3rd Workshop on
Analysis, Geometry and
Probability

September 28 - October 2, 2015
Ulm University, Germany
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Conference Information

Following the workshops in Ulm (2013) and in Moscow (2014), this is the 3rd joint workshop of Ulm University (UULm, Germany) and Lomonosov Moscow State University (MSU, Russia) on Analysis, Geometry and Probability. The workshop is organized by the Institutes of Analysis, Mathematical Finance, Pure Mathematics, Number Theory and Probability Theory, Statistics, and Stochastics of Ulm University.

Confirmed invited speakers:

- Eustasio del Barrio (Uni Valladolid)
- Victor Buchstaber (MSU)
- Alexander Bulinski (MSU)
- Henning Bruhn-Fujimoto (UULm)
- Klaus Deckelnick (Uni Magdeburg)
- Shota Gugushvili (Uni Leiden)
- Dirk Lebiedz (UULm)
- Markus Pauly (UULm)
- Hans-Peter Scheffler (Uni Siegen)
- Albert Shiryaev (MSU)
- Robert Stelzer (UULm)
• Stanislav Stepin (MSU)
• Alexey Tuzhilin (MSU)
• Rico Zacher (UULm)

Scientific committee:

• Alexander Bulinski (MSU)
• Anna Dall’Acqua (UULm)
• Alexander Lindner (UULm)
• Victor Buchstaber (MSU)
• Boris Kashin (MSU)
• Markus Pauly (UULm)
• Albert Shiryaev (MSU)
• Volker Schmidt (UULm)
• Evgeny Spodarev (UULm)
• Ulrich Stadtmüller (UULm)
• Robert Stelzer (UULm)
• Stefan Wewers (UULm)

In addition to the above mentioned members of the scientific committee from Ulm, the local organizing team includes:

• Patricia Alonso-Ruiz
• Dennis Dobler
• Michael Harder
• Renate Jäger
• Jürgen Kampf
• Frederik Klingler
• Bernadette Maiwald
• Eva Nacca
• Alexander Nerlich
• Matthias Neumann
• Judith Olszewski
• Stefan Roth
• Adrian Spener
• Christian Steck

Registration July 31, 2015
Abstract submission July 31, 2015
Conference fee 50 €
Contact renate.jaeger@uni-ulm.de
Conference Web-Page https://www.uni-ulm.de/index.php?id=64428

Conference venue
The first two days of the conference and the morning of the third day will take place in the Senatssaal at Helmholtzstraße 16. From Wednesday afternoon on the conference will take place in room 2.20 of Helmholtzstraße 18.

Travel information
Christian Steck (0049 176 70797595, christian.steck@uni-ulm.de) can pick you up, when you arrive at Ulm main station, and guide you to the B&B- or to the Ibis-hotel. Please send him an email with your arrival time and your mobile phone number.

We recommend all participants to buy a DING ticket for the week from September 28 till October 4 (local traffic for Ulm and Neu-Ulm, price: 18.90 €). This
CONFERENCE INFORMATION

is available e.g. at the ticket machine in front of the main station (where buses and trams leave).

On Monday morning Michael Harder will pick you up at the B&B-hotel at 7:40 and at the IBIS hotel at 7:55.

In order to get from the city center to the university take bus line 3. Leave the bus at bus stop “Botanischer Garten”. There are buses at least every ten minutes most of the day. The schedule is available under [http://www.ding.eu/fileadmin/content/schedules_ding/live/din_87003__j15.pdf](http://www.ding.eu/fileadmin/content/schedules_ding/live/din_87003__j15.pdf). After leaving the bus, follow the road “Helmholtzstraße” (that is the road that turns to the right in front of the bus stop) to its end. At the end of the Helmholtzstraße you will find the buildings number 16 and 18.

Reimbursement of travel costs
The guests from the MSU have to fill in the forms concerning the reimbursement of travel costs on Monday morning. Please come to the office of Renate Jäger, room 1.64, at the first floor of Helmholtzstraße 18. Our administration needs some days to prepare the cash.

Internet access
WLAN with internet access is available in all buildings of the university. Participants who use the eduroam system can use it at Ulm University. Other participants can use the following account during the workshop:

User name: wlan.wagp2015@gast.uni-ulm.de
Password: x4Nu9qCDQ

Social Program

- On Monday, September 28, there will be a get-together at 6 p.m. in front of the Senatssaal.

- On Wednesday, September 30th, there will be a guided tour of the city lasting about 2 hours. We will visit Ulm’s historic centre including its gothic cathedral with the highest church tower in the world. The tour will start at 5 p.m. sharply in front of the Stadthaus (the white building at the southern end of the square in front of the cathedral).
• On Thursday, October 1, at 7 p.m. there will be a conference dinner. It will take place at the restaurant “Drei Kannen” in Ulm’s city center (Hafenbad 31/1). Coming from the university you have to leave the bus at “Theater”. Then turn left into Olgastraße – you can take the tram if you like, but you already have to leave the tram at the next station “Justizgebäude”. Then turn right into Hafenbad – that is the first street turning to the right after the tram station “Justizgebäude”. Soon you will see the restaurant on the right side.

The costs for a 3-course menu vary from 16.50 € to 22.60 € (without drinks) depending on the choice of the main course (for invited speakers this is included in the invitation). There are three ways of registering for the conference dinner: You can fill in the form on the conference webpage, you can write an e-mail to eva.nacca@uni-ulm.de and there will be a last opportunity to register on Monday, September 28.
Program
Monday, September 28

Location: Senatssaal, Helmholtzstraße 16

8.15 - 9.00 Declaration of travel expenses (in room 1.64 of Helmholtzstraße 18; only for the guests from Moscow) (p. 8)
8.30 - 9.00 Registration (in front of the Senatssaal)

9.00 - 10.30 Victor Buchstabber
Fullerenes and polygonal partitions of surfaces (p. 22)
10.30 - 11.00 Coffee break
11.00 - 12.30 Alexey A. Tuzhilin
Proteins conformation and the database Protein Data Bank: geometrical validity testing (p. 32)

12.30 - 14.00 Lunch

14.00 - 15.30 Stanislav A. Stepin
Short-time asymptotics for semigroups from diffusion class and beyond (p. 31)
15.30 - 16.00 Nikolay Yu. Erokhovets
Fullerenes and combinatorics of 3-dimensional flag polytopes (p. 39)
16.00 - 16.30 Coffee break
16.30 - 17.00 Nataliya V. Prudnikova
Endo-Kroto operation on the space of fullerenes (p. 50)
17.00 - 17.30 Georgii Sechkin
Topology of dynamics of a nonhomogeneous rotationally symmetric ellipsoid (p. 54)
17.30 - 18.00 Vsevolod Salnikov
Probabilistic properties of topologies of finite metric spaces’ minimal fillings and rectilinear Steiner minimal trees (p. 52)

18.00 Get together (p. 8)
Tuesday, September 29

Location: Senatssaal, Helmholtzstraße 16

9.00 - 10.30  Albert N. Shiryaeve
Quickest detection problems
discrete and continuous time (p. 29)

10.30 - 11.00  Coffee break

11.00 - 12.30  Robert Stelzer
Lévy-driven CARMA Processes (p. 30)

12.30 - 14.00  Lunch

14.00 - 15.00  Peter Scheffler
Implicit extremes and implicit max-stable laws (p. 28)

15.00 - 15.30  Georgiy Shevchenko
Small ball probabilities and representations with respect to
Gaussian processes (p. 55)

15.30 - 16.00  Johannes Goldbach
\( f \)-implicit max-infinitely divisible distributions (p. 43)

16.00 - 16.30  Coffee break

16.30 - 17.00  Martin Drapatz
On spatial random recurrence equations (p. 38)

17.00 - 17.30  Nikolai A. Slepov
Modification of the MDR method related to generalized
penalty function (p. 57)

17.30 - 18.00  Dennis Dobler
Inference procedures for cumulative incidence functions (p. 37)
# Wednesday, September 30

**Location:** Senatssaal, Helmholtzstraße 16

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<td>Alexander V. Bulinski</td>
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<td>Operator-stable and operator-self-similar random fields (p. 48)</td>
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<td>15.30 - 16.00</td>
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Thursday, October 1

Location: Room 2.20, Helmholtzstraße 18

9.00 - 10.30 Rico Zacher
Non-local in time sub-diffusion equations (p. 33)

10.30 - 11.00 Coffee break

11.00 - 12.00 Klaus Deckelnick
Finite element methods for elliptic PDEs on surfaces (p. 24)

12.00 - 13.30 Lunch

13.30 - 14.30 Shota Gugushvili
Non-parametric Bayesian inference for multi-dimensional compound Poisson processes (p. 25)

14.30 - 15.00 Stefan Roth
An inverse problem for infinitely divisible random fields with integral representation (p. 51)

15.00 - 15.30 Coffee Break

15.30 - 16.00 Artem M. Savchuk
Uniform stability for the inverse Sturm-Liouville problem. Recovering of a potential from a finite set of spectral data (p. 53)

16.00 - 16.30 Mikhail A. Tuzhilin
Relation between the circular molecule and 4-dimensional singularity in the saddle-saddle case (p. 59)

16.30 - 17.00 Egor D. Kosov
Estimates of polynomials on spaces with logarithmically concave measures (p. 46)

19.00 Conference dinner (p. 9)
Friday, October 2

Location: Room 2.20, Helmholtzstraße 18

9.00 - 10.30  Henning Bruhn-Fujimoto  
The probabilistic method in discrete mathematics (p. 21)

10.30 - 11.00  Coffee break

11.00 - 11.30  Christian Steck  
Models of curves and quotient singularities (p. 58)

11.30 - 12.00  Iurii N. Shteinikov  
On the divisibility of Fermat quotients (p. 56)

12.00 - 12.30  Hassan Jolany  
Song-Tian approach for solving the finite generation of canonical ring of a projective variety (p. 42)

12.30 - 14.00  Lunch

14.00 - 14.30  Matthias Neumann  
Statistical modeling of three-phase structures with completely connected phases (p. 49)

14.30 - 15.00  Timothy Brereton  
Estimating the velocities of interacting charge carriers in disordered media (p. 36)

15.00 - 15.30  Coffee break

15.30 - 16.00  Jürgen Kampf  
A functional central limit theorem for Lebesgue integrals of mixing random fields (p. 44)

16.00 - 16.30  Alexey A. Kozhevin  
Variable selection method with group overlapping (p. 47)
Abstracts
Invited Lectures
Eustasio del Barrio, University of Valladolid

A contamination model for approximate stochastic order

Stochastic ordering among distributions has been considered in a variety of scenarios. Economic studies often involve research about the ordering of investment strategies or social welfare. However, as noted in the literature, stochastic orderings are often a too strong assumption which is not supported by the data even in cases in which the researcher tends to believe that a certain variable is somehow smaller than other. Instead of considering this rigid model of stochastic order we propose to look at a more flexible version in which two distributions are said to satisfy an approximate stochastic order relation if they are slightly contaminated versions of distributions which do satisfy the stochastic ordering. The minimal level of contamination that makes this approximate model hold can be used as a measure of the deviation of the original distributions from the exact stochastic order model. Our approach is based on the use of trimmings of probability measures. We discuss the connection between them and the approximate stochastic order model and provide theoretical support for its use in data analysis, including asymptotic distributional theory as well as non-asymptotic bounds for the error probabilities of our tests. We also provide simulation results and a case study for illustration.
Henning Bruhn-Fujimoto, Ulm University

The probabilistic method in discrete mathematics

A common problem in any branch of mathematics is to prove the existence of an object with certain, specified properties. This could, for instance, be something as mundane as showing that $\sin(x)$ has a root in $[2, 4]$. Often the simplest proof consists in explicitly describing or constructing such an object, that is, we could verify that $\pi$ is such a root. Sometimes, however, a direct proof is unavailable, and more indirect existence proofs are called for. A proof technique that has turned out to be very powerful in discrete mathematics is the so called probabilistic method: devise a suitable probability space and show that the desired object occurs with positive probability, which means, in particular, that it has to exist.

In the talk I will give a first introduction to the probabilistic method and its use in graph theory.
Victor Buchstaber, Moscow State University and Steklov Mathematical Institute

Fullerenes and polygonal partitions of surfaces

We consider polygonal partitions of a closed 2-surface $M^2$, in which the intersection of any two polygons is either empty or their common edge. Such a polygonal partition is called simple if any its vertex is contained in exactly 3 polygons. The combinatorics of such partitions is an area of research at the intersection of classical and most modern branches of mathematics and its applications. It is known that the condition on the surface partition to be simple allows to supplement classical Euler’s formula, which connects the numbers $f_0$, $f_1$ and $f_2$ of vertices, edges and polygons belonging to the surface partition, by a formula connecting the numbers $p_3$, ..., $p_k$, ..., where $p_k$ is the number of $k$-gones belonging to this partition. Implications of this formula are non-trivial already in the case of a sphere considered as the boundary of a convex three-dimensional body. For example, for a simple decomposition of a sphere involving only pentagons and hexagons, the number of pentagons should be 12.

Results on combinatorics of simple polygonal partitions have become very actual in connection with the discovery of remarkable molecules of carbon, namely fullerenes (Nobel Prize in Chemistry, 1996, R. Curl, H. Kroto, R. Smalley). The mathematical model of a fullerene is a simple polygonal partition of a sphere on hexagons and pentagons. The big push intensifying the research in this field was given by the discovery of such a carbon structure as graphene (Nobel Prize in Physics, 2010, A. Geim, K. Novoselov).

The mathematical model of graphene is the hexagonal simple partition of the plane. The graphene plane modulo a lattice defines a hexagonal partition of the torus. In our focus will be the problems of combinatorial geometry and algebraic topology, motivated by problems of quantum physics and chemistry of fullerenes, graphene, and other carbon structures such as nanotubes and nanobuds. The lecture is intended for a broad audience.
Methods of variable selection

In a number of stochastic models a studied variable (response) $Y$ depends on some collection of (random) factors $X = (X_1, \ldots, X_n)$. For example, in medical and biological research $Y$ can characterize the health state of a patient whereas the components of $X$ describe genetic and nongenetic factors. In this regard we refer to the genome-wide association studies (GWAS). One of the challenging problems concerning the response analysis consists in identification of significant (or influential) collection of factors $(X_{i_1}, \ldots, X_{i_r})$, $1 \leq i_1 < \ldots < i_r \leq n$, such that $Y$ depends on it in essential way, in a certain sense. Many complementary methods for solving this problem were introduced. They can be classified into three categories according to their strategies, namely, exhaustive, stochastic and heuristic search. Note that probabilistic and statistical techniques, machine learning and computer simulation are combined in such investigations. We concentrate on multi-step designs. Main attention will be paid to MDR (multifactor dimensionality reduction) method introduced by M. Ritchie et al. in 2001. This method was applied and further developed in more than 200 publications. The lecture is based on a cycle of recent author’s papers. We consider statistical estimation of the error functional for the response forecast based on i.i.d. observations, a penalty function estimate and a cross-validation procedure. This method permits to comprise nonbinary response. The regularized estimates of the mentioned functional are defined and a central limit theorem is established for them. We also discuss the results of computer simulation showing the effectiveness of our approach.

The work is supported by RSF, project 14-21-00162.
Klaus Deckelnick, Otto von Guericke University of Magdeburg

**Finite element methods for elliptic PDEs on surfaces**

Partial differential equations on fixed or moving surfaces appear in a variety of applications, e.g. in multiphase flows or diffusion induced grain boundary motion. Quite often the corresponding mathematical models involve a coupling between surface and bulk equations giving rise to complicated systems. For this reason the development and analysis of numerical methods plays an important role in understanding the behaviour of solutions.

The talk will focus on the following model problem:

\[-\Delta_\Gamma u + u = f \]  

on \(\Gamma\),

where \(\Gamma\) is a given compact hypersurface without boundary and \(\Delta_\Gamma\) denotes the Laplace-Beltrami operator. In order to discretize this problem with the help of the finite element method the equation is first reformulated in variational form after which the space of test functions is replaced by a suitable finite-dimensional (finite element) space. In addition, a full discretization of the problem requires the approximation of \(\Gamma\) by a suitable discrete hypersurface \(\Gamma_h\). Roughly speaking, one can distinguish the following two approaches:

a) The finite element space is constructed on a direct piecewise polynomial approximation \(\Gamma_h\) of \(\Gamma\);

b) The finite element space is induced by an outer triangulation of an open neighbourhood of \(\Gamma\), while \(\Gamma_h\) itself is represented in implicit form.

The talk will introduce corresponding numerical schemes and discuss their analysis.
Non-parametric Bayesian inference for multi-dimensional compound Poisson processes

Joint work with Frank van der Meulen and Peter Spreij

Given a sample from a discretely observed multi-dimensional compound Poisson process, we study the problem of non-parametric estimation of its jump size density $r_0$ and intensity $\lambda_0$. We take a non-parametric Bayesian approach to the problem and determine posterior contraction rates in this context, which, under some assumptions, we argue to be optimal posterior contraction rates. In particular, our results imply existence of Bayesian point estimates that converge to the true parameter pair $(r_0, \lambda_0)$ at these rates. We will also present some simulations to illustrate the practical performance of our method.

References:


Dirk Lebiedz, Ulm University

**From Microscopic to Macroscopic Dynamics in Kinetic Multi-Scale Modeling**

Joint work with Pascal Heiter and Jonas Unger

We will elucidate analytic, geometric and statistical issues related to the computation of slow invariant attracting manifolds (SIAM) in kinetic multiple time scale ordinary differential equation (ODE) models. Based on a Riemannian geometry view on the phase space of ODE vector fields we introduce a variational problem formulation for SIAM characterization and computation. Both analytic and numerical aspects of the problem are addressed, numerical real-time optimization techniques can be exploited for highly efficient computation of SIAMs in applications to high-dimensional models of chemical reaction kinetics. We start by motivating our research by addressing the challenging problem of modeling and numerical simulation of detailed reactive flow models as arising e.g. in combustion and chemical engineering. We then introduce fundamental concepts from chemical reaction kinetics. Finally we point out the development and implications of our variational approach to SIAM computation.

References:


An Excursion to Randomization-Type Tests

Joint work with Edgar Brunner, Lutz Dümbgen, Arnold Janssen and Frank Konietschke

In a nutshell, the main purpose of statistical hypothesis testing is to decide (with a small pre-specified error probability) that the unknown underlying distribution of a given sample belongs to a specific class of distributions (the so called alternative). When turning from parametric hypotheses (class of possibly underlying distributions is described by a finite dimensional space) to larger nonparametric hypotheses classical test procedures (as e.g. the two sample $t$-test) are in general not valid anymore. To this end, the current talk will propagate the application of different kinds of randomization-type tests as powerful solutions. Therefore, the first part will introduce this class of tests and explain the corresponding basic finite sample theory. Afterwards more recent considerations for even larger classes of alternatives will be discussed in several examples.

Some References:


Peter Scheffler, University of Siegen

**Implicit Extremes and Implicit Max-Stable Laws**

Joint work with Stilian Stoev, University of Michigan, Ann Arbor

Let $X_1, \ldots, X_n$ be iid $R^d$-valued random vectors and $f \geq 0$ be a non-negative function. Let also $k(n) = \text{Argmax}_{i=1, \ldots, n} f(X_i)$. We are interested in the distribution of $X_{k(n)}$ and their limit theorems. In other words, what is the distribution the random vector where a function of its components is extreme. This question is motivated by a kind of inverse problem where one wants to determine the extremal behavior of $X$ when only explicitly observing $f(X)$. We shall refer to such types of results as to *implicit extremes*. It turns out that, as in the usual case of explicit extremes, all limit *implicit extreme value* laws are *implicit max-stable*. We characterize the regularly varying implicit max–stable laws in terms of their spectral and stochastic representations. We also develop a theory of regular variation on general cones.

References:

Albert N. Shiryaev, Steklov Mathematical Institute, Moscow State University

Quickest detection problems – discrete and continuous time

We observe a random process \( X = (X_t) \) on an interval \([0, T]\), \( T \leq \infty \). The following objects \( \theta \) and \( \tau \) which are introduced and considered below are essential throughout the lectures:

- \( \theta \) is a parameter or a random variable, it is a hidden, nonobservable characteristic; for example, it can be a time when observed process \( X = (X_t) \) changes its character of behavior or its characteristics;

- \( \tau \) is a stopping (Markov) time which serves as the time of “alarm”, it warns of the coming of the time \( \theta \).

The following observed process \( X = (X_t) \) plays the crucial role:

\[
X_t = \mu(t - \theta)^+ + \sigma B_t,
\]

where \( B = (B_t)_{t \geq 0} \) is a Brownian motion. We formulate four variants of the quickest detection problem. One of them is Variant A: to find

\[
A(c) = \inf_{\tau} \left[ P^G(\tau < \theta) + cE^G(\tau - \theta)^+ \right],
\]

where \( P^G \) is a distribution with respect to a priori distribution \( G \).

We formulate also other problems (solved and unsolved).

The work is supported by RSF, project 14-21-00162. References:

Robert Stelzer, Ulm University

Lévy-driven CARMA Processes

Joint work with Tina Marquardt, Eckhard Schlemm, Florian Fuchs and Zywilla Fechner.

We present an outline of the theory of certain Lévy-driven, multivariate stochastic processes, where the processes are represented by rational transfer functions (Continuous-time AutoRegressive Moving Average or CARMA models) and their applications in non-Gaussian time series modelling. We discuss in detail their definition, their spectral representation, the equivalence to linear state space models and further properties like the second order structure and the tail behaviour under a heavy-tailed input. Furthermore, we study the estimation of the parameters using quasi-maximum likelihood estimates for the auto-regressive and moving average parameters, as well as how to estimate the driving Lévy process.
Stanislav A. Stepin, Moscow State University

**Short-time asymptotics for semigroups from diffusion class and beyond**

A relationship between Feynman-Kac formula and parametrix representation for Schroedinger semigroup proves to be useful for evaluation of the regularized trace and calculation of the heat invariants, i.e. coefficients of the heat kernel short-time asymptotics. In view of the asymptotic analysis to be carried out for evolutionary semigroups beyond the diffusion type class we revisit path integral approach to the study of heat kernel asymptotics and heat trace estimations. Within this approach for the case of diffusion with a drift the heat kernel asymptotic properties are specified. Making use of parametrix expansion and Born approximation instead of path integrals we investigate semigroups generated by potential perturbations of bi-Laplacian. Namely short-time asymptotics for the corresponding Schwartz kernel and regularized trace are derived.
Proteins conformation and the database Protein Data Bank: geometrical validity testing

The investigation of polypeptides conformation (3D-structure) is well-known and very important problem. In particular, its great importance is related to the fact that conformation changes of proteins in living cells caused by some mutations may lead to serious diseases. Notice that experimental determination of such mutations consequences is time consuming and expensive process. Therefore, it is naturally and important to work out theory and software for performing "those experiments" by means of computer. Unfortunately, the modeling problem itself turns out to be very hard and, in spite of many efforts of the worldwide community, is very far from final solution. Notice that this problem stands at the interfaces of many sciences such as biology, chemistry, physics, geometry, variational calculus, probability, computational mathematics. Thus, it is necessary to attract attention of specialists from very different branches of science and to create a possibility for the interested novices to get fast abreast of and to start their own experiments with the data collected. However, it turned out that the modern state of biological information collected in the main internet database Protein Data Bank (PDB) devoted to the conformation of biomolecules is very far from perfection. That is why one needs to workout effective methods for verification and extracting correct information from the database.

In our lecture we present several geometrical and statistical methods to analyze the information in PDB for consistency and general theory fitting. In addition, we include a list of examples demonstrating the necessity of careful analysis and sampling of the PDB items. In particular, we show some examples visualizing the distribution of disturbance level of the famous Pauling plane law, and of CIS-configurations rareness. In addendum, we discuss a method for automatic recognition of helices in a protein, based on discrete analogues of curvature and torsion of a smooth curve.

The work was supported by Russian Science Foundation (RSF), project 14-50-00029.
Rico Zacher, Ulm University

Non-local in time subdiffusion equations

Partially joint work with Jukka Kemppainen, Juhana Siljander, and Vicente Vergara

We will consider a class of non-local in time diffusion equations, where instead of the usual time derivative one has an integro-differential operator w.r.t. time. Important special cases are time-fractional and ultraslow diffusion equations, which have seen much interest during the last years, mostly due to their applications in the modeling of anomalous diffusion. I will discuss several aspects of these equations, such as well-posedness, regularity, and the long-time behaviour of solutions. Among others, I will show that the decay behaviour is markedly different from the heat equation case.

References:


Contributed Talks
ABSTRACTS

Timothy Brereton, Ulm University

Estimating the velocities of interacting charge carriers in disordered media

Joint work with Aaron Smith, Rafał Kulik, and Volker Schmidt

Charge transport in disordered materials (such as organic semiconductors) can be modeled by considering charge carriers as moving on the vertices of a geometric graph with periodic boundary conditions. The vertices have energies assigned to them. The dynamics of the charge carriers are then described by a continuous time Markov chain, whose transition rates are determined by the differences in energies between vertices of the graph.

One of the key quantities of interest when considering charge transport is the average speed of a charge carrier as it travels through the material under the influence of an external electric field. Often, Monte Carlo methods need to be used to estimate this speed. However, Monte Carlo simulation is difficult because realistic models of disordered materials have many traps (i.e., low energy regions with large rates leading into them and small rates leading out of them) in which charge carriers become stuck for long periods of time. This poses a significant problem for simulation, as almost all computational effort is spent on simulating the charge carriers hopping around in the trap regions. We propose a method for “coarsening” the state space in such a manner that we do not need to simulate the exact dynamics of the charge carriers in the trap regions whilst still extracting all the information we need in order to estimate their speed consistently.
Dennis Dobler, Ulm University

**Inference Procedures for Cumulative Incidence Functions**

Joint work with Jan Beyersmann and Markus Pauly

The analysis of cumulative incidence functions (and more generally of transition probability matrices of non-homogeneous Markov processes) is of great importance (especially in medical applications) and it constantly gives rise to new statistical developments. While observations may be incomplete, e.g. due to random left-truncation and right-censoring, estimation of these matrices is conducted by employing the Aalen-Johansen estimator which is based on counting processes. However, results of weak convergence towards a Gaussian process cannot be utilized straightforwardly since the complicated limiting covariance structure depends on unknown quantities. Already established tests, which are popular in the literature, have a simple limit distribution but may have poor power.

In order to construct asymptotically valid and powerful inference procedures, we introduce a large variety of resampling techniques using a martingale representation of this estimator. A new aspect to this approach is given by the possibility to choose these multipliers dependent on the data, covering, for instance, the Wild bootstrap as well as the Weird bootstrap. In doing so, we gain conditional weak convergence towards a Gaussian process with correct covariance functions resulting in consistent tests and confidence bands.

For small samples the performance in the simple competing risks set-up is assessed via simulation studies illustrating the type I error control and analyzing the power of the developed tests and confidence bands.
Martin Drapatz, Ulm University

On spatial random recurrence equations

We consider random recurrence equations

\[ Y(i, j) = A_0(i - 1, j)Y(i - 1, j) + A_1(i, j - 1)Y(i, j - 1) + c(i, j), \]

where \( i, j \in \mathbb{Z} \) and \((A_0(i - 1, j), A_1(i, j - 1), c(i, j))_{i,j \in \mathbb{Z}}\) is an independent and identical distributed (i.i.d.) sequence of random variables. Relations to time series models (more precisely random field models) and percolation theory will be discussed.
Nikolay Yu. Erokhovets, Moscow State University

**Fullerenes and combinatorics of 3-dimensional flag polytopes**

The talk is based on the joint work with V.M. Buchstaber.

Let $P$ be a simple convex 3-polytope. A $k$-belt is a cyclic sequence $(F_1, \ldots, F_k)$ of 2-faces, such that $F_{i_1} \cap \cdots \cap F_{i_r} \neq \emptyset$ if and only if $\{i_1, \ldots, i_r\} \in \{\{1, 2\}, \ldots, \{k-1, k\}, \{k, 1\}\}$. $P$ is a flag polytope if it is not a simplex and does not contain 3-belts.

**Theorem 1.** A simple 3-polytope $P$ is flag if and only if it is combinatorially equivalent to a polytope obtained from the cube by a sequence of edge truncations and truncations along two incident edges lying in a $k$-gonal face with $k \geq 6$.

A fullerene is a simple convex 3-polytope with all facets being pentagons and hexagons.

**Theorem 2.** Any fullerene $P$ is a flag polytope. It contains no 4-belts and has $12 + k$ five-belts, where 12 belts surround pentagons and $k$ belts consist of hexagons with any hexagon intersecting neighbours by opposite edges. Moreover, if $k > 0$ then $P$ consists of two dodecahedral caps and $k$ hexagonal 5-belts between them.

We give applications of these results to the toric topology.

The work is supported by the Russian President grant MK-600.2014.1 and the RFBR grant 14-01-31398-a.
Arnold Janssen, Heinrich Heine University of Duesseldorf

Preferences of goodness-of-fit tests: A survey about the analysis of non-parametric power functions

Goodness of fit tests are usually consistent for nonparametric models. However, they do not meet the power of oracle tests (Neyman Person tests) for local alternatives when the distributions would be known. The statistician likes to distinguish and to compare the power of different competing tests. It is shown that under certain circumstances every test has a preference for a finite dimensional space of alternatives. Apart from this space, the power function is almost flat on balls of alternatives. There exists no test which pays equal attention to an infinite number of orthogonal alternatives. The results are not surprising. Every statistician knows that it is impossible to separate an infinite sequence of different parameters simultaneously if only a finite number of observations is available.

The conclusions of the results are two-fold.

1. The statistician should analyze the goodness of fit tests of his computer package in order to get some knowledge and an impression about their preferences.

2. A well-considered choice of tests requires some knowledge about preferences concerning alternatives which may come from the practical experiment. A guide to the construction of tests is given. A principle component decomposition of goodness of fit tests has been studied in Janssen (1995, 2000, 2003).

Global power functions of one-sided Kolmogorov-Smirnov tests for a restricted class of alternatives were obtained by Anděl (1967) and Hájek and Šidák (1967). We refer also to the early work of Neuhaus (1976), Milbrodt and Strasser (1990) and Rahnenfuehrer (2003).

References


Hassan Jolany, University of Lille

**Song-Tian approach for solving the finite generation of canonical ring of a projective variety**

Existence of canonical metric on a projective variety was a long standing conjecture which the major part of this conjecture is about varieties which do not have definite first Chern class. There is a program which is known as Song-Tian approach for finding canonical metric on canonical model of a projective variety and its connection with Weil-Petersson metrics along a divisor with conical and cusp singularities. I give a logarithmic version of this program and strengthen the previous results of Song-Tian. In final I explain the analogous method of Song-Tian for Sasakian manifolds.

References:


Johannes Goldbach, University of Siegen

\textit{f-Implicit Max-Infinity Divisible Distributions}

Joint work with Hans-Peter Scheffler

Let $f : \mathbb{R}^d \to [0, \infty)$ be continuous and 1-homogeneous with $f(x) = 0 \iff x = 0$. In applications $f$ will be referred to as the \textit{loss function}. We equip $\mathbb{R}^d$ with a specific non-commutative but associative (inner) binary operation $\vee_f$, called the \textit{f-max operation}. It turns out that $(\mathbb{R}^d, \vee_f)$ is a semigroup but not necessarily a topological one. This yields, in a natural way, to the concept of so-called \textit{f-implicit max-infinity divisible (f-imid) distributions}. Our aim is to establish a theory of this new concept extending the theory of \textit{f-implicit max-stable distributions}, analogous to the case of infinity divisible and stable distributions regarding the $+$-operation and the $\vee$-operation, respectively. Under some mild assumptions on $x \mapsto \mathbb{P}(f(X) \leq x)$ for a given random vector $X$ we then show that $X$ is \textit{f-imid}. For the moment the general case still remains as an open question that might be solved using the theory of so called $\vee_f$-\textit{compound poisson processes}.

References:


Central limit theorems for random fields have been studied for a long time. In 1984 Gorodetskii [1] proved a first central limit theorem for integrals of the form \( \int_{W_n} X(t) \, dt \), where \((X(t))_{t \in \mathbb{R}^d}\) is a random field and \((W_n)_{n \in \mathbb{N}}\) is a sequence of integration domains tending to \(\mathbb{R}^d\) in an appropriate way. A central limit theorem for \( \int_{W_n} f(X(t)) \, dt \) with a map \( f : \mathbb{R} \to \mathbb{R} \) is an easy corollary of this. Meschenmoser and Shashkin [2] showed a functional central limit theorem for Lebesgue measures of excursion sets of random fields, i.e. for integrals of the form \( \int_{W_n} \mathbf{1}_{[u, \infty)}(X(t)) \, dt \), \( u \in \mathbb{R} \), where the stochastic process is indexed by \( u \). We will extend the result of [2] to a functional central limit theorem for \( \int_{W_n} f(X(t)) \, dt \), where the stochastic process is indexed by the function \( f : \mathbb{R} \to \mathbb{R} \), which is assumed to be Lipschitz continuous. While replacing indicator functions by Lipschitz continuous functions is straightforward, we need an entirely different approach, since the index set of the stochastic process is much bigger now (it is the real line in [2] and the space of Lipschitz continuous function in this talk).

The functional central limit theorem is derived for a stationary and measurable random field which fulfills some \( \alpha \)-mixing condition as well as some integrability conditions. We show that the sequence \((\Phi_n)_{n \in \mathbb{N}}\) of stochastic processes defined by

\[
\Phi_n(f) := \frac{\int_{W_n} f(X(t)) \, dt - \lambda_d(W_n) \cdot \mathbb{E} f(X(0))}{\sqrt{\lambda_d(W_n)}}
\]

converges in distribution to a centered Gaussian process \( \Phi \) with

\[
\text{Cov}(\Phi(f), \Phi(g)) = \int_{\mathbb{R}^d} \text{Cov}(f(X(0)), g(X(t))) \, dt.
\]

As topology we use the weak topology on the dual space of the space of Lipschitz continuous functions. The proof is essentially based on a result from Oppel [3], which tells us that it suffices to show that the finite-dimensional distributions converge and that the limiting process has a version with linear and continuous paths.
We will also discuss the question whether the variance of the limiting process is strictly positive. For Gaussian random fields with non-negative covariance function we show that the asymptotic variance is strictly positive except for some trivial counterexamples. On the other hand, based on Poisson-Voronoi mosaics, we can construct an example of a random field for which the variance of \( \Phi \) vanishes for all functions \( f : \mathbb{R} \rightarrow \mathbb{R} \) simultaneously.

References:


Egor D. Kosov, Moscow State University

**Estimates of polynomials on spaces with logarithmically concave measures**

We will discuss several new estimates for polynomials on spaces with logarithmically concave measures. One of the important examples of logarithmically concave measures is Gaussian measure and the results are new for this measure too. One of such results is an estimate of $L^1$-norm of a polynomial $f$ by $L^1$-norm of its restriction to a set $U$ of positive measure:

$$\int fd\mu \leq C \int_U fd\mu,$$

where constant $C$ depends only on the degree of the polynomial and measure of the set $U$. Some distributional inequalities for polynomials will also be considered. Moreover, we will discuss some approaches on which proofs of the presented results are based.

This work was supported by the Russian Science Foundation grant N 14-11-00196.
Variable selection method with group overlapping

In our talk we consider model from genome-wide association studies (GWAS) in which binary or continuous response variable depends on predictors $X_1, \ldots, X_p$ where $X_j$ takes values in $\{0, 1, 2\}$ for all $j$. The aim is to find all the predictors that essentially influence on response. This task leads to high-dimensional problem where number of predictors exceeds the number of observations and dependence between the predictors due to linkage disequilibrium (LD) may exist.

There are different methods for this task solution. One of them proposed in [1] takes into account certain dependence between predictors. Authors employ three-step approach which is based on combining the predictors into non-overlapping groups, estimation of the number of groups and variable selection by group LASSO.

We modify method introduced in [1] by another hierarchical clustering which allows overlaps between groups of the predictors.

This work is partially supported by RFBR grant 13-01-00612.

References:

Dustin Kremer, University of Siegen

**Operator-stable and operator-self-similar random fields**

Joint work with Hans-Peter Scheffler

There is an increasing interest in so called operator-self-similar random fields due to applications and as they provide practical dependence structures expressed by linear operators. Underlining the theoretical importance of this concept, we will show that (under mild assumptions) any random field is operator-self-similar if and only if its domain of attraction (which we shall define) is not empty. On the other hand, operator-stable distributions seem to be an attractive and - in the context of multivariate limit theory - appropriate choice for the corresponding marginals. Combining both ideas, we will give comprehensive examples of such fields in terms of a harmonic and a moving-average representation, respectively, as proposed in [1] using stochastic integral representations and homogeneous functions (see [2]).

References:


Matthias Neumann, Ulm University

**Statistical modeling of three-phase structures with completely connected phases**

Joint work with Jakub Staněk, Omar Pecho, Lorenz Holzer, Viktor Beneš, Volker Schmidt

In this talk a new parametric model for three-phase structures in $\mathbb{R}^d$, $d \geq 3$ is presented, where each phase is completely connected with probability 1. In order to obtain complete connectivity in the model, it is based on three connected random graphs, so-called beta-skeletons, see [2], as backbones of the three phases. Each phase is then given by those points in $\mathbb{R}^d$ which are closer (with respect to the Euclidean distance) to the corresponding graph than to the other two graphs. For this model a relationship between the expected total edge lengths of the three beta-skeletons per unit volume and the volume fractions of the phases is established by a simulation study for $d = 3$. Furthermore, we derive a formula for the expected total edge length of a beta-skeleton per unit volume in arbitrary dimensions, see also [1] for $d = 2$. This makes it possible to use the model for statistical description of three phase structures with completely connected phases, where the volume fractions can be adjusted by the model parameters.

For fitting the model to three-dimensional tomographic data from materials science we suggest parameter estimation by minimizing the difference between relevant microstructural characteristics of experimental tomographic data and simulated structures with the Nelder-Mead method, see [3]. A generalization of the model has shown its potential to describe image data of a three-phase microstructure occurring in solid oxide fuel cells.

References:


Nataliya V. Prudnikova, Moscow State University

Endo-Kroto operation on the space of fullerenes

The talk is based on the joint work with V.M. Buchstaber.

A mathematical fullerene is a simple closed convex three-dimensional polytope with only pentagonal and hexagonal faces. We consider the space of combinatorial types of fullerenes $F = \bigcup F_n$ where $n$ is the number of hexagons. This paper deals with Endo-Kroto operation (E-K). The fullerene is named admissible if he has a patch consisting of two non-adjacent pentagons joined by a hexagon. Inadmissible fullerene is a fixed point of the operator E-K. Endo-Kroto operation transfers an admissible fullerene into admissible and increases the number of hexagons by 1. Thus we have an infinite orbit. The fullerene without hexagons $F_0$ - dodecahedron - is a fixed point E-K. There is no fullerene with one hexagon, and there is only one fullerene with two hexagons; it is called a Barrel. Starting from Barrel and applying the operator E-K it is possible to obtain all the points of $F_4$ and $F_5$. Also, there are fullerenes, which can not be received by applying a sequence of Endo-Kroto operations - IPR-fullerenes, where none of the pentagons have common edge. The most well-known of these, $C_{60}$ is inadmissible. Moreover, it can be verified that if the fullerene has a symmetry group and we apply the operator E-K on the patch and on its image under symmetry, then we will receive the fullerenes with the same combinatorial type.

The paper describes the results of investigation of applying the Endo-Kroto operation on the space of fullerenes.

The work is supported by the RNF grant 14-11-00414.
An Inverse Problem for Infinitely Divisible Random Fields with Integral Representation

Joint work with Evgeny Spodarev

Given \( n \) observations \( X(t_1), \ldots, X(t_n) \) of a \( d \)-dimensional, stationary infinitely divisible random field \( X = \{ X(t) = \int_{\mathbb{R}^d} f(x - t) \Lambda(dx) \} \), we provide three nonparametric estimation approaches for the Lévy characteristics of the independently scattered random measure \( \Lambda \). Existence and uniqueness of a solution for this inverse problem will be discussed in the case of a simple function \( f \) using a one to one correspondence between the Lévy triplets of \( X \) and \( \Lambda \). We also give \( L_2 \)-error bounds for the estimated Lévy measures.

References:


Probabilistic properties of topologies of finite metric spaces’ minimal fillings and rectilinear Steiner minimal trees

Both Steiner minimal tree problem and minimal filling problem [1] are proved to be NP-hard. That is why even approximate solutions are of a great interest. Here we want to divide the task into two different parts: first to find an underlying tree structure or so-called topology — how nodes are connected and then to find a particular representative of the topology which solves the problem. The later part is comparably fast for both tasks, meaning that there are efficient algorithms, but for the first part it is not the case. That’s why we want to introduce a probability measure on the space of topologies, which favorites such topologies, that are likely to contain an optimal solution.

One of the main contributions of this work is that we introduce such a probability measure for minimal fillings of finite additive metric spaces as well as an algorithm for its computation. We also perform various numerical experiments to check the consistency of this measure and make some analytical computations of asymptotic behavior for families of graph structures.

Another important contribution is that we start a discussion of probabilistic properties for the Steiner problem itself, in particular for the Manhattan metrics and get analytical results for the small amount of terminals (nodes for which the Steiner problem is considered).

References:

Uniform stability for the inverse Sturm-Liouville problem. Recovering of a potential from a finite set of spectral data

Joint work with A.A. Shkalikov.

We deal with two classical inverse problems for the Sturm-Liouville operator

\[ Ly = -y'' + q(x)y, \quad x \in [0, \pi], \quad q \in W^{-1}_2[0, \pi]. \]

The first one was originated by Borg. The problem is to recover a potential

\[ q(x) \leftarrow \{\lambda_n\}_1^\infty \cup \{\mu_n\}_1^\infty \]

by given two spectra of this operator with Dirichlet-Neumann and Dirichlet boundary conditions. The second inverse problem was launched by Gelfand, Levitan and Marchenko. This problem is to recover a potential \( q(x) \) by spectral function of operator \( L \) with Dirichlet boundary conditions. In our case \( x \in [0, \pi] \) the spectral function is fully determined by eigenvalues and norming constants.

Given only finitely many, say \( 2N \), eigenvalues (or \( N \) eigenvalues and \( N \) norming constants) do not permit to recover the potential \( q \) explicitly. However, we can associate with such a finite set of spectral data the function \( q_{2N} \) which we call the \( 2N \)-approximation of the potential \( q \). Our main result can be roughly formulated as follows:

\[ \|q - q_N\|_{\kappa-1} \leq CN^{\kappa - \theta}, \]

provided that \( \kappa \in (0, \theta) \) and we a priori know that \( q \in W^\theta_2 \).
Let us consider an ellipsoid of revolution moving on a smooth horizontal plane under the action of gravity. We construct topological invariants for this system and classify corresponding Liouville foliations up to Liouville equivalence. Two systems are called equivalent if they have the same closure of integral trajectories of systems solutions. Suppose that the mass distribution in the ellipsoid is such that it has an axis of dynamical symmetry coinciding with the axis of geometric symmetry. Moments of inertia about principal axes of inertia perpendicular to symmetry axis are equal to each other. We also assume that the center of mass lies on this symmetry axis (as in the Lagrange top) at distance $s$ from the geometric center of the body.

A free rigid body has six degrees of freedom. We need three coordinates to describe the position of an arbitrary point in the body (e.g., the center of mass) with respect to a fixed space frame, and three more coordinates to describe the orientation of principal axes.

In our case, there is one holonomic constraint: the height of the center of mass above the plane is determined by the orientation of principal axes. Thus, the number of degrees of freedom is reduced to five. Let us write the equation in Euler's form using $f' = \{f; H\}$, where $H$ is the Hamiltonian, and $\{,\}$ is the Poisson bracket on $e(3)^\ast$. Then in standard $(S, R)$ coordinates we get the following first integrals: $H = \frac{1}{2} \sum_{i=1}^{3} S_i^2 A_i + U$, where $U$ is the potential energy and $A$ is a constant, and $K = S_3$.

Using the Fomenko-Zieshang invariants, we prove the following result.

**Theorem.** The Liouville foliation associated with the above-described problem can be embedded in the foliation corresponding to the Zhukovsky system describing a heavy gyrostat.

Note that N. E. Zhukovsky (1899) found a generalization of Euler's integrable case, with Hamiltonian $H = \frac{1}{2} \sum_{i=1}^{3} \frac{(S_i + \lambda_i)^2}{A_i}$. The additional integral is the same as in the Euler's case: $K = S_1^2 + S_2^2 + S_3^2$. 
Small ball probabilities and representations with respect to Gaussian processes

The talk will be devoted to stochastic integral representations of the form

$$\xi = \int_0^T \psi(s)dX(s),$$

(1)

where $\phi$ is an adapted process, and $X$ is a Hölder continuous process of order $\mu > 1/2$. Studying such representations is motivated by applications in financial mathematics, where $\phi$ plays a role of a risky component of self-financing portfolio.

A sufficient condition for representation (1) will be formulated in terms of the Hölder exponent $\gamma$ and small ball exponents for $X$. In view of this, some new results on small ball probabilities for Gaussian processes will be given.
Iurii N. Shteinikov, Moscow State University

**On the divisibility of Fermat quotients**

For a prime $p$ and an integer $a$ with $gcd(a, p) = 1$ the Fermat quotient $q_p(a)$ is defined as $q_p(a) = \frac{a^{p-1} - 1}{p}$. For $p$ let $l_p$ be the smallest $a$ for which $p$ does not divide $q_p(a)$. I will consider the tasks of estimating $l_p$ for

1) all primes $p$,

2) all $p$, with the exception of primes from a set with relative zero density.

The recent estimates are based on results about the distribution of elements of multiplicative subgroups of residue rings and exponential sums.

This work is supported by the RSF grant 14-11-00433.
Nikolai A. Slepow, Moscow State University

**Modification of the MDR method related to generalized penalty function**

We are interested in models described by a binary response variable $Y$ (e.g., indicating the state of a patient’s health) depending on huge number of factors $X = (X_1, \ldots, X_n)$ with values in a finite set. The problem is to find the most significant collection of factors and an appropriate function $F$ depending on these factors to predict $Y$. The accuracy of such prediction is characterized by an error functional $Err(F)$ involving some penalty function, see [1].

To find the significant (in a sense) factors, we use a modification of the multifactor dimensionality reduction (MDR) method introduced in [2]. Namely, following [1] we employ a penalty function to evaluate $Err(F)$. However, we use prediction algorithms such that one has to specify various thresholds for $P(Y = 1|X_\alpha = x_\alpha)$ where $X_\alpha = (X_{i_1}, \ldots, X_{i_r})$ and $1 \leq i_1 < \ldots < i_r \leq n$. The advantages of this approach are demonstrated.

This work is partially supported by RFBR grant 13-01-00612.

References:


Christian Steck, Ulm University

**Models of curves and quotient singularities**

This talk is devoted to resolution of tame cyclic quotient singularities on integral Noetherian schemes. In dimension 2 such singularities can be resolved by a procedure resembling the classical Hirzebruch-Jung resolution on complex surfaces. The methods are then applied to compute regular models of curves over local fields.
Relation between the circular molecule and 4-dimensional singularity in the saddle-saddle case

Many dynamical systems are integrable Hamilton systems with two degrees of freedom, for example, the Lagrange top or the humidistat in the gravity field. Two integrals of such systems generate Momentum map. Classical Liouville theorem describes the foliation on trajectories in preimages of sufficiently small neighborhoods of regular values of the Momentum map. For singular values the situation is much more difficult. A.T. Fomenko has suggested an effective method to describe the boundary of a singular value neighborhood preimage by means of so-called marked circular molecule. The next step is to investigate when such boundary determine completely the foliation of whole preimage.

It is well-known that this situation holds for the singular values of types center-saddle, center-center and focus-focus, but in the saddle-saddle case it is not true. To demonstrate this, Grabezhnoy constructed two examples of different singularities with coincided marked circular molecules. These two examples there are the only ones known nowadays. In our talk we present an infinite series of different singularities with coincided circular molecules. Besides that, we describe some new relations between the circular molecule and the corresponding foliation.

I would like to thank academision A.T. Fomenko for stating the problem and permanent attention to my work.
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