Limit Theorems in Probability, Statistics and Number Theory

Conference in honor of Friedrich Götze’s 60th birthday

3 – 6 August 2011

Department of Mathematics
Bielefeld University
Location: ZiF (Center for Interdisciplinary Research)
Plenary Hall

This workshop is part of the conference program of the DFG-funded CRC 701
Spectral Structures and Topological Methods in Mathematics
at Bielefeld University.

Organizers: Guido Elsner, Barbara Gentz, Holger Kösters

In case of any problems or questions feel free to contact Guido Elsner at 0521/106-4781
http://www.math.uni-bielefeld.de/sfb701/2011_LimitTheorems
Programme

Wednesday, 3 August 2011

9:30 – 9:45 Opening

9:45 – 10:25 Leonid Pastur (Institute for Low Temperature Physics and Engineering, Kharkov)
Asymptotics of Orthogonal Polynomials, Quasiperiodic Jacobi Matrices, and Random Matrices

10:30 – 11:00 Coffee Break

11:00 – 11:40 Marek Bozejko (University of Wroclaw)
Noncommutative Fock spaces, generalized Gaussian and Levy processes with applications to noncommutative probability

11:45 – 12:25 Roland Speicher (University of Saarland, Saarbrücken)
Limit Theorems in Free Probability

12:30 – 14:00 Lunch Break

14:00 – 14:40 Jens Marklof (University of Bristol)
From the Lorentz gas to random graphs: new applications of measure rigidity in statistical physics, number theory and combinatorics

14:45 – 15:25 Jonathan P. Keating (University of Bristol)
Large values of zeta and random landscapes

15:30 – 16:15 Coffee Break

16:15 – 16:55 Holger Kösters (Bielefeld University)
Regularized Inverses of Sample Covariance Matrices

18:00 Classical Concert

afterwards Reception and Conference Dinner
Programme

Thursday, 4 August 2011

9:45 – 10:25  **David Mason** (University of Delaware)  
Randomly Weighted Lévy Processes

10:30 – 11:00  *Coffee Break*

11:00 – 11:40  **Grigorii Margulis** (University of Yale)  
Distribution of values of irrational quadratic forms at integral points

11:45 – 12:25  **Rabi Bhattacharya** (University of Arizona)  
Nonparametric Statistics on Manifolds with Applications

12:30 – 14:00  *Lunch Break*

14:00 – 14:40  **Anton Wakolbinger** (Goethe University Frankfurt)  
Exploring random genealogies: from a discrete example to a continuum limit

14:45 – 15:25  **Frank den Hollander** (University of Leiden)  
Disordered Catalytic Diffusion

15:30 – 16:00  *Coffee Break*

16:00 – 16:40  **Ildar Ibragimov** (Russian Academy of Sciences, St. Petersburg)  
The uniqueness theorem for analytic functions. A statistical approach.
Programme

Friday, 5 August 2011

9:00 – 9:40  Craig A. Tracy (UC Davis)
Turbulent Liquid Crystals, KPZ Universality and the Asymmetric
Simple Exclusion Process

9:45 – 10:25  Jinho Baik (University of Michigan)
Complete matchings and random matrix theory

10:30 – 11:00  Coffee Break

11:00 – 11:40  Neil O’Connell (University of Warwick)
Tropical combinatorics and Whittaker functions

11:45 – 12:25  Mark Rudelson (University of Missouri)
Row products of random matrices

12:30 – 14:00  Lunch Break

14:00 – 14:40  Anton Bovier (University of Bonn)
The extremal process of branching Brownian motion

14:45 – 15:25  Peter Bickel (University of California, Berkeley)
Inference for unlabelled graphs

15:30 – 16:00  Coffee Break

16:00 – 16:40  Sergey Bobkov (University of Minnesota)
Entropic forms of the central limit theorem

19:00  Informal Dinner
Wernings Weinstube, Alter Markt 1, 33602 Bielefeld
Programme

Saturday, 6 August 2011

9:30 – 10:10  Erwin Bolthausen (University of Zürich)
An iterative construction of solutions of the TAP equations

10:30 – 14:00  Ceremony and Reception

including speeches by

- Prof. Dr.-Ing. Gerhard Sagerer, President of Bielefeld University
- Prof. Dr. Etienne Emmrich, Vice Chairman of the Department of Mathematics
- Prof. Dr. Matthias Löwe, University of Münster

and a talk by

Willem van Zwet (University of Leiden)
Special cases


Abstracts

Leonid Pastur (Institute for Low Temperature Physics and Engineering, Kharkov)

Asymptotics of Orthogonal Polynomials, Quasiperiodic Jacobi Matrices, and Random Matrices

We discuss the asymptotics of orthogonal polynomials, stressing their spectral aspects and similarity in two cases of polynomials orthonormal on a finite union of disjoint intervals with respect to the Szego weight and polynomials orthonormal on the whole with respect to varying weights and having the same union of intervals as the set of oscillations of asymptotics. In both cases we construct double infinite finite band Jacobi matrices with generically quasiperiodic coefficients and show that each of them is an isospectral deformation of another. We find also the Integrated Density of States and the Lyapunov Exponent of Jacobi matrices via the quantities, entering the asymptotics.

Basing on these results and their certain developments, we study the variance and the characteristic function of linear eigenvalue statistics of hermitian Matrix Models as their size tends to infinity. Assuming that the test function of statistics is smooth enough, we show first that if the support of the Density of States of the corresponding random matrix is a finite union of disjoint intervals, then the variance of statistics is asymptotically quasiperiodic in the matrix size. We show next that the fluctuation law of statistic is not asymptotically Gaussian in many cases.

Marek Bozejko (University of Wroclaw)

Noncommutative Fock spaces, generalized Gaussian and Levy processes with applications to noncommutative probability

In my talk we will consider the following subjects:

1. $q$-Fock spaces ($q = 1$ - bosonic, $q = -1$ - fermionic, $q = 0$ - free Fock space, and arbitrary real $q$ and complex $q$ of modulus 1).

2. Generalized $q$-CCR relations of the form

   $$a(f)a^*(g) - qa^*(g)a(f) = \langle f, g \rangle_1,$$

   for $f, g$ in a real Hilbert space (case $q = 1$ this are classical CCR relations, $q = -1$, this are anticommuting relations, $q = 0$ the Cuntz relations used by Voiculescu for the construction of the free probability).

3. The construction of $q$-Brownian motion $B_t$, $q$-Ornstein-Uhlenbeck process $U_t$, and ultracontractivity of $q$-Ornstein-Uhlenbeck process, i.e. $U_t$ maps $L^2$ into $L^\infty$ for $q$ in $(-1, 1)$.

4. Applications to
   (a) Non-commutative versions of Khinchine and Poincare-Sobolev inequalities.
   (b) Construction new von Neumann algebras and new factors of type II and type III.
   (c) Free infinite divisibility of Normal $N(0, 1)$ and $q$-Gaussian law for $q$ in $[0, 1]$, which is theta one function of Jacobi.

References:


**Roland Speicher** (University of Saarland, Saarbrücken)

*Limit Theorems in Free Probability*

My talk will be about limits theorems in free probability theory and, in particular, what we can say about the speed of convergence in such situations. Quite a bit of this is related to and inspired by work of Friedrich Goetze and coworkers.

**Jens Marklof** (University of Bristol)

*From the Lorentz gas to random graphs: new applications of measure rigidity in statistical physics, number theory and combinatorics*

Measure rigidity of flows on homogeneous spaces is a powerful tool that has recently seen many spectacular applications in number theory and mathematical physics. In this lecture I will discuss applications of measure rigidity to three seemingly unrelated problems: kinetic transport in the periodic Lorentz gas, diameters of random circulant graphs and Frobenius’ coin exchange problem.

**Jonathan P. Keating** (University of Bristol)

*Large values of zeta and random landscapes*

It is a longstanding problem to determine the largest values taken by the Riemann zeta-function on its critical line. It is another much-studied problem to determine the highest points in random landscapes with long-range correlations. In the latter case it is believed that the high points are determined by a freezing transition. Recent work with Yan Fyodorov suggests that these problems are related, via random matrix theory.

**Holger Kösters** (Bielefeld University)

*Regularized Inverses of Sample Covariance Matrices*

Several classical methods in multivariate statistics are based on inverses or regularized inverses of sample covariance matrices. It seems natural to ask how these methods perform in situations (frequently encountered in modern statistics) where both the number and the dimension of the observations are large. In this talk I will present some related results from the viewpoint of random matrix theory and discuss the implications of the underlying distributional assumptions.

This is joint work with Noureddine El Karoui.
David Mason (University of Delaware)

Randomly Weighted Lévy Processes

Mason and Zinn (2005) determined exactly when a certain randomly weighted self-normalized sum converges in distribution, partially verifying a 1965 conjecture of Leo Breiman. Specifically they were interested in the asymptotic distribution as \( n \to \infty \) of sums of the form

\[
\sum_{i=1}^{n} \frac{X_i Y_i}{\sum_{i=1}^{n} Y_i},
\]

where \( \{Y, Y_i : i \geq 1\} \) denotes a sequence of i.i.d. random variables, \( Y \) is non-negative and \( \{X, X_i : i \geq 1\} \) is a sequence of i.i.d. random variables, independent of \( \{Y, Y_i : i \geq 1\} \), and \( X \) is in the class \( \mathcal{X} \) of random variables satisfying \( \mathbb{E}|X| < \infty \).

We shall motivate and solve the following randomly weighted self-normalized Lévy process version of this problem. Let \( V_t, t \geq 0, \) be a subordinator without drift, i.e. a positive Lévy process having canonical measure \( \Lambda \) satisfying \( 0 < \int_{0}^{1} x \Lambda (dx) < \infty \) and having Laplace transform

\[
\mathbb{E} \exp(-u V_t) = \exp(-t \Phi(u)),
\]

where with \( u \geq 0 \)

\[
\Phi(u) = \int_{0}^{\infty} (1 - \exp(-ux)) \Lambda (dx).
\]

Further let \( X_t, t \geq 0, \) be an array of i.i.d. \( X \) random variables satisfying \( \mathbb{E}|X| < \infty \).

Consider the randomly weighted Lévy process

\[
U_t = \sum_{0 \leq s \leq t} X_s \Delta V_s,
\]

where \( \Delta V_s = V_s - V_{s-} \). We characterize, under regularity conditions, when \( U_t/V_t \) converges in distribution as \( t \to \infty \) or \( t \downarrow 0 \) to a non-degenerate random variable. Surprisingly, the arcsine law is one of the possible subsequential limit laws.

This talk is based on joint work with Peter Kevei of Szeged University with the help of Ross Maller.

References:


Grigorii Margulis (University of Yale)

Distribution of values of irrational quadratic forms at integral points

A quadratic form is called irrational if the ratio of at least two of its non-zero coefficients is irrational. I will give a survey of results on asymptotic distribution of values of irrational quadratic forms at integral points.
Rabi Bhattacharya (University of Arizona)

Nonparametric Statistics on Manifolds with Applications

The general theory of nonparametric statistics on manifolds $M$ presented here is of recent origin. It builds much of its framework on the notion of the Fréchet mean of a probability measure $Q$, namely, the point on the manifold which minimizes the expected squared distance from a random variable with distribution $Q$. The nonparametric methods are intrinsic or extrinsic, depending on the distance used on $M$. The extrinsic distance is the distance induced from a good embedding of $M$ in an Euclidean space, while the intrinsic distance is the geodesic distance on the manifold when endowed with a Riemannian structure. In examples, it is often the case that the nonparametric methods yield sharper inference than their parametric counterparts provide. Although we consider an application to paleomagnetism where $M$ is the sphere $S^2$, our main emphasis is on landmarks based shape spaces. The latter include (i) Kendall's similarity spaces invariant under Euclidean rigid motions and scaling which are useful in morphometrics and medical diagnostics based on 2D images, (ii) affine shape spaces invariant under affine transformations, useful in scene recognition based on satellite images, and (iii) projective shape spaces used in machine vision and robotics. We also briefly consider 2D continuous images, and nonparametric estimation of shape densities.

This talk is based on joint work with Vic Patrangenaru and Abhishek Bhattacharya, and is supported in part by the NSF grant DMS 1107053.

Anton Wakolbinger (Goethe University Frankfurt)

Exploring random genealogies: from a discrete example to a continuum limit

The idea to represent random genealogical forests in terms of exploration processes dates back to Ted Harris's seminal exposé on “walks and trees” which he wrote about 60 years ago. Ever since then the connection between “walks” and “trees” has provided interesting insights and results. In this lecture we will concentrate on a case with competitive interaction between individuals, for which a particular “pecking order” leads to a sequence of exploration processes that converge to reflected Brownian motion with a local-time drift, and will discuss some properties of this continuum limit.

This is joint work with Etienne Pardoux.

Frank den Hollander (University of Leiden)

Disordered Catalytic Diffusion

In this talk I present an overview of what is known for the parabolic Anderson model in a dynamic random environment. This model describes, for instance, the evolution of a “reactant” under the influence of a “catalyst”. Four choices for the catalyst dynamics are considered:

1. white noise
2. independent simple random walks
3. symmetric exclusion process
(4) symmetric voter model
all starting from equilibrium. The focus is on the quenched and the annealed Lyapunov
exponents, which capture the growth rate of the reactant conditional on, respectively,
averaged over the catalyst dynamics. These exponents turn out to display an interesting
dependence on the diffusion constant of the reactant, with qualitatively different behavior
in different dimensions.

Ildar Ibragimov (Russian Academy of Sciences, St. Petersburg)

The uniqueness theorem for analytic functions. A statistical approach.

This work continues author’s investigations devoted to the statistical approach to the
uniqueness theorem for analytic functions. The uniqueness theorem says that if two
functions \( f \) and \( g \) are holomorphic in a region \( G \) and \( f(z) = g(z) \) for all \( z \) in some
sequence of distinct points with limit point in \( G \), then \( f(z) = g(z) \) everywhere in \( G \).
The theorem means in particular that if an entire analytic function is observed on an
interval \( I \), it can be restored immediately in the whole complex plane. Of course, this
problem of restoration is an ill posed one and small perturbations of the observations
may drastically change the solution on large distance from the region of observation. We
are interesting how far from the region of observation a consistent restoration is possible
under small stochastic perturbations.

There are a few possible statements of the problem. In this talk we consider the
following one. We are observing a Poisson random set \( \Pi_\varepsilon \) on a region \( G \subset \mathbb{R}^d \). The set
\( \Pi_\varepsilon \) has the intensity measure \( \varepsilon^{-1} \Lambda \) where \( \varepsilon > 0 \) is a known small parameter and \( \Lambda \) is
an unknown measure. It is supposed that the measure \( \Lambda \) is absolutely continuous with
respect to the Lebesgue measure and has the density (the intensity density) \( \lambda(x) \) and
the unknown density \( \lambda \) belongs to a known class \( F \) of entire analytic functions.

We show that if

\[
F = F(M, \sigma, \rho) = \{ f : \max_{|z_j| \leq R_j} |f(z_1, \ldots, z_d)| \leq M \exp\{\sigma R_1^{\rho_1} + \cdots + \sigma d R_d^{\rho_d}\},
\]

the consistent estimation of \( \lambda(z) \) is possible approximately in \((\ln 1/\varepsilon)^{d \bar{\rho}} \) — vicinities of \( G \),
\( \bar{\rho} = \max_j \rho_j \), and impossible outside of these vicinities.

Another influence of the uniqueness theorem looks as follows. Suppose that \( F \) con-
sists of functions \( f \) whose Fourier transform is zero outside a bounded set \( K \). Then on
the base of observations \( \Pi_\varepsilon \) on \( \mathbb{R}^d \) it is possible to construct the estimates \( \lambda^*_\varepsilon \) of \( \lambda \) such that

\[
E\left\{ \int_{\mathbb{R}^d} |\lambda(x) - \lambda^*_\varepsilon(x)|^2 dx \right\} \leq C \text{mes}K \varepsilon
\]

But if one uses the observations \( \Pi_\varepsilon \subset G \) only, then

\[
\inf_{\lambda} \sup_{\lambda \in F} E \int_{\mathbb{R}^d} |\lambda(x) - \hat{\lambda}(x)|^2 \asymp \varepsilon^{d \left( \frac{|\ln \varepsilon|}{\ln |\ln \varepsilon|} \right)^{\bar{\rho}}},
\]

Supported by the RFBR (11-01-00577-a), RFBR-DFG (09-01-91331-a),
NSh (4472.2010.1).
Craig A. Tracy (UC Davis)

Turbulent Liquid Crystals, KPZ Universality and the Asymmetric Simple Exclusion Process

We report on (1) recent experimental work on stochastically growing interfaces and (2) new theoretical developments for the KPZ equation, a stochastic nonlinear PDE, and the closely related asymmetric simple exclusion process.

References:


(2) Theoretical developments:


Jinho Baik (University of Michigan)

Complete matchings and random matrix theory

Over the last decade or so, it has been found that the distributions that first appeared in random matrix theory describe an increasing number of objects in probability and combinatorics some of which do not come from matrix at all. We consider one more such an example from the so-called maximal crossing and nesting of random complete matchings. The asymptotic analysis is based on the Riemann-Hilbert problem for a Hankel determinant associated to a discrete measure.

This is a joint work with Bob Jenkins at the university of Michigan.

Neil O’Connell (University of Warwick)

Tropical combinatorics and Whittaker functions

The Robinson-Schensted-Knuth (RSK) correspondence is a combinatorial mapping which plays a fundamental role in the theory of Young tableaux, symmetric functions and representation theory. It is also the basic structure which lies behind the solvability of a particular family of combinatorial models in probability and statistical physics which include longest increasing subsequence problems, directed last passage percolation in 1+1
dimensions, the totally asymmetric exclusion process, queues in series and discrete models for surface growth. There is a geometric version of the RSK correspondence which was introduced by A.N. Kirillov, known as the tropical RSK correspondence. We show that, with respect to a particular family of product measures on its domain, the tropical RSK correspondence is closely related to \( \text{GL}(N, \mathbb{R}) \)-Whittaker functions and yields an analogue in this setting of the Schur measures on integer partitions. As an application, we give an explicit integral formula for the generating function of the partition function of a one-dimensional discrete directed polymer model recently introduced by Timo Seppalainen.

This is joint work with Ivan Corwin, Timo Seppalainen and Nikos Zygouras.

Mark Rudelson (University of Missouri)

Row products of random matrices

We define the row product of \( K \) matrices of size \( d \) by \( n \) as a \( d^K \) by \( n \) matrix, whose rows are entry-wise products of rows of these matrices. This construction arises in certain computer science problems. We study the question, to which extent the spectral and geometric properties of the row product of independent random matrices resemble those properties for a matrix with independent random entries. In particular, we show that while the general volume ratio property doesn’t hold for these matrices, it still holds in case of a cross-polytope.

Anton Bovier (University of Bonn)

The extremal process of branching Brownian motion

We prove that the extremal process of branching Brownian motion, in the limit of large times, converges weakly to a cluster point process. The limiting process is a (randomly shifted) Poisson cluster process, where the positions of the clusters is a Poisson process with exponential density. The law of the individual clusters is characterized as branching Brownian motions conditioned to perform “unusually large displacements”, and its existence is proved.

This is joint work with Louis-Pierre Arguin and Nicola Kistler.

Peter Bickel (University of California, Berkeley)

Inference for unlabelled graphs

In view of the emergence of dense networks such as the Internet, and manifestations such as Facebook, a great deal of attention has recently been given to unlabelled graphs possibly with covariates. A heavily studied problem has been the identification of communities of individuals, corresponding to vertices of an unlabelled graph. A description of these and other problems may be found in the recent monographs of Newman (2010), Kleinberg et al. (2010) and Kolaczyk (2010). There is a well developed inference literature in the social sciences, see Wasserman and Faust (1994) but the network sizes
addressed tend to be small. Chen and I recently introduced a nonparametric framework for probabilistic ergodic models of infinite unlabelled graphs (PNAS2009) and made some connections with modularities arising in the physics literature and community models in the social sciences. Our hope is to develop exploratory and confirmatory methods in this framework which have the power of clarifying and testing parametric assumptions in this complex setting that their analogues have in the study of models for samples of independent observations. We will advance and give some results on methods we have developed for both dense and sparse graphs.

This is joint work with Aiyon Chen, Liza Levina, and Sharmodeep Bhattacharyya.

Sergey Bobkov (University of Minnesota)

Entropic forms of the central limit theorem

In the talk there will be given a review of several results about the entropic central limit theorems.

This is joint work with G.P. Chistyakov and F. Götze.

Erwin Bolthausen (University of Zürich)

An iterative construction of solutions of the TAP equations

The TAP equations (Thouless-Anderson-Palmer) are supposed to describe the “pure states” in the Sherrington-Kirkpatrick model of spin glasses. A proof of them has been given by Talagrand in the high-temperature regime which is supposed but not proved to be the region above the de Almayda-Thouless line. We propose an iterative construction of solutions which is shown to converge up to, and including, the de Almayda-Thouless line.

Willem van Zwet (University of Leiden)

Special cases

In this talk I’ll discuss the importance of special cases in mathematics.
### Registered Participants

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Craig Tracy (UC Davis)
Vladimir Ulyanov (Moscow State University)
Martin Venker (Bielefeld University)
Ernest Vinberg (Moscow State University)
Willem van Zwet (University of Leiden)
Anton Wakolbinger (Goethe University Frankfurt)
Andrei Zaitsev (Steklov Mathematical Institute, St. Petersburg)
Thomas Zink (Bielefeld University)

(as of 4th August, 2011)
Directions from the Tramway to the ZiF

After arriving at the tram stop “Universität” with the tram line 4, you can reach the ZiF by walking up the hill. There are signposts along the way.

Alternatively, limited shuttle service from the bus stop “Universität” to the ZiF will be provided on a private basis. If you are interested in this service, please contact us in advance.