govern these waiting periods. We assume Poisson arrivals for new messages and allow general service and switchover time distributions. The results are formulas for the mean average queueing delay and characterisations of the cases where the wait-and-see strategies yield a lower delay compared to the exhaustive strategy.

The work of S. Schwinn is supported by the Excellence Initiative of the German Federal and State Governments via the Graduate School of Computational Engineering at Technische Universität Darmstadt.

References:

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Joint work with: Frank Aurzada

Vitalii Senin
TU Berlin

Tue, 18:45
Get Together

Pesin's formula for isotropic Brownian flows

Pesin's formula is a relation between the entropy of a dynamical system and its positive Lyapunov exponents. This formula was first established by Pesin in the late 1970s for some deterministic dynamical systems acting on a compact Riemannian manifold. Later were obtained plenty of generalizations of it. For example, different authors have proved the formula for some random dynamical systems, or have relaxed the condition of state space compactness. Nevertheless, it has never been obtained for dynamical systems with invariant measure, which is infinite. The problem is that if invariant measure is infinite, then the notion of entropy becomes senseless. Invariant measure of isotropic Brownian flows is the Lebesgue measure on $\mathbb{R}^d$, which is, clearly, infinite. Nevertheless, we define entropy for such a kind of flows using their translation invariance. Then we study the analogue of Pesin's formula for these flows using the defined entropy.

Hans-Jörg Starkloff
TU Bergakademie Freiberg

Tue, 18:45
Get Together

Variational analysis for the solution of random differential equations

For the solution of differential equations with random parameters different methods are known. Their practical use yields in general approximations for quantities of interest of the solution, often without quantitative measures of the goddness of approximation. On the other side similar results derived by different approximate solution methods can be an indicator of the quality of the used solution methods.

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One not so well known and quite different solution method was developed by V. G. Zadorozhnij (Voronesh). It uses results of variational analysis, in particular the concept of variational derivative. In the present work we will present shortly this method and report about some related results.

Alexander Steinicke
Universität Graz

Tue, 18:45
Get Together

L^p-solutions of BSDEs with Jumps – Existence and Comparison

Let $X = (X_t)_{t\in[0,T]}$ be a Lévy process on an interval $[0, T]$ with triplet (γ,σ,ν), Brownian part $(\sigma W_t)_{t\in[0,T]}$ and associated compensated Poisson random measure $\tilde{N}$.
We consider the stochastic backward differential equation of the form

$$Y_t = \xi + \int_t^T f(s, Y_s, Z_s, U_s)ds - \int_t^T Z_s dW_s - \int_{(t,T]\times(\mathbb{R}\setminus\{0\})} U_s(x)\tilde{N}(ds, dx),$$

for $0 \le t \le T$, where $\xi \in L^p$ for $p > 1$ and $\int_0^T |f(s, 0, 0, 0)|ds \in L^p$. The generator f is Lipschitz in (y, z, u), where the Lipschitz constants may vary in time.
We show that the above equation admits solution processes (Y, Z, U) such that

$$\sup_{t\in[0,T]} |Y_t| \in L^p, \quad \left[\int_0^T |Z_s|^2 ds\right]^{\frac{1}{2}} \in L^p$$

and also

$$\left[\int_0^T \int_{\mathbb{R}\setminus\{0\}} |U_s(x)|^2 \nu(dx)ds\right]^{\frac{1}{2}} \in L^p,$$

where the latter condition is an innovation, since in the case $p \in]1, 2[$ this was not clear yet from the literature. Our method is to use a priori-estimates which we prove on sufficiently small time-intervals. Moreover, we show a comparison theorem for L^p-solutions Y, Y' of BSDEs with associated generators f, f', $f \le f'$ that satisfy a monotonicity condition, if for f and all $u, u' \in L^2(\nu)$ additionally the inequality

$$f(s, y, z, u) - f(s, y, z, u') \le \int_{\{x\in\mathbb{R}\setminus\{0\}:u'>u\}} (u'(x) - u(x))\nu(dx)$$

holds.

Joint work with: Stefan Kremsner

Nino Svanidze

Tue, 18:45
Get Together

Semi Markovian Queuing System with Bifurcation of Arrivals

In this work multi component standby system with repairable components are studied. The system consists of m main (operative) and n standby identical components. It is supposed that for normal operation of the system it is advisable that in the group of main components all m components be operative. But if their number is less, the system continuous functioning with reduced economical effectiveness. Failure of main unit generates two services for the system – 1) replacement of failed main unit by stand by one, and 2) repair of failed unit. The failed main component must be replaced with operative standby one, thus if at failure moment there is a free standby component in the system, its replacement operation will commence. The failed components, both the main and standby, are repaired. Both of this maintenance operation should be performed in parallel mode. We have l maintenance servers for replacement and one server for repair. Repair and replacement times are random variables. Replacement time is exponentially distributed. Replacement time distribution function $G(x)$ is arbitrary.

In case when service channels are busy, requests queues for replacement or repair are formed. Thus, we have a closed queuing system (finite source queuing system) with two types of services – replacement and repair.
Mathematical model for dependability and performance analysis is constructed and investigated. Explicit solution for transient probabilities in terms of matrix exponential is obtained. The result of the research can be used for further analysis of the system to derive some important characteristics with different distribution functions of repair time.

Joint work with: Revaz Kakubava

Wayne Tarrant
Rose-Hulman Institute of Technology

Tue, 18:45
Get Together

Self-organized criticality faithfully describes systemic risk in the interbank loan market

In the past thirty years we have seen Black Monday, the S&L crisis, the burst of the Japanese Asset Price bubble, the Scandinavian bank crisis, Black Wednesday, the Mexican crisis, the Asian crisis, the 1998 Russian crisis, the dot-com bubble, the Turkish crisis, the 9-11 attacks, an Argentine default, the sub-prime crisis and the collapse of Lehman Brothers, the GM bankruptcy, the European sovereign crisis, the downgrading of the US credit rating, and the most recent Russian crisis. After the disastrous 2008 crash, economists put a renewed effort into searching for why crashes keep recurring. Most researchers in this area are currently concerned with locating contagious links, giving some measure of total systemic risk, or predicting how much loss will occur when the complete collapse comes. The aim here is a different one. Understanding the mechanism of systemic collapse in interbank lending before trying to accomplish each of the above goals leads to a more thorough ability to compute and to a better understanding of the nature of the risk. Hopefully it can lead to predictive tools that may help us avoid or ameliorate the next crash.
As always it is difficult to find data on bank assets, as each bank considers this to be proprietary data. Thus this work utilizes simulation based upon previous research that shows that bank capitals are skewed right, that banks with larger capitals tend to have more links to other banks, and that loan sizes tend to correlate to bank capitals. From these previous empirical results, a matrix of initial bank capitals and loans is derived.
New loans of sizes that follow similarly right skewed distributions are added to the initial setup. At the addition of each new loan, a determination is made about whether this causes a bank to fail the Basel ratios. If the Basel ratio is broached, a default is set in motion. This wipes out loans that this bank owed to other banks and also reduces the capital of all banks to which the defaulting bank owes money. Sometimes this leaves the system with just the removal of this bank. Other times the avalanche of debt destruction causes a ripple effect, a cascading of banks defaulting.
When varying the initial distributions of capital and loans among different right-skewed distributions, varying the distributions of sizes of loans, and considering different methods of default, patterns emerge. Although the achievement of such states varies in time length, similar critical states continue to occur. This led to the discovery that this mechanism followed the results of a 1987 paper of Bak, Tang, and Wiesenfeld, in which they introduced the concept of self-organized criticality.
Self-organized criticality is a property of a system that returns to similar critical states over wide arrays of initial parameters and different choices of dynamics for the system. It is characterized by Pareto laws in sizes of cascades, no matter what initial conditions and governing dynamics are in the system. It is seen in seismology, neurobiology, cosmology, and now in financial crisis.
Over many different simulations for varying parameters, the sizes of avalanches were noted. For each simulation the maximum likelihood estimator was computed for a Zipf law, a discrete version of the Pareto law. Since this is a discrete situation, the MLE must be computed through the use of a Hurwitz zeta function (a generalization of the Riemann zeta function) and its derivative. Using a chi-square goodness of fit test, it is proved that sizes of avalanches follow Zipf's law. This is evidence that the situation of systemic financial risk is well described by the model of self-organized criticality. This should

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lead to better understanding of the mechanisms of systemic collapse and to the ramifications of such collapse.

Joint work with: Ethan Petersen • Justin Calareso

Dorothee Westphal
University of Kaiserslautern

Tue, 18:45
Get Together

Expert Opinions and their Approximation for Multivariate Stock Returns with Gaussian Drift

We investigate a financial market with multivariate stock returns where the drift is an unobservable Ornstein-Uhlenbeck process. Information is obtained by observing stock returns and unbiased expert opinions.
The optimal trading strategy of an investor maximizing expected logarithmic utility of terminal wealth depends on the conditional expectation of the drift given the available information, the filter. We investigate properties of the filters and their conditional covariance matrices. This includes the asymptotic behaviour for an increasing number of expert opinions on a finite time horizon and conditions for convergence on an infinite time horizon with regularly arriving expert opinions.
In the situation where the number of expert opinions goes to infinity on a finite time horizon we distinguish between the case where experts have some minimal level of reliability and experts whose uncertainty increases with increasing frequency of information dates. The latter case leads to a diffusion approximation where the limiting diffusion can be interpreted as a continuous-time expert. This approximation for high-frequency experts thus allows to work with a simpler model in which more explicit solutions can be derived.
We deduce properties of the value function using its representation as a functional of the conditional covariance matrices.

References:

[1] J. Sass, D. Westphal, R. Wunderlich (2017): Expert opinions and logarithmic utility maximization for multivariate stock returns with Gaussian drift, *International Journal of Theoretical and Applied Finance* **20** (4), 1750022.

Joint work with: Jörn Sass • Ralf Wunderlich

Ufuk Yolcu
Giresun University

Tue, 18:45
Get Together

Winsorized Mean-Pi Artificial Neural Network based on Robust Learning for Time Series Forecasting

Different kinds of artificial neural networks (ANNs) have been commonly utilized for time series forecasting. One of them is Pi-Sigma ANN proposed by Ghos and Shin (1992). Although Pi-Sigma ANNs can produce successful forecasting results, they can be negatively affected by outlier(s) in time series because of their multiplicative structure. ANNs with robust architecture or robust learning algorithm can be used to forecast time series with outliers.
ANNs with robust architecture such as Median ANN, Trimmed-Mean ANN, Median-Pi ANN, and ANNs with robust learning algorithms based on M-estimator or Trimmed-Mean such as robust Multiplicative neuron model ANN and robust Pi-Sigma ANN are some of them which have been proposed in the literature for forecasting time series with outlier(s). In this study, a new robust ANN with both robust architecture and robust learning algorithm based on winsorized mean. The new neural network is called Winsorized Mean-Pi ANN (WP-ANN) because winsorized mean neuron model and multiplicative neuron model are employed at its architecture. Moreover, the learning algorithm of WP-ANN is based on winsorized mean performance measure and particle swarm optimization. To investigate the performance of the proposed WP-ANN, datasets from the International Time Series Forecast Competition 2016

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(CIF-2016) have been analyzed in case of outlier. The obtained results are compared with the results of some other robust ANNs. Application results prove that the forecasting performance of WP-ANN is promising and competitive.

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Tue, 18:45
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Regularity structures for the primitive equations

The primitive equations are a geophysical model describing the behaviour of the ocean and the atmosphere on a large scale. They can be derived from the Navier–Stokes equations by assuming hydrostatic balance in the vertical direction. This is justified because the movement in this direction is much smaller than in the horizontal ones. The primitive equations in 3 dimensions were already solved globally for multiplicative white noise in time by Debussche, Glatt-Holtz, Temam and Ziane in [1]. Our goal is to investigate the 2 dimensional primitive equations with a force term $f(x,z) = z\xi$ with ξ a white noise in time and in the x-direction. The reason for that is that we already can see its characteristic behaviour in this case. But we cannot use space-time white noise in all spacial variables because then the primitive equations are not subcritical anymore.
Let $\Omega := (0,1) \times (-h,0)$ with a small h. Let v, w, π, f be realvalued distributions on $\Omega \times (0,T)$ and $u = (v,w)$. Then the primitive equations in 2 dimensions are given by

$$\partial_t u - \Delta u = -u \cdot \nabla v - \partial_x \pi + f \qquad \text{in } \Omega \times (0,T), \tag{0.1}$$

$$\operatorname{div} u = 0 \qquad \text{in } \Omega \times (0,T), \tag{0.2}$$

$$\partial_z \pi = 0 \qquad \text{in } \Omega \times (0,T). \tag{0.3}$$

The technique we will use are regularity structures, which were introduced by Martin Hairer to solve subcritical nonlinear SPDEs like KPZ and Φ^4_d for $d = 2, 3$ ([2]).
In the case of the Navier–Stokes equations regularity structures were already used successfully by Rongchan Zhu and Xiangchan Zhu in ([3]). For the Navier–Stokes equations in 2D they even found a global solution ([4]). Unfortunately one can't translate their proof to the primitive equations because of the anisotropic nature of the primitive equations. We have to solve it as a coupled PDE-PDE system. In our talk an abstract integration map of order 0 is needed to handle the equation (0.2). It is then possible to build a regularity structure for the primitive equations. There one can find a solution to a fixed point equation in some D^γ space. After that we show how to find a converging sequence of models $(\Pi^\varepsilon, \Gamma^\varepsilon)$ for the regularity structure. This will give us the renormalised equations for white noise convoluted with a mollifier ϱ_ε such that the sequence of their solutions converges for $\varepsilon \to 0$. At last the limit of this sequence, which does not depend on the mollifier, is the local solution for the primitive equations.

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Joint work with: Martin Saal • Volker Betz

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