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Holger Dette
Ruhr-Universität Bochum
Optimal designs, orthogonal polynomials and random matrices

The talk explains several relations between different areas of mathematics: Mathematical statistics, random matrices and special functions. We give a careful introduction in the theory of optimal designs, which are used to improve the accuracy of statistical inference without performing additional experiments. It is demonstrated that for certain regression models orthogonal polynomials play an important role in the construction of optimal designs. In the next step these results are connected with some classical facts from random matrix theory. In the third part of this talk we discusss some new results on special functions and random matrices. In particular we analyse random band matrices, which generalize the classical Gaußschen ensemble. We show that the random eigenvalues of such matrices behave similarly as the deterministic roots of matrix orthogonal polynomials with varying recurrence coefficients. We study the asymptotic zero distribution of such polynomials and demonstrate that these results can be used to find the asymptotic proporties of the spectrum of random band matrices.

Irene Fonseca
Carnegie Mellon University, Pittsburgh
Variational Methods in Materials Science and Image Processing

Several questions in applied analysis motivated by issues in computer vision, physics, materials sciences and other areas of engineering may be treated variationally leading to higher order problems and to models involving lower dimension density measures. Their study often requires state-of-the-art techniques, new ideas, and the introduction of innovative tools in partial differential equations, geometric measure theory, and the calculus of variations. In this talk it will be shown how some of these questions may be reduced to well understood first order problems, while in others the higher order terms play a fundamental role. Applications to phase transitions, to the equilibrium of foams under the action of surfactants, imaging, micromagnetics, thin films, and quantum dots will be addressed.

Bernhard Keller
Université Diderot Paris
Cluster algebras and applications

Sergey Fomin and Andrei Zelevinsky invented cluster algebras at the beginning of the last decade as a tool for studying dual canonical bases and total positivity in semisimple Lie groups. It soon turned out that the algebraic/combinatorial framework they created is also relevant in a large array of other subjects including Teichmüller theory, Poisson geometry, quiver representations and the study of Donaldson-Thomas invariants in algebraic geometry. In this talk, I will give a concise introduction to cluster algebras and sketch two significant applications: one in Lie theory and one in the study of certain discrete dynamical systems.

Matthias Kreck
Hausdorff Research Institute for Mathematics (HIM), Bonn - Cantor-Medaille
On the quantization of topology

Although I have no idea of physics I will start with some basic ideas of classical mechanics and their quantum counterparts to motivate the concept of topological (or geometric or conformal) quantum field theories as suggested by Atiyah and Siegel. All this will be done very slowly. In the remaining time I want to report about some recent joint work with Hohnhold, Stolz and Teichner which gives a description of de Rahm cohomology in the language of quantum field theories. Stolz and Teichner have done something similar and much more complicated for K theory and conjecturally for elliptic cohomology. This sheds some light on some general principles of constructing certain cohomology theories and corresponding equivariant cohomology theories which will be addressed at the end.

Shrawan Kumar
University of North Carolina at Chapel Hill
Hermitian eigenvalue problem and its generalization: A survey

The classical Hermitian eigenvalue problem addresses the following question: What are the possible eigenvalues of the sum A+B of two Hermitian matrices A and B, provided we fix the eigenvalues of A and B. A systematic study of this problem was initiated by H. Weyl (1912). By virtue of contributions from a long list of mathematicians, notably Weyl (1912), Horn (1962), Klyachko (1998) and Knutson-Tao (1999), the problem is finally settled. The solution asserts that the eigenvalues of A+B are given in terms of certain system of linear inequalities in the eigenvalues of A and B. These inequalities can be given explicitly and are related to a classical problem in Schubert calculus.
Belkale (2001) gave an optimal set of inequalities for the problem in this case. The Hermitian eigenvalue problem has been extended by Berenstein-Sjamaar (2000) and Kapovich-Leeb-Millson (2005) for any semisimple complex algebraic group. Their solution is again in terms of a system of linear inequalities. Again these inequalities can be given explicitly and they are related to a classical problem in Schubert calculus. However, their solution is far from being optimal. In a joint work with P. Belkale, we define a deformation of the cup product used for the Schubert calculus and use this new product to generate our system of inequalities which solves the problem for any semisimple complex algebraic group optimally (as shown by Ressayre).

Ladislav Kvasz
Karls-Universität Prag
Geometrie und die Geschichte der Malerei

Bei der Behandlung des Zusammenhanges von Geometrie und Malerei beschränkt sich die Fachliteratur häufig auf die Zeit der Renaissance; manchmal wird noch der Kubismus erwähnt. In dem Vortrag wird versucht, eine systematische Parallele zwischen diesen beiden Gebieten auszuarbeiten. Anlehnend an Wittgensteins Abbildtheorie der Bedeutung kann man die Entwicklung der Geometrie rekonstruieren. Wenn wir die Abbildtheorie auf Bilder anwenden, die in geometrischen Texten vorkommen und wenn wir die so gewonnene Theorie mit der Geschichte der Malerei in Beziehung bringen, zeigen sich uns eine Reihe interessanter Berührungspunkte. Bei den bekannten Bildern der Frührenaissance (Giotto, Lorenzetti, Massaccio), der Hochrenaissance (Alberti, Leonardo, Uccello), und der Spätrenaissance (Dürer, Holbein), des Manierismus (El Greco), des Barrocks (Rembrandt, Velázquez, Pozzo), des Impressionismus (Renoir, Manet), des Postimpressionismus (Seurat, Cézanne), des Kubismus (Picasso, Braque) und der abstrakten Malerei (Kandinski) wird ihre geometrische Struktur untersucht. Es wird versucht, die Entwicklung der synthetischen Geometrie mit diesen Bildern in Beziehung zu bringen. Konkreter zeigen sich Verbindungen von projektiver Geometrie mit Dürer, nichteuklidischer Geometrie mit Velázquez und Pozzo, dem Erlanger Programm mit Manet und Seurat und der kombinatorischen Topologie mit Cézanne, Braque und Picasso.

Christian Lubich
Eberhard Karls Universität Tübingen
Differential equations to roam pseudospectra

The talk relates different areas of mathematics: differential equations, matrix manifolds and numerical linear algebra. It requires no deep understanding of any of these, but combines them in a surprising way. When studying the ?-pseudospectrum of a matrix, one is often interested in computing the extremal points having maximum real part or modulus. This is a crucial step, for example, when computing the distance to instability of a stable system. Using the key property that the pseudospectrum is determined via perturbations by rank-1 matrices, we derive two different continuous dynamical systems leading to the critical rank-1 perturbations associated with the extremal points of (locally) maximum real part and modulus. This approach also allows us to track the boundary contour of the pseudospectrum in a neighbourhood of the extremal points. The technique we propose is related to an idea recently developed by Guglielmi and Overton, who derived discrete dynamical systems instead of the continuous ones we present. The method appears promising in dealing with large-size, sparse problems. The talk is based on joint work with Nicola Guglielmi.

Ken Ono
Emroy University, Atlanta
Adding and Counting

One easily sees that 4 = 3+1 = 2+2 = 2+1+1 = 1+1+1+1, and so we say that there are 5 partitions of 4. The stuff of partitions seems like mere child's play. Professor Ono will explain how the simple task of adding and counting has fascinated many of the world's leading mathematicians: Euler, Ramanujan, Hardy, Rademacher, to name just a few. As is typical in number theory, many of the most fundamental (and simple to state) questions have remained unsolved. In 2010, Ono, with the support of the American Institute for Mathematics and the National Science Foundation, assembled an international team of distinguished researchers to attack some of these problems. He will announce their findings: new theories which solve some of these famous old questions.

Francisco Santos
Universidad de Cantabria, Santander
Counter-examples to the Hirsch conjecture

The Hirsch conjecture, stated in 1957, said that if a polyhedron is defined by n linear inequalities in d variables then its combinatorial diameter should be at most n-d. That is, it should be possible to travel from any vertex to any other vertex in at most n-d steps (traversing an edge at each step). The unbounded case was disproved by Klee and Walkup in 1967. In this talk I describe my construction of the first counter-examples to the bounded case (polytopes). The conjecture was posed and is relevant in connection to linear programming since the simplex method, one of the mathematical algorithms with the greatest impact in science and engineering, solves linear programming problems by traversing the graph of the feasibility polyhedron. In the first half of the talk we will explain this connection.

Simone Warzel
Technisches Universität München, Noether-Vorlesung
Effects of disorder: the mathematics of the Anderson model

Motivated by the quest for a theory of quantum transport in disordered media, in 1958 the physicist P.W. Anderson came up with a model for a quantum particle in a random energy landscape. Among its interesting features is a conjectured sharp transition from a regime of localized eigenstates to one of diffusive transport. Until today it remains a mathematical challenge to establish these features in the framework of random Schrödinger operators. In this talk, I will give an introduction into the mathematical results and tools in the field, which combines spectral analysis with probability theory. I will also describe some recently discovered surprising effects of disorder on the spectra of Schrödinger operators in a tree-graph geometry.

Sektion 1

Algebra

Anne Henke (Oxford), Steffen Koenig (Stuttgart), Gunter Malle (Kaiserslautern)

Montag, 19. September **Hörsaalgebäude, Hörsaal D**

14:00 Shrawan Kumar (Chapel Hill)
Geometry of orbits of permanents and determinants

15:00 Guido Pezzini (Erlangen)
A constructive approach to the classification of wonderful varieties

15:30 Sebastian Herpel (Bochum)
On the smoothness of centralizers in reductive groups

16:00h – 16:30h Pause

16:30 Maurizio Martino (Bonn)
Partial KZ functors for Cherednik algebras

17:30 Volodymyr Mazorchuk (Uppsala)
2-representations of finitary 2-categories

Dienstag, 20. September **Hörsaalgebäude, Hörsaal D**

14:00 Markus Linckelmann (Aberdeen)
On Hochschild cohomology of block algebras

15:00 Susanne Danz (Oxford)
On the double Burnside ring of a finite group

15:30 Christine Bessenrodt (Hannover)
Kronecker products of characters of the symmetric groups with few components

16:00h – 16:30h Pause

16:30 Ghislain Fourier (Köln)
Weyl modules and Schur positivity

17:00 Florian Eisele (Aachen)
Liften von Algebren zu Ordnungen

17:30 Gabriele Nebe (Aachen)
Extremale Gitter

Mittwoch, 21. September **Hörsaalgebäude, Hörsaal D**

14:00 Gerhard Hiß (Aachen)
Hecke algebras in representation theory

15:00 Felix Noeske (Aachen)
Erzeugung von Hecke-Algebren

15:30 Michael Cuntz (Kaiserslautern)
From Hopf algebras to toric varieties via the Weyl groupoid

16:00h – 16:30h Pause

16:30 Bernhard Keller (Paris)
Quiver mutation and quantum dilogarithm identities

17:30 Sarah Scherotzke (Paris)
Linear recurrence relations for cluster variables of affine quivers

18:00 Philipp Lampe (Bielefeld)
Cluster algebras and quantum shuffles

Donnerstag, 22. September **Hörsaalgebäude, Hörsaal D**

14:00 Leonard Scott (Virginia)
New graded methods in representation theory

15:00 Vanessa Miemietz (East Anglia, Norwich)
Homological algebras for GL_2

16:00h – 16:30h Pause

16:30 Simon Riche (Clermont-Ferrand)
Constructible sheaves on affine Grassmannians and geometry of the dual group

17:30 Catharina Stroppel (Bonn)
Convolution algebras and affine Schur algebras

Christine Bessenrodt
Leibniz Universität Hannover
Kronecker products of characters of the symmetric groups with few components

One of the central open problems in the character theory of the symmetric groups is the problem of decomposing the Kronecker products of their characters into irreducible characters. As James and Kerber remark in their book *The representation theory of the symmetric group*, a product of irreducible characters of S_n is "in general reducible". Jointly with Kleshchev, we have shown in 1999 that such a product is even only homogeneous in the (trivial) case of multiplying with a character of degree 1; we have also classified products with two homogeneous components for determining the homogeneous character products for the alternating groups. Furthermore, we conjectured in 1999 a classification of products with at most four homogeneous components. This conjecture has now been verified; on the way towards this result new information on constituents in Kronecker products has been obtained.

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Michael Cuntz
Universität Kaiserslautern
From Hopf algebras to toric varieties via the Weyl groupoid

In the classification of finite dimensional Nichols algebras of diagonal type, the so-called Weyl groupoids played an important role. Meanwhile, the finite Weyl groupoids have been thoroughly investigated, including a complete classification. It turns out that they correspond to simplicial arrangements satisfying a certain integrality axiom. This integrality translates to the smoothness of the toric varieties associated to the corresponding fans.

Susanne Danz
University of Oxford
On the double Burnside ring of a finite group

In recent years, the double Burnside ring $B(G,G)$ of a finite group G has proved to have important connections with modular representation theory of finite groups, with topology, and with the theory of fusion systems on finite p-groups. For these and other applications, one needs to carry out explicit computations in the ring $B(G,G)$, in order to determine certain units or idempotents. However, the multiplicative structure of $B(G,G)$ is, in general, non-commutative and rather involved. In this talk I will focus on distinguished subrings of the double Burnside ring $B(G,G)$, and present a candidate for a non-commutative analogue of the well-known mark homomorphism of the commutative Burnside ring. This homomorphism translates the complicated multiplication rule of these subrings into a much more transparent one. If time permits, I will also outline some applications to the theory of fusion systems. This is joint work with Robert Boltje.

Florian Eisele
RWTH Aachen
Liften von Algebren zu Ordnungen

Ich werde über einen neuen Ansatz sprechen, eine endlich-dimensionale Algebra, die über einem Körper F der Charakteristik p (z. B. $F = \mathbb{F}_p$) definiert ist, zu einer Ordnung zu liften, die über einem diskreten Bewertungsring $\mathcal{O}$ mit Restklassenkörper F (z. B. $\mathcal{O} = \mathbb{Z}_p$) definiert ist. Unter dem Begriff "Ordnung" versteht man in diesem Kontext $\mathcal{O}$-Algebren, die als $\mathcal{O}$-Modul frei und endlich erzeugt sind, wobei das wichtigste Beispiel für diesen Vortrag der Gruppenring $\mathcal{O}G$ einer endlichen Gruppe G ist. Ich werde insbesondere auf Ergebnisse über Blöcke von Diederdefekt und die Gruppenringe der $\mathrm{SL}_2(q)$ (für p-Potenzen q) eingehen. In beiden Fällen lassen sich die jeweiligen Blöcke über $\mathcal{O}$ beschreiben, und interessanterweise sind (zumindest im Fall der Diederblöcke) auch Rückschlüsse auf die über F definierten Blöcke möglich.

Ghislain Fourier
Universität zu Köln
Weyl modules of map algebras

The category of finite-dimensional modules for a map algebra (the regular functions from affine variety to a simple, complex Lie algebra) is not semi-simple, the simple modules are classified by a class of functions on the variety with values in the weight lattice. In analogy to the work on finite-dimensional modules for simple Lie algebras in characteristic p, we will define and study Weyl modules, which will be in some sense the largest indecomposable modules with a certain unique simple quotient. These Weyl modules have their origin in the study of simple finite-dimensional modules for quantized affine algebras. We will furthermore show how these modules can be defined for generalized current algebras or even equivariant map algebras. If time permits, we will relate the study of the structure of Weyl modules to conjectures about generators and relations for fusion products as well as to conjectures about Schur positivity of certain symmetric functions.

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Fourier, Ghislain, Khandai, Tanusree, Kus, Deniz, Savage, Alistair. Local Weyl modules for equivariant map algebras with free abelian group actions. *submitted*, arXiv:1103.5766v1.

Sebastian Herpel
Ruhr Universität Bochum
On the smoothness of centralizers in reductive groups

Let G be a connected reductive algebraic group over an algebraically closed field. The question whether the scheme-theoretic centralizer of a closed subgroup of G is smooth, or equivalently whether the dimensions of the global and infinitesimal centralizers coincide, occurs naturally in many contexts. We introduce a condition for the characteristic of the ground field that is slightly weaker than the notion of “very good” characteristic. We go on to show that this condition is necessary and sufficient for the smoothness of all centralizers of closed subgroup schemes. Reductive groups defined in such “pretty good” characteristic are closely related to so called standard groups, for instance to groups satisfying the standard hypotheses of Jantzen.

Gerhard Hiß
RWTH Aachen
Hecke algebras in representation theory

Hecke algebras i.e., endomorphism rings of suitable modules of group algebras, constitute an essential tool in the representation theory of finite groups. In groups of Lie types, Hecke algebras also arise as deformations of group algebras of Weyl groups. In this area, applications of Hecke algebras are rather varied: in non-defining characteristics Hecke algebras serve to classify irreducible representations, in defining characteristics a famous conjecture of Alperin can be proved with the help of Hecke algebras. A possible generalisation of this approach to arbitrary groups is investigated in a recent joint paper with Steffen König and Natalie Naehrig. A further area of applications of Hecke algebras are the condensation methods in computational representation theory. My talk will give a survey, largely free of technical details, on the various applications of Hecke algebras.

Bernhard Keller
Université Paris Diderot
Quiver mutation and quantum dilogarithm identities

Quiver mutation is an elementary operation on quivers which appeared in physics in Seiberg duality in the 1990s and in mathematics in Fomin-Zelevinsky’s definition of cluster algebras in 2002. In this talk, I will show how, by comparing sequences of quiver mutations, one can construct identities between products of quantum dilogarithm series. These identities generalize the classical pentagon identity of Faddeev-Kashaev-Volkov and the identities obtained recently by Reineke. Morally, the new identities follow from Kontsevich-Soibelman’s theory of refined Donaldson-Thomas invariants. They can be proved rigorously using the theory linking cluster algebras to quiver representations.

Shrawan Kumar
University of North Carolina at Chapel Hill
Geometry of orbits of permanents and determinants

Let $\mathfrak{v}$ be a complex vector space of dimension m and let $E := \mathfrak{v} \otimes \mathfrak{v}^* = \operatorname{End} \mathfrak{v}$. Consider $\det \in Q := S^m(E^*)$, where $\det$ is the function taking determinant of any $X \in \operatorname{End} \mathfrak{v}$. Fix a basis $\{e_1, \ldots, e_m\}$ of $\mathfrak{v}$ and a positive integer $n < m$ and consider the function $\mathrm{p} \in Q$, defined by $\mathrm{p}(X) = x_{1,1}^{m-n} \operatorname{perm}(X^o)$, X^o being the component of X in the right down $n \times n$ corner, where any element of $\operatorname{End} \mathfrak{v}$ is represented by a $m \times m$-matrix $X = (x_{i,j})_{1 \le i,j, \le m}$ in the basis $\{e_i\}$ and perm denotes the permanent. The group $G = \mathrm{GL}(E)$ canonically acts on Q. Let $\mathcal{X}_{\det}$ (resp. $\mathcal{X}_{\mathrm{p}}$) be the G-orbit closure of det (resp. p) inside Q. Then, $\mathcal{X}_{\det}$ and $\mathcal{X}_{\mathrm{p}}$ are closed (affine) subvarieties of Q which are stable under the standard homothecy action of $\mathbb{C}^*$ on Q. Thus, their affine coordinate rings $\mathbb{C}[\mathcal{X}_{\det}]$ and $\mathbb{C}[\mathcal{X}_{\mathrm{p}}]$ are nonnegatively graded G-algebras over the complex numbers $\mathbb{C}$.
The aim of this talk is to study some geometric results about the varieties $\mathcal{X}_{\det}$ and $\mathcal{X}_{\mathrm{p}}$ and to study $\mathbb{C}[\mathcal{X}_{\det}]$ and $\mathbb{C}[\mathcal{X}_{\mathrm{p}}]$ as G-modules. The work is motivated by the geometric approach initiated by Mulmuley-Sohoni to solve the Valiant's conjecture in Geometric Complexity Theory.

Philipp Lampe
Universität Bielefeld
Cluster algebras and quantum shuffles

Cluster algebras are commutative algebras introduced by Fomin-Zelevinsky. By definition, the generators of a cluster algebra are grouped into clusters, and every cluster can be reached from an initial cluster by a mutation process. Various mathematical objects turned out to carry a cluster structure and hence the theory of cluster algebras has become a very active field of research. In this talk, we want to discuss Fomin-Zelevinsky's original motivation for introducing cluster algebras, namely the study of Lusztig's canonical bases. The universal enveloping algebra $U(\mathfrak{sl}_n)$ is a non-commutative algebra whose modules are the $\mathfrak{sl}_n$-representations. Every ordered basis of $\mathfrak{sl}_n$ gives rise to a PBW basis of $U(\mathfrak{sl}_n)$. We restrict to the subalgebra $\mathfrak{n} \subset \mathfrak{sl}_n = \mathfrak{n}_- \oplus \mathfrak{h} \oplus \mathfrak{n}$. Lusztig has defined a canonical basis $\mathscr{B}$ of $U_q(\mathfrak{n})$ which has better structural properties than the PBW bases in the sense that subsets of $\mathscr{B}$ give bases of irreducible representations. Lusztig's construction involves the passage to the quantized universal enveloping algebra $U_q(\mathfrak{n})$. For special cases, we describe how duals of canonical basis elements can be written as quantum shuffles and equip a subalgebra of the graded dual $U_q(\mathfrak{n})^*_{gr}$ with the structure of a quantized cluster algebra. The work quantizes work of Geiß-Leclerc-Schröer where cluster variables are asscoiated with rigid modules over the preprojective algebra.

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Markus Linckelmann
University of Aberdeen
On Hochschild cohomology of block algebras

The Hochschild cohomology of a finite dimensional algebra A over a field is a graded-commutative k-algebra which encodes cohomological information on A viewed as a bimodule. In the context of block algebras (that is, indecomposable direct factors of finite group algebras), some of the finiteness conjectures in that area, such as Donovan's, would imply that for a fixed defect group there should be only finitely many isomorphism classes of Hochschild cohomology algebras of blocks with a fixed defect group. Using recent work of Benson and Symonds on the Castelnuovo-Mumford regularity of finite group cohomology, we show that there are only finitely many Hilbert series of Hochschild cohomology algebras of blocks with a fixed defect. This extends in particular a classic result of Brauer and Feit bounding the dimension of the degree zero component of Hochschild cohomology in terms of the defect. The methods used range from standard block theory to local cohomology in commutative algebra. This is joint work with Radha Kessar.

Maurizio Martino
Universität Bonn
Partial KZ functors for Cherednik algebras

Rational Cherednik algebras were introduced by Etingof and Ginzburg as a family of algebras which deform the coordinate rings of certain quotient singularities. An important feature of these algebras is their connection to finite-dimensional Hecke algebras, via the KZ functor. I will describe "partial" versions of these, which arise from normalisers of parabolic subalgebras. As an application, I will explain how to use these to re-prove a theorem of P.Shan, which categorifies certain higher level Fock spaces. This is joint work with I.Gordon.

Volodymyr Mazorchuk
Uppsala University
2-representations of finitary 2-categories

In the talk I will try to describe how one constructs and compares principal and cell 2-representations of finitary 2-categories. Based on a joint work with Vanessa Miemietz.

Vanessa Miemietz
University of East Anglia, Norwich
Homological algebras for GL_2

For the general linear group of rank two over an algebraically closed field of positive characteristic, we explicitly describe various extension algebras related to its representation theory. This is based on a 2-functorial and combinatorial approach to construct all rational representations from just the base field and a notion of homological duality for 2-functors. It is joint work with Will Turner.

Gabriele Nebe
RWTH Aachen
Extremale Gitter

Das klassische Kugelpackungsproblem fragt nach einer optimalen Anordnung gleichgroßer Kugeln im Euklidischen Raum $\mathbf{R}^n$, so dass der Anteil des von den Kugeln eingenommenen Raumes möglichst groß wird. Die dichtesten Kugelpackungen sind bisher nur bis zu Dimension $n = 3$ bekannt. Unter der zusätzlichen Annahme, dass die Mittelpunkte der Kugeln ein Gitter bilden, also eine Untergruppe von $\mathbf{R}^n$, kennt man die dichtesten Gitter bis Dimension 8 und in Dimension 24.
In Dimension 8 und 24 sind die dichtesten Gitter genau die **extremalen Gitter**, das sind gerade unimodulare Gitter, deren Dichte so groß ist, wie die Theorie der Modulformen es zulässt. In dem Vortrag möchte ich Ihnen die Konstruktion eines extremalen Gitters in Dimension 72 vorstellen, dessen Existenz bis 2010 ein vieldiskutiertes offenes Problem war.

Felix Noeske
RWTH Aachen
Erzeugung von Hecke-Algebren

Hecke-Algebren spielen eine wichtige Rolle in der Darstellungstheorie. Ihre Realisierung als Endomorphismenringe von Moduln endlicher Gruppenalgebren beispielsweise, erlaubt unter geeigneten Voraussetzungen, die Modulkategorie der Gruppenalgebra durch die Morita-äquivalente Hecke-Algebra zu untersuchen. Motiviert durch praktische Rechnungen stellt sich das Problem, für eine solche Hecke-Algebra ein handhabbares Erzeugendensystem anzugeben. In diesem Vortrag wollen wir auf dieses Problem eingehen und Möglichkeiten vorstellen, es zu lösen.

Guido Pezzini
Universität Erlangen-Nürnberg
A constructive approach to the classification of wonderful varieties

In 2001 Luna started a research program to classify spherical G-varieties, for G a complex reductive algebraic group. They are a common generalization of well-known G-varieties such as complete homogeneous spaces G/P, symmetric and also toric varieties. The main step of the classification consists in studying invariants of some particular spherical varieties, that are called wonderful. These invariants can also be represented as combinatorial objects, called spherical systems, attached to the Dynkin diagram of G. The combinatorics which arises is quite involved, but is also capable of encode many geometrical informations and constructions, such as G-equivariant morphisms, fiber products, etc. In the talk we will discuss some techniques that describe the generic stabilizer of a wonderful variety starting from its spherical system. We will also explain how these techniques have been applied in joint works with Paolo Bravi to complete the classification, reducing the problem to a finite number of cases.

Simon Riche
Université Blaise Pascal, Clermont Ferrand II
Constructible sheaves of affine Grassmannians and geometry of the dual group

Works of many others (including Kazhdan-Lusztig, Ginzburg, Mirkovic-Vilonen, Bezrukavnikov) show that there exist fruitful connections between the algebraic geometry of some varieties attached to a reductive group and the constructible geometry (or topology) of some varieties attached to the loop group of the dual reductive group (in the sense of Langlands). I will describe new results in this direction obtained in joint works with Pramod Achar and Victor Ginzburg.

Sarah Scherotzke
Université Paris Diderot - Paris 7
Linear recurrence relations for cluster variables of affine quivers

Recently, Assem Reutenauer and Smith have introduced families of sequences associated to the vertices of an acyclic quiver Q. These sequences consist of cluster variables. They proved that if the sequences associated with Q satisfy linear recurrence relations, then Q is necessarily affine or Dynkin. Conversely, they conjectured that the sequences associated with a quiver of Dynkin or affine type always satisfy linear recurrence relations. In my talk I will present a proof of the Assem-Reutenauer-Smith conjecture using the representation-theoretic approach to cluster algebras. More precisely, our main tool is the categorification of acyclic cluster algebras via cluster categories. This is joint work with Bernhard Keller.

Leonard Scott
University of Virginia
New graded methods in representation theory

This talk describes recent work with Brian Parshall. Given a finite dimensional algebra A, there is a familar graded algebra gr$A$ obtained by summing quotients of successive powers of the radical of A. Forming gr$A$ might be a first step in, say, trying to find a Koszul algebra related to A. However, it is notoriously difficult to prove Koszulity of gr$A$ or other nice properities, such as quasi-heredity (even when A is quasi-hereditary). We succeed in proving both Koszulity and quasi-heredity of gr$A$ in some familiar cases involving algebras arising from quantum and algebraic groups. Known Koszulity results of Andersen-Jantzen-Soergel for the small quantum group and characteristic $p > 0$ restricted enveloping algebra are a starting point, though some methods are quite general. The results apply in type A to q-Schur algebras at a root of unity (char. 0) and Schur algebras (char. p), with restrictions.

Literatur

H. Andersen, J. Jantzen, W. Soergel, Representations of quantum groups at a pth root of unity and of semisimple groups in characteristic p, Astérique **220** (1994).
B. Parshall and L. Scott, New graded methods in representation theory. arXiv:0910.0633.

Catharina Stroppel
Universität Bonn
Convolution algebras and affine Schur algebras

Convolution algebras play an important role in representation theory, a standard tool to construct non-commutative algebras. I will explain a very special example of such a convolution algebra extending earlier work of Vasserot-Varagnolo and Khovanov-Lauda and Rouquier who introduced the so-called quiver Hecke algebra to study the representation theory of the symmetric group in positive characteristic via the representation theory of such an algebra. Its geometric and representation theoretic origin equips this new theory with an interesting grading which refines decomposition numbers. I want to illustrate this in one specific example, namely the affine Schur algebras and relate it to the combinatorics of higher level Fock spaces.

Sektion 2

Algebraische Geometrie und Komplexe Analysis

Peter Heinzner (Bochum), Stefan Kebekus (Freiburg)

Montag, 19. September **Seminargebäude, S14**

14:00 Christian Liedtke (Stanford Düsseldorf)
Rational curves on K3 surfaces

15:00 Daniel Lohmann (Freiburg)
Families of canonically polarized manifolds over log Fano varieties

16:00h – 16:30h Pause

16:30 Hiro-o Tokunaga (Tokio)
Splitting curves for double covers and the topology of the complements of certain curves on rational ruled surfaces

17:30 Frank Kutzschebauch (Bern)
A solution to the Gromov-Vaserstein problem

Dienstag, 20. September **Seminargebäude, S14**

14:00 Thomas Peternell (Bayreuth)
Untermannigfaltigkeiten mit positivem Normalenbündel – eine Vermutung von Hartshorne

15:00 Stefan Müller-Stach (Mainz)
Abelsche Varietäten und Thetafunktionen auf kompakten Riemannschen Mannigfaltigkeiten

16:00h – 16:30h Pause

16:30 Christian Böhning (Göttingen)
Rationality properties of linear group quotients

17:30 Christian Miebach (Calais)
Quotients of bounded domains of holomorphy by proper actions of ?

Mittwoch, 21. September **Seminargebäude, S14**

14:00 Alex Küronya (Freiburg)
Arithmetic properties of volumes of divisors

15:00 Martin Möller (Frankfurt)
Curves in the moduli space of curves: Slopes and Lyapunov exponents

16:00h – 16:30h Pause

16:30 Hannah Markwig (Saarbrücken)
What corresponds to Broccoli in the real world?

17:30 Stefan Nemirovski (Bochum)
Levi problem and semistable quotients

Donnerstag, 22. September **Seminargebäude, S14**

14:00 Sönke Rollenske (Mainz)
Lagrangian fibrations on hyperkähler manifolds

15:00 Daniel Greb (Freiburg)
Lagrangian fibrations on hyperkähler fourfolds

16:00h – 16:30h Pause

16:30 Daniel Huybrechts (Bonn)
t.b.a.

17:30 George Marinescu (Köln)
Equidistribution of zeros of holomorphic sections of high tensor powers of line bundles

Christian Böhning
Universität Göttingen
Rationality properties of linear group quotients

In this survey talk we will report on some recent progress on the rationality problem for quotients V/G where V is a linear representation of the linear algebraic group G. Most results will represent joint work of the speaker with Fedor Bogomolov, Hans-Christian Graf von Bothmer, and Gianfranco Casnati.
Along with general structural results we will give some applications to moduli spaces of plane curves of large degree, Lueroth quartics and tetragonal curves of genus 7. We will also outline elements of the obstruction theory, stable and unramified group cohomology, and some recent results in this direction.

Daniel Greb
Albert-Ludwigs-Universität Freiburg
Lagrangian fibrations on hyperkähler fourfolds

In this talk I will report on a joint project with Christian Lehn and Sönke Rollenske. Beauville asked if any Lagrangian torus inside a hyperkähler manifold is a fibre of a (meromorphic) Lagrangian fibration. Building on previous work which settles the question in a non-algebraic situation, we show that the answer to the strongest form of Beauville's question is positive in dimension four. An important ingredient of the proof is a detailed study of almost holomorphic Lagrangian fibrations on projective hyperkähler manifolds using the recent advances in the minimal model program.

Daniel Huybrechts
Universität Bonn
t.b.a.

Alex Küronya
Albert-Ludwigs-Universität Freiburg
Arithmetic properties of volumes of divisors

The volume of a Cartier divisor on an irreducible projective variety describes the asymptotic rate of growth of the number of its global sections. As such, it is a non-negative real number, which happens to be rational whenever the section ring of the divisor in question is finitely generated.
In a joint work with Catriona Maclean and Victor Lozovanu we study the multiplicative semigroup of volumes of divisors. We prove that this set is countable on the one hand, on the other hand it contains transcendental elements.

Frank Kutzschebauch
Universität Bern
A solution to the Gromov-Vaserstein Problem

Any matrix in $Sl_n(\mathbb{C})$ can (due to the Gauss elimination process) be written as a product of elementary matrices. If instead of the complex numbers (a field) the entries in the matrix are elements of a ring, this becomes a delicate question. In particular the rings of maps from a space $X \to \mathbb{C}$ are interesting cases. A deep result of Suslin gives an affirmative answer for the polynomial ring in m variables in case the size of the matrix (n) is greater 2. In the topological category the problem was solved by Thurston and Vaserstein. For holomorphic functions on $\mathbb{C}^m$ the problem was posed by Gromov in the 1980's. We report on a complete solution to Gromov's problem. A main tool is the Oka-Grauert-Gromov-h-principle in Complex Analysis. This is joint work with Björn Ivarsson.

Christian Liedtke
Stanford Düsseldorf
Rational Curves on K3 surfaces

We show that complex projective K3 surfaces with odd Picard rank contain infinitely many rational curves. Our method of proof is via reduction modulo positive characteristic, where results on Tate conjecture/Weil conjecture provide us with the desired rational curves. We lift these rational curves back to characteristic zero using moduli spaces of stable maps in mixed characteristic. This work is joint with Jun Li and extends the original approach of Bogomolov, Hassett, and Tschinkel.

Daniel Lohmann
Albert-Ludwigs-Universität Freiburg
Families of canonically polarized manifolds over log Fano varieties

The Shafarevich hyperbolicity conjecture states that a smooth family of curves of general type is necessarily isotrivial if the base is given by $\mathbb{P}^1$, $\mathbb{C}$, $\mathbb{C}\setminus\{0\}$, or an elliptic curve. With the aid of the minimal model program we show the following related result.
Let X be a smooth projective variety and D a reduced divisor on X. Assume that D is snc, i.e., all components of D are smooth and intersect transversally. Then any smooth family of canonically polarized varieties over $X \setminus \mathrm{Supp}(D)$ is isotrivial if the divisor $-(K_X + D)$ is ample.
In order to prove this result, we consider the induced moduli map to the coarse moduli space of canonically polarized manifolds. A result by Kebekus and Kovács gives a relation between this moduli map and the minimal model program. In particular, the minimal model program for the pair (X,D) leads to a fiber space, and the moduli map restricted to a general fiber is constant. Finally, we apply a generalization of a theorem by Araujo which describes the different minimal model programs for the pair (X,D) in more detail.

George Marinescu
Universität zu Köln
Equidistribution of zeros of holomorphic sections of high tensor powers of line bundles

Hannah Markwig
Universität des Saarlandes, Saarbrücken
What corresponds to Broccoli in the real world?

Welschinger invariants count real rational curves on a toric Del Pezzo surface belonging to an ample linear system and passing through a generic conjugation invariant set of points P, weighted with ± 1, depending on the nodes of the curve. They can be determined via tropical geometry, i.e. one can define a count of certain tropical curves (which we refer to as Welschinger curves) and prove a Correspondence Theorem stating that this tropical count equals the Welschinger invariant. It follows from the Correspondence Theorem together with the fact that the Welschinger invariants are independent of P that the corresponding tropical count of Welschinger curves is also independent of the chosen points. However, if P consists of not only real points but also pairs of complex conjugate points, no proof of this tropical invariance within tropical geometry has been known so far.
We introduce broccoli curves, certain tropical curves of genus zero which are similar to Welschinger curves. We prove that the numbers of broccoli curves through given (real or complex conjugate) points are independent of the chosen points. In the toric Del Pezzo situation we show that broccoli invariants equal the numbers of Welschinger curves, thus providing a proof of the invariance of Welschinger numbers within tropical geometry. In addition, counting Broccoli curves yields an invariant in many more cases than counting Welschinger curves. Therefore, it is an interesting question whether there is a meaningful invariant count of real curves that corresponds directly to the tropical Broccoli count.
Joint work with Andreas Gathmann and Franziska Schroeter.

Christian Miebach
Université du Littoral Côte d'Opale, Calais
Quotients of bounded domains of holomorphy by proper actions of $\mathbb{Z}$

We consider a bounded domain of holomorphy D in $\mathbb{C}^n$ with a closed one parameter group of automorphisms. In this situation we have a proper action of the group $\mathbb{Z}$ on D, and we would like to know whether the quotient manifold $D/\mathbb{Z}$ is Stein. I will speak about a result obtained with Karl Oeljeklaus wich answers this question positively in the case that D is simply-connected and 2-dimensional. As an application we obtain a normal form for such domains in which $\mathbb{Z}$ acts by translations.

Martin Möller
Goethe-Universität Frankfurt
Curves in the moduli space of curves: Slopes and Lyapunov exponents.

The numerical invariants of curves in the moduli space of curves have a long history, mainly aiming to describe 'all curves' in the moduli space of curves. One possible precise formulation of such problem is to describe the cone of moving curve in moduli space of curves. This problem and most problems of similar flavor are today still open. In this talks, we propose to compare two numerical invariants of different origin. The slope is an algebro-geometric invariant and measures the ratio of intersection numbers of the curve with natural divisors. In contrast, Lyapunov exponents are invariants from dynamical systems and measure the growth rate of cohomology classes under parallel transport of some geodesic flow. We show how these two quantities are related and how to characterize curves where extremal values are attained.

Stefan Müller-Stach
Johannes-Gutenberg Universität Mainz
Abelsche Varietäten und Thetafunktionen auf kompakten Riemannschen Mannigfaltigkeiten

Wir erklären eine Konstruktion von Moore-Witten (2000), die zu kompakten Riemannschen Mannigfaltigkeiten (insb. Kählermannigfaltigkeiten) mit Zusatzstrukturen Abelsche Varietäten und damit Thetafunktionen konstruieren, und die in der Stringtheorie eine Bedeutung durch Partitionsfunktionen erhalten. Natürlich erklären wir die Physik nicht, hingegen eine erweiterte mathematische Sichtweise auf diese Konstruktionen, die auch Weilsche Intermediate Jacobians einschließt. Der Vortrag hat eher Überblickscharakter. (Zusammenarbeit mit V. Srinivas und C. Peters, Preprint 2011 auf arXiv.org)

Stefan Nemirovski
Unabhängige Universität Moskau
Levi Problem and Semistable Quotients

Geometric invariant theory for reductive group actions on Stein manifolds can be applied to function theory using an approach initiated by Tetsuo Ueda in 1980. The talk will discuss these applications and related geometric questions.

Thomas Peternell
Universität Bayreuth
Untermannigfaltigkeiten mit positivem Normalenbündel - eine Vermutung von Hartshorne.

Jeder lernt in der Linearen Algebra, dass sich zwei lineare Unterräume X und Y im komplex-projektiven Raum P schneiden, sofern $\dim X + dim Y \geq \dim P$. Ersetzt man P durch eine beliebige projektive Mannigfaltigkeit, so ist das i.a. natürlich falsch. Hartshorne hat in den 60er Jahren vermutet, dass diese Aussage jedoch richtig bleibt, wenn man eine Positivitätsvoraussetzung an die Normalenbündel von X und Y macht. Letzlich ist dies ein Problem über höherdimensionale Zykel. In dem Vortrag diskutiere ich den Stand der Vermutung, Beweismethoden in speziellen Fällen und verwandte Probleme über konvexe Räume und semi-positive Geradenbündel.

Sönke Rollenske
Universität Mainz
Lagrangian fibrations on hyperkähler manifolds

Hyperkähler (also called irreducible holomorphic symplectic) manifolds form an important class of manifolds with trivial canonical bundle. One fundamental aspect of their structure theory is the question whether a given hyperkähler manifold admits a Lagrangian fibration. I will report on a joint project with Daniel Greb and Christian Lehn investigating the following question of Beauville: if a hyperkähler manifold contains a complex torus T as a Lagrangian submanifold, does it admit a (meromorphic) Lagrangian fibration with fibre T? I will describe a complete positive answer to Beauville's Question for non-algebraic hyperkähler manifolds, and give explicit necessary and sufficient conditions for a positive solution in the general case using the deformation theory of the pair (X, T).

Hiro-o Tokunaga
Tokyo Metropolitan University
Splitting curves for double covers and the topology of the complements of certain curves on rational ruled surfaces

Let Σ be a smooth projective surface. Let $f' : Z' \to \Sigma$ be a double cover, i.e, Z': a normal projective surface, f': a finite surjective morphism of degree 2. Let $\mu : Z \to Z'$ be the minimal resolution and we put $f = \mu \circ f'$.

1. An irreducible curve D on Σ is called *a splitting curve* with respect to f if f^*D is of the form

$$f^*D = D^+ + D^- + E$$

   where $D^+ \neq D^-$, $f(D^+) = f(D^-) = D$ and Supp(E) is contained in the exceptional set of μ.

2. Let D be a splitting curve on Σ with respect to $f : Z \to \Sigma$. If the double cover is determined by the branch locus $\Delta(f)$ (e.g., the case when Σ is simply connected), we say that

$$\Delta(f) \textit{ is a quadratic residue curve mod } D.$$

In this talk, we discuss "*reciprocity*" for quadratic residue curves on rational ruled surfaces under some special setting and consider its application to the topology of the complements of curves.

Sektion 3

Arithmetische Geometrie und Zahlentheorie

Kathrin Bringmann (Köln), Ulrich Goertz (Essen), Don Zagier (MPI Bonn)

Montag, 19. September **Seminargebäude, S22**

14:00 Ken Ono (Atlanta)
An Atkin-Lehner theorem for modular forms modulo l

15:00 Anton Mellit (Köln)
t.b.a.

16:30 Valentin Blomer (Göttingen)
Applications of the Kuznetsov formula for GL(3)

Dienstag, 20. September **Seminargebäude, S22**

14:00 Sander Zwegers (Köln)
On Nahm's Conjecture

15:00 Clemens Fuchs (Zürich)
News on a problem of Diophantus

Mittwoch, 21. September **Seminargebäude, S22**

14:00 Martin Raum (Bonn)
Biharmonische Modulformen und nichtkritische L-Werte

15:00 Jean-François Dat (Paris)
Two modular local Langlands correspondences and their geometric realizations

16:30 Jan Kohlhaase (Münster)
p-adisch symmetrische Räume und lokal analytische Darstellungen

17:30 Ulrich Derenthal (München)
Rationale Punkte auf kubischen Flächen

Donnerstag, 22. September **Seminargebäude, S22**

14:00 Laurent Fargues (Paris)
The p-adic geometry of moduli spaces of abelian varieties

15:00 Eugen Hellmann (Bonn)
Familien von filtrierten phi-Moduln und kristallinen Darstellungen

16:00h – 16:30h Pause

16:30 Torsten Wedhorn (Paderborn)
Zips

Valentin Blomer
Universität Göttingen
Applications of the Kuznetsov formula for GL(3)

Starting from the Poisson summation formula, the Selberg trace formula for the torus $\mathbf{R}/\mathbf{Z}$, we discuss classical applications of the Kuznetsov trace formula for $GL(2)$ in various areas of number theory. We proceed to develop a fairly explicit Kuznetsov formula on $GL(3)$ and give several new applications to L-functions, exceptional eigenvalues, and large sieve inequalities.

Anton Mellit
Universität zu Köln
Multiplication laws for differential equations

Jean-François Dat
Université Pierre et Marie Curie Paris 6
Two modular local Langlands correspondences and their geometric realizations

The “classical” local Langlands correspondence for a p-adic field may be formulated in two almost-equivalent ways, depending on whether one uses complex coefficients, or l-adic ones. The bridge between both formulations is the passage from continous l-adic Galois representations to Weil-Deligne representations. When one tries to go to mod l coefficients, such a bridge is no longer available, and it turns out that there are at least two ways of defining a mod l “Langlands correspondence”. Moreover, none of them relates the most natural Galois objects with the most natural automorphic objects. The first construction is due to Vigneras and associates a Weil-Deligne representation to any irreducible representation of some GL_n. The main justification for Emerton’s construction is that it is supposed to be “realized” in the cohomology of some global objects (suitable Shimura varieties), although by now only the case n=2 is fairly understood. Vigneras’ construction was more of a representation theoretic nature, but we will explain how it can be realized in the cohomology of some local objects (the so-called “Lubin-Tate” spaces).

Ulrich Derenthal
Ludwig-Maximilians-Universität München
Rational points on cubic surfaces

Cubic surfaces defined over number fields often contain infinitely many rational points. A conjecture of Manin predicts the distribution of these points precisely. One can approach this conjecture by parameterizing rational point on the surface by integral points on universal torsors, certain higher-dimensional varieties that can be described explicitly using Cox rings. We will give an introduction to the universal torsor approach to Manin's conjecture and report on recent progress.

Literatur

Franke, J., Manin, Yu. I., Tschinkel, Yu. (1989). Rational points of bounded height on Fano varieties. *Invent. Math.*, **95**, 421 - 435.
Derenthal, U. (2009). Counting integral points on universal torsors. *Int. Math. Res. Not. IMRN*, **14**, 2648 - 2699.
Browning, T. D., Derenthal, U. (2009). Manin's conjecture for a cubic surface with D_5 singularity. *Int. Math. Res. Not. IMRN*, **14**, 2620 - 2647.

Laurent Fargues
Université Paris-Sud
Curves and vector bundles in p-adic Hodge theory

Given an algebraically closed complete valued field of characteristic p, we construct a curve over $\mathbb{Q}_p$ and classify vector bundles on it. To some objects in p-adic Hodge theory we associate Galois equivariant vector bundles on this curve. As a particular case of the classification of vector bundles on this curve we find back the two main theorems of p-adic Hodge theory: weakly admissible is equivalent to admissible and De Rham implies potentially semi-stable. This is joint work with Jean-Marc Fontaine.

Clemens Fuchs
ETH Zurich
News on a problem of Diophantus

Let q be a non-zero rational number. In the talk we investigate the following question: For which q do there exist infinitely many sets consisting of five non-zero rational numbers such that the product of any two of them plus q is a perfect square (i.e. a square of a rational number)? This question for four (instead of five) rational numbers has already been studied by Diophantus of Alexandria and later looked at by Pierre de Fermat, Leonhard Euler and others. We shall first give a quick survey on the history of the problem and highlight some milestone results. Then we discuss a very recent result obtained jointly with Andrej Dujella which says that there are infinitely many square-free such q and, on assuming the Parity Conjecture for the twists of an explicitly given elliptic curve, that their density is at least $1/2$. For the proof we first consider a related question for polynomials with integral coefficients. We prove that, up to certain admissible transformations, there is precisely one set of non-constant linear polynomials such that the product of any two of them with the exception of one combination, plus a given linear polynomial is a perfect square.

Eugen Hellmann
Universität Bonn
Familien von filtrierten phi-Moduln und kristallinen Darstellungen

Filtrierte phi-Moduln sind Objekte der semi-linearen Algebra, die beim Studium gewisser p-adischer Galoisdarstellungen auftreten. Diejenigen Objekte, die Galoisdarstellungen entsprechen, heißen schwach zulässig und werden durch eine Semi-Stabilitätsbedingung beschrieben. Wir betrachten Familien von solchen Objekten und konstruieren einen Raum, der die schwach zulä-ssigen filtrierten phi-Moduln parametrisiert. Über einer offenen Teilmenge des schwach zulässigen Ortes gibt es eine Familie von Galoisdarstellungen, die der Einschränkung der Familie filtrierter phi-Moduln entspricht.

Jan Kohlhaase
Universität Münster
p-Adisch symmetrische Räume und lokal analytische Darstellungen

Es sei p eine Primzahl, $\mathbb{Q}_p$ der Körper der p-adischen Zahlen und K ein endlicher Erweiterungskörper von $\mathbb{Q}_p$. Eine tiefliegende Beschreibung der Arithmetik von K gelingt in der sogenannten *lokalen Langlandskorrespondenz* über die stetigen Darstellungen der linearen Gruppen $\mathrm{GL}_n(K)$ auf komplexen, diskret topologisierten Vektorräumen. In der jüngeren Vergangenheit scheint durch die Betrachtung stetiger Darstellungen auf *p-adischen* topologischen Vektorräumen eine wesentliche Verfeinerung dieser Korrespondenz möglich geworden. In meinem Vortrag möchte ich auf diese neuen Entwicklungen eingehen und eine Klasse p-adischer Darstellungen vorstellen, die von Modulräumen formaler Gruppen herrührt. Diese Darstellungen bilden auch im Hinblick auf eine mögliche geometrische Realisierung der p-adischen Langlandskorrespondenz den Gegenstand aktueller Forschung.

Ken Ono
Emory University, Atlanta
An Atkin-Lehner theorem for modular forms modulo ℓ

In joint work with Nick Ramsey, we obtain the mod ℓ analog of the first theorem of Atkin and Lehner in their work on newforms. We use the geometric theory of modular forms to obtain this result, and we give a number of examples of this general theory (e.g. the partition function and the coefficients of Klein's j-function).

Martin Raum
Max-Planck-Institut für Mathematik, Bonn
Biharmonische Modulformen und nichtkritische L-Werte

Die formale Erzeugendenfunktion der nichtkritischen L-Werte einer holomorphen, elliptischen Modulform lässt sich als einseitige Taylor Entwichlung einer auf der oberen Halbebene definierte Funktion schreiben. Wir führen biharmonische Modulformen ein, die wie harmonische Maaßformen zerlegt werden können und deren so zustandekommenden Deformationsdefizite mit obigen Funktionen übereinstimmen. Hieraus enwickeln wir eine Theorie, die eine bemerkenswert klare Parallelität zur klassischen Eichler-Shimura Theorie besitzt.

Literatur
Bringmann, K., Diamantis, N. und Raum, M. (2011). Mock period functions, biharmonic Maass forms, and non-critical values of L-functions

Sander Zwegers
Universität zu Köln
On Nahm's Conjecture

We consider certain q-series depending on parameters (A,B,C), where A is a positive definite r times r matrix, B is a r-vector and C is a scalar, and ask when these q-series are modular forms. Werner Nahm (DIAS) has formulated a partial answer to this question: he conjectured a criterion for which A's can occur, in terms of torsion in the Bloch group. For the case r=1, the conjecture has been shown to hold by Don Zagier (MPIM and CdF). For r=2, Masha Vlasenko (MPIM) has found a counterexample. In this talk we'll discuss further counterexamples and other aspects of Nahm's conjecture.

Torsten Wedhorn
Paderborn
Zips

Sektion 4

Didaktik und Geschichte

Rainer Kaenders (Köln), Eberhard Knobloch (Berlin), Horst Struve (Köln)

Mittwoch, 21. September **Seminargebäude, S21**

14:00 Thomas Sonar (Braunschweig)
Declination tables in early modern England

15:00 Bernardo Mota (Berlin)
Appolonius, Epicureans and the bisection of a Line

16:00h – 16:30h Pause

16:30 Lutz Führer (Frankfurt)
Mathematischer Unterricht und/oder Reformpädagogik

17:20 Andres Büchter (Düsseldorf)Hans-Wolfgang Henn (Dortmund)
Didaktisch orientierte Konzepte für die elementarmathematische Ausbildung von Lehramtsstudierenden

18:10 Myriam-Sonja Hantke (Köln)
Die Metaphysik der Zahlen

Andreas Büchter, Hans-Wolfgang Henn
Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, Technische Universität Dortmund
Didaktisch orientierte Konzepte für die elementarmathematische Ausbildung von Lehramtsstudierenden

Angehende Fachmathematikerinnen und Fachmathematiker eignen sich in den grundlegenden Vorlesungen der ersten Semester ein fachliches Handwerkzeug an, mit dessen Hilfe sie in vertiefenden Veranstaltungen selbst authentisch Mathematik betreiben; so können sie ein ”stimmiges Bild von Mathematik” (Gernot Stroth) entwickeln. Demgegenüber ist die fachmathematische Ausbildung von Lehramtsstudierenden häufig auf die grundlegenden Vorlesungen beschränkt, sodass sie bereits hier die Möglichkeit haben müssen, ein stimmiges Bild von Mathematik zu entwickeln, indem Begriffe und Theorien problemorientiert entwickelt werden.
Darüber hinaus benötigen Lehramtsstudierende in ihrer eigenen Ausbildung übertragbare Modelle für gutes fachliches Lernen, die sie aus ihrer eigenen Schulzeit (zu) häufig nicht kennen. Wichtige didaktische Prinzipien, wie z.B. den genetischen Aufbau von Lerneinheiten, können Studierende aber nicht alleine in Didaktikveranstaltungen lernen, sie müssen diese Prinzipien selbst in ihrer fachlichen Ausbildung erfahren können. Im Vortrag wird anhand erprobter paradigmatischer Beispiele aus der Analysis und der Stochastik gezeigt, wie eine entsprechende didaktische orientierte elementarmathematische Ausbildung von Lehramtsstudierenden konzipiert sein kann.

Literatur

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Büchter, A. & Henn, H.-W. (2007). *Elementare Stochastik. Eine Einführung in die Mathematik der Daten und des Zufalls.* 2., überarbeitete und erweiterte Auflage. Berlin/Heidelberg: Springer.

Lutz Führer
Universität Frankfurt
Mathematischer Unterricht und/oder Reformpädagogik?

Im ersten Drittel des 20. Jahrhunderts gab es einen außerordentlichen Boom pädagogisch ambitionierter Literatur, die eine radikale Erneuerung von Unterricht und Schule forderte. Das alles ist von der erziehungswissenschaftlichen Historiographie unter dem Schlagwort „Reformpädagogik“ inzwischen vielfältig durchgearbeitet und in letzter Zeit auch entzaubert worden. Trotzdem prägen die damaligen Ideen, Schlagworte und Mythen (J. Oelkers) heute wieder viele „Expertisen“ zur Schulreform, wenn es über diagnostisch-exakte Unterrichtsforschung hinaus um „Politikberatung“ geht. Im Gegensatz zu den nachträglichen Defizitanalysen stützen sich heute konstruktive methodische und curriculare Empfehlungen eher auf Kognitionsmodelle, Euphemismen, moralische Appelle und Gesinnungslyrik denn auf empirische Untersuchungen, soziologische Risiken, Bildungstheorien oder wissenschaftstheoretische Exegesen. Woher kommt das, und warum wird der offensichtliche Widerspruch zwischen Outputorientierung und Reformpädagogik so standhaft ignoriert? Anhand reformpädagogischer Beispiele für den mathematischen Normalunterricht, d. h. für Rechnen, Raumlehre oder Mathematikunterricht an öffentlichen Schulen vor rund einhundert Jahren, soll der Frage nachgegangen werden, inwiefern wenigstens damals stimmige Begründungen für den mathematiknahen Unterricht konkretisiert werden konnten, oder auch – warum – nicht.

Myriam-Sonja Hantke
Universität zu Köln
Die Metaphysik der Zahlen

In der Mathematik gibt es verschiedene Zahlbereiche: die natürlichen, rationalen, irrationalen, reellen und komplexen Zahlen. Dazu treten noch hyperkomplexe und hyperrationale Zahlen. Diese unterschiedlichen Zahlen werden in der Mathematik voneinander unterschieden, doch was ist ihr gemeinsamer metaphysischer Grund? Worin gründen sie? Was ist ihr Wesen? In meinem Vortrag möchte ich in einem ersten Schritt zunächst historisch nach dem metaphysischen Grund der Zahlen fragen. In Anknüpfung an Platon, I. Kant, F.W.J. Schelling und insbesondere C.A. Eschenmayer möchte ich in einem zweiten Schritt systematisch die Metaphysik der Zahlen entwickeln, die allererst den Grund von Arithmetik und Geometrie legt.

Bernado Mota
University of Lisbon
Apollonius, Epicureans and the Bisection of a Line

According to Proclus, the celebrated geometer Apollonius tried to clarify some of the principles and propositions of Elements I. His contribution includes a restatement of several definitions (line, plane angle), an attempted demonstration of the first common notion and several alternative proofs corresponding to Elements 1.9 and 1.10 (bisection of an angle and of a limited line), 1.11 (to draw the perpendicular to a straight line from a point on it) and 1.23 (to construct an angle equal to a given angle on a given straight line). The standard account of Apollonius' notes on elementary geometry is as follows. Apollonius is a commentator and his marginal footnotes did not cause any significant change to the Elements. Furthermore, his arguments somehow seem inadequate because they interfere with the Euclidean order of presentation, assuming theorems proved in the third book of the Elements while demonstrating far more elementary results. Some have tried to spare his proposals by considering them as belonging to practical rather than theoretical geometry. In my view, however, Apollonius' proposals rather appear to pinpoint the problematic topics concerning the axiomatisation of geometry of his time. Moreover, they are closely related to the agenda pursued by mathematicians and philosophers of the following generation whose fundamental research implied careful examination of the foundations of geometry. In my presentation, I will first describe Apollonius' alternative proofs of Elements 1.9-11. I will then provide an overview of the objections raised against Elements 1.1-10, as reported by Proclus; I will emphasize that these objections help to determine the conditions under which it is possible to prove that a given finite straight line has been bisected. It is my believe that a reappraisal of Apollonius' contributions and a reassessment of the objections raised against Elements 1.1-10 will help to shed light on the state-of-the-art of elementary geometry of around the 2nd century BC. As they are reported by Proclus, these episodes appear to illustrate different stages and crucial developments in the axiomatisation of geometry which may have helped shaping the received text of Elements 1.

Thomas Sonar
Technische Universität Braunschweig
Declination tables in early modern England

Tables for the declination of the sun were in use by Portuguese navigators as early as the 15th century. Coming from Spain the technique of navigating with the help of declination tables was brought to England in the 16th century. Since these tables were not intelligible to English mariners new tables were designed and the technique of navigation was transformed within three generations to a fairly easy task. In the talk we describe the way from the declination tables of Martin Cortés to that of Edward Wright.

Literatur

Sonar, Th. (2010). The 'Regiments' of sun and pole star: on declination tables in early modern England. *Int. J. Geomath*, **1**, 5 - 21.

Sektion 5

Differentialgleichungen

Bernold Fiedler (Berlin), Gero Friesecke (München/Warwick), Hans Christoph Grunau (Magdeburg), Guido Sweers (Köln)

Montag, 19. September **Teil A – Seminargebäude, S11**

14:00 Felix Schulze (Berlin)
Stabilitätsresultate für Krümmungsflüsse

15:00 Luca Mugnai (Leipzig)
Approximation of Helfrich's functional via diffuse interfaces

16:00h – 16:30h Pause

16:30 Armin Schikorra (Zürich)
Regularity theory for fractional harmonic maps into manifolds

17:30 Ruben Jakob (Tübingen)
The „Thread Problem": Its different analytic formulations, classical results and modern methods

Teil B – Seminargebäude, S12

14:00 Stefan Neukamm (Leipzig)
Homogenization and dimension reduction in finite elasticity

14:30 Sergey Tikhomirov (Berlin)
Shadowing in partially hyperbolic systems

15:30 Philipp Reiter (Freiburg)
Non-convex anisotropic energies

16:00h – 16:30h Pause

16:30 Fotios Giannakopoulos (Aachen)
Existenz und Stabilität periodischer Lösungen bei zyklisch gekoppelten nichtlinearen Differentialgleichungen mit Zeitverzögerung

17:00 André Fischer (Darmstadt)
Nonlinear instability of the Ekman spiral

17:30 George Smyrlis (Athen)
Multiple solutions for semilinear Neumann problems

18:00 Mark Groves (Saarbrücken)
Existence and stability of fully localized three-dimensional gravity-capillary solitary water waves

Dienstag, 20. September **Teil A – Seminargebäude, S11**

14:00 Christian Stinner (Zürich)
Large time behavior in a quasilinear viscous Hamilton-Jacobi equation with degenerated diffusion

15:00 László Székelyhidi (Bonn)
Die inkompressiblen Eulergleichungen: Nichteindeutigkeit und Selektionsprinzipien

16:00h – 16:30h Pause

16:30 Glen Wheeler (Magdeburg)
On the curve diffusion flow of planar curves

17:30 Vu Hoang (Karlsruhe)
Analysis of semi-infinite periodic structures

Teil B – Seminargebäude, S12

14:00 Pavel Gurevich (Berlin)
Periodic solutions for parabolic equations with hysteresis

14:30 Bernd Schmidt (München)
On discrete to continuum limits for elastic systems

15:00 Stefan Liebscher (Berlin)
Bifurcation without parameter

15:30 Juliette Hell (Berlin)
Dynamics at infinity

16:00h – 16:30h Pause

16:30 Tim Seger (Konstanz)
Regularity theory for an elliptic parabolic system

17:00 Mario Kaip (Konstanz)
Mixed order systems and application to parabolic boundary value problems

17:30 Tobias Nau (Konstanz)
Ein operatortheoretischer Zugang zu Evolutionsgleichungen in zylinderförmigen Gebieten

18:00 Samuel Littig (Dresden)
Konvergenz der Eigenwerte des p-Laplace Operators für p gegen 1

Mittwoch, 21. September **Teil A – Seminargebäude, S11**

14:00 Patrick Dondl (Bonn)
Pinning and depinning of interfaces in random media

15:00 Sebastian Herr (Bonn)
Energy-critical nonlinear Schrödinger equations

16:00h – 16:30h Pause

16:30 Anja Schlömerkemper (Bonn)
Uniformly G-equivalent theories for nonconvex discrete systems

17:30 Matthias Kurzke (Bonn)
Motion laws for Ginzburg-Landau type vortices

Teil B – Seminargebäude, S12

14:00 Rico Zacher (Halle-Wittenberg)
Regularity and long-time behaviour for nonlinear nonlocal in time PDEs

15:00 Hans Knüpfer (Bonn)
Propagation of three-phase contact lines – well-posedness and regularity

16:00h – 16:30h Pause

16:30 Miles Simon (Magdeburg)
t.b.a.

17:30 Anna Dall'Acqua (Magdeburg)
Willmore surfaces with boundary

Donnerstag, 22. September **Teil A – Seminargebäude, S11**

14:00 Matthias Schneider (Heidelberg)
Geschlossene magnetische Geodäten

15:00 Simon Blatt (Zürich)
Analysis of O'Hara's knot energies

16:00h – 16:30h Pause

16:30 Ivano Primi (Heidelberg)
Some mathematical models from life sciences

17:30 Thomas Blesgen (Leipzig)
On isothermal phase field models with a geometrically linear elastic energy

Teil B – Seminargebäude, S12

14:00 Stefan Krömer (Köln)
Weak lower semicontinuity of multiple integrals revisited: the role of lower bounds

14:30 Bernd Kawohl (Köln)
On an overdetermined boundary value problem

15:00 Enea Parini (Köln)
Optimale Konstanten für eine Einbettung höherer Ordnung und ein etwas merkwürdiges Eigenwertproblem

15:30 Zoja Milbers (Dresden)
Notwendige Bedingung für Eigenlösungen des 1-Laplace-Operators mittels innerer Variationen

16:00h – 16:30h Pause

16:30 Bernold Fiedler (Berlin)
Why the string equation is wrong: theory and experiments

17:00 Eleutherius Symonides (Eichstätt-Ingolstadt)
Die harmonische Deformation ebener Kurven

17:30 Martin Väth (Berlin)
Reaktions-Diffusionsgleichungssysteme mit Hindernissen

Simon Blatt
ETH Zürich
Analysis of O'Hara's knot energies

All of us know how hard it can be to decide whether the cable spaghetti lying in front of us is really knotted or whether the knot vanishes into thin air after pushing and pulling at the right strings. In this talk we approach this problem using gradient flows of a family of energies introduced by O'Hara in 1991-1994. We will see that this allows us to transform any closed curve into a special set of representatives - the stationary points of these energies - without changing the type of knot. We prove longtime existence and smooth convergence to stationary points for these evolution equations.

Thomas Blesgen
Max-Planck-Institut für Mathematik in den Naturwissenschaften
Über isothermale Phasenfeld-Modelle mit geometrisch-linearer elastischer Energie

Eine neue Klasse von Phasenfeldmodellen wird hergeleitet und studiert, bei der die elastische Energie quasikonvex ist und die Bildung von Mikrostruktur auf kleineren Längenskalen mit berücksichtigt. Nach einem kurzen Überblick über die verwendete Elastizitätstheorie und ältere Ansätze wird beispielhaft für die elastische Cahn-Hilliard-Gleichung die globale Existenz schwacher Lösungen in bestimmten Mikrostruktur-Regimen mit zwei verschiedenen Ansätzen gezeigt. Erste numerische Simulationen illustrieren typische Eigenschaften der Lösung und erlauben einen Vergleich zu früheren Modellen mit linearer Elastizität.

Anna Dall'Acqua
Otto-von-Guericke-Universität Magdeburg
Willmore surfaces with boundary

The Willmore functional associates to a surface the integral, over the surface, of its mean curvature squared. Critical points of this functional are called Willmore surfaces and are solutions of a fourth order non-linear elliptic p.d.e., the Willmore equation. Examples of Willmore surfaces are spheres and minimal surfaces. The Willmore equation may be considered as a frame invariant counterpart of the clamped plate equation. This equation is of interest not only in mechanics and membrane physics but also in differential geometry.
The problem we are interested in is the existence of Willmore surfaces which obey suitable boundary conditions. Being the Willmore equation of fourth order, one needs to impose two sets of boundary conditions on the boundary. In this talk we give an overview on results concerning existence, regularity, uniqueness and stability properties of Willmore surfaces satisfying Dirichlet or natural boundary conditions in certain symmetric situations. We use methods from the Calculus of Variations.

Literatur

Bergner, M., Dall'Acqua, A., Fröhlich, S. (2010). Willmore surfaces of revolution with two prescribed boundary circles, to appear in *The Journal of Geometric Analysis*.
Dall'Acqua, A. (2011) Uniqueness for the homogeneous Dirichlet Willmore boundary value problem, *preprint*.
Dall'Acqua, A., Fröhlich, S., Grunau, H.-Ch., Schieweck, F. (2011). Symmetric Willmore Surfaces of revolution satisfying arbitrary Dirichlet boundary data *Advances in Calculus of Variations*, **4**, 1–81.

Patrick Dondl
Rheinische Friedrich-Wilhelms-Universität Bonn
Pinning and depinning of interfaces in random media

We consider a parabolic model for the evolution of an interface in random medium. The local velocity of the interface is governed by line tension and a competition between a constant external driving force $F > 0$ and a heterogeneous random field $f(x, y, \omega)$, which describes the interaction of the interface with its environment. To be precise, let $(\Omega, \mathbf{F}, \mathbf{P})$ be a probability space, $\omega \in \Omega$. We consider the evolution equation

$$\partial_t u(x,t,\omega) = \Delta u(x,t,\omega) - f(x,u(x,t,\omega),\omega) + F$$

with zero initial condition. The random field $f > 0$ has the form of localized smooth obstacles of random strength.
In particular, we are interested in the macroscopic, homogenized behavior of solutions to the evolution equation and their dependence on F. We prove that, under some assumptions on f, we have existence of a non-negative stationary solution for F small enough. This means that all solutions to the evolution equation become stuck if the driving force is not sufficiently large. Given stronger assumptions on f, but still without a uniform bound on the obstacle strength, we also show that for large enough F the interface will propagate with a finite velocity.
Joint work with Nicolas Dirr (Cardiff University) and Michael Scheutzow (TU Berlin).

Literatur

N. Dirr, P. W. Dondl, G. R. Grimmett, A. E. Holroyd, and M. Scheutzow (2010). Lipschitz Percolation. *Elect. Comm. in Probab.*, **15**, 14–21.
N. Dirr, P. W. Dondl, and M. Scheutzow (2010). Pinning of Interfaces in Random Media. *arXiv:0911.4254v2 [math.AP]*.
P. W. Dondl and M. Scheutzow (2011). Positive speed of propagation in a semilinear parabolic interface model with unbounded random coefficients. *arXiv:1102.5691v1 [math.PR]*.

Bernold Fiedler
Berlin
Why the string equation is wrong: theory and experiments

Flageolet is a very common technique to play harmonics on string instruments: the finger touches the string slightly, at integer partitions, to produce a peculiar whistling-like sound. The standard string equation, alias the linear wave equation on the interval, does not accomodate such an effect. I discuss several generalizations, based on live qualitative and quantitative experiments on my violin and its strings during the talk. Thanks are due to Stefan Liebscher, for helpful hints on friction, and to Wolfgang Boettcher, for helpful demonstrations on his cello.

André Fischer
Center of Smart Interfaces, TU Darmstadt
Nonlinear instability of the Ekman spiral

Consider the three-dimensional Navier-Stokes equation in an infinite layer $\mathbb{R}^2 \times (0,d)$, $d \in (0,\infty)$. It is well-known that there is a stationary solution, the *Ekman spiral*. The question of linear instability for the Ekman spiral is connected to an ODE eigenvalue problem of Orr-Sommerfeld type which was not possible to solve analytically so far in the literature. The numerical treatment of this ODE implies that there are unstable wave perturbations for Reynolds numbers $Re > 55$. With the help of these wave functions we show nonlinear instability towards L^2-perturbations in this situation via certain measure spaces. (Joint work with Jürgen Saal.)

Fotios Giannakopoulos
RWTH Aachen
Existenz und Stabilität periodischer Lösungen bei zyklisch gekoppelten nichtlinearen Differentialgleichungen mit Zeitverzögerung

Zyklische Prozesse spielen sowohl in der Natur als auch in der Technik eine wichtige Rolle. Hyperzyklen, in denen sich selbst reproduzierende Einzelzyklen von Nukleinsäuren durch eine in sich geschlossene Schleife katalytischer Kopplungen verbunden sind, Regulationsprozesse, die bei der Synthese von Proteinen stattfinden, und Regelkreise mit nichtlinearer Charakteristik gehören zu den prominentesten Beispielen. Charakteristische Eigenschaften solcher Prozesse sind selbst erregte Schwingungen und Multistabilität.
Mathematisch lässt sich die Dynamik zyklischer Prozesse mit Hilfe von Systemen nichtlinearer Differentialgleichungen mit Zeitverzögerung beschreiben, die eine zyklische Kopplungsstruktur aufweisen.
Gegenstand meines Vortrags ist die Existenz und Stabilität periodischer Lösungen bei zyklisch gekoppelten nichtlinearen Differentialgleichungen mit Zeitverzögerung.

Mark Groves
Universität des Saarlandes
Existence and stability of fully localised three-dimensional gravity-capillary solitary water waves

A solitary wave of the type advertised in the title is a critical point of the Hamiltonian, which is given in dimensionless coordinates by

$$H(\eta,\xi)=\int_{\mathbb{R}^2}\left\{\frac{1}{2}\xi G(\eta)\xi+\frac{1}{2}\eta^2+\beta\sqrt{1+\eta_x^2+\eta_z^2}-\beta\right\},$$

subject to the constraint that the impulse

$$I(\eta,\xi)=\int_{\mathbb{R}^2}\eta_x\xi$$

is fixed. Here $\eta(x,z)$ is the free-surface elevation, ξ is the trace of the velocity potential on the free surface, $G(\eta)$ is a Dirichlet-Neumann operator and $\beta>1/3$ is the Bond number. In this talk I show that there exists a minimiser of H subject to the constraint $I=2\mu$, where $0<\mu\ll 1$. The existence of a solitary wave is thus assured, and since H and I are both conserved quantities its stability follows by a standard argument. 'Stability' must however be understood in a qualified sense due to the lack of a global well-posedness theory for three-dimensional water waves.

Pavel Gurevich
Freie Universität Berlin
Periodic solutions for parabolic equations with hysteresis

We consider a parabolic equation in a multidimensional domain with nonlocal hysteresis feedback control in the boundary condition. This problem was originally formulated in [1]. By reducing the problem to a discontinuous infinite-dimensional dynamical system, we construct all periodic solutions with exactly two switchings on the period and study their stability. In particular, we show that coexistence of several periodic solutions with different stability properties (including saddles) is possible. Bifurcations of periodic solutions are investigated.
The results are obtained jointly with Sergey Tikhomirov and published in [2,3].

Literatur

Glashoff, K., Sprekels, J. (1982). The regulation of temperature by thermostats and set-valued integral equations. *J. Integral Equ.*, **4**, 95 - 112.
Gurevich P. (2011). Periodic solutions of parabolic problems with hysteresis on the boundary. *Discrete Cont. Dynam. Systems. Series A*, **29**, No. 3, 1041 - 1083.
Gurevich, P., Tikhomirov, S. (2010). Symmetric periodic solutions of parabolic problems with hysteresis. *arXiv:1010.4064v1 [math.AP]*.

Juliette Hell
Freie Universität Berlin
Dynamics at Infinity

We interpret blow-up phenomena as heteroclinic orbits connecting a bounded invariant set to infinity. The question addressed is: Which parts of the bounded dynamics give birth to exploding trajectories? Via Poincaré compactification, infinity is made accessible to topological methods of detection of heteroclinics, such as Conley index theory. Furthermore the artificial dynamics in the sphere at infinity provides information on the shape of the blow-up. This talk emphasizes applications of compactification methods to partial differential equations whose leading order is a homogenous polynomial of degree d. In particular we will focus on slowly non-dissipative reaction-diffusion equations (joined work with Nitsan Ben-Gal).

Literatur

Nitsan Ben-Gal. Grow-Up Solutions and Heteroclinics to Infinity for Scalar Parabolic PDEs *Ph.D. Thesis, Brown University, 2010*,
Juliette Hell. Conley Index at Infinity *Doktorarbeit, Freie Universität Berlin, 2010*
Juliette Hell. Conley Index at Infinity. *Preprint, arXiv:1103.5335v1*

Sebastian Herr
Universität Bonn
Nonlinear dispersive equations in critical spaces

I will review harmonic analysis methods for solving the initial value problem associated to nonlinear dispersive evolution equations. For certain nonlinear Schrödinger equations and other interesting models such as the KP-II equation, the Zakharov system or pseudo-relativistic Hartree equations I am going to report on recent progress concerning the well-posedness problem in (approximately) scale-invariant Sobolev spaces.

Vu Hoang
GRK 1294/Institut für Analysis, Karlsruher Institut für Technologie (KIT)
Analysis of semi-infinite periodic structures

Traditionally, the Floquet transform is used to analyze periodic structures which are infinitely extended in all space directions. Since there is the possibility of building optical devices from photonic crystal materials, the mathematical understanding of structures arising from the truncation of an infinite crystal is also of great importance. A typical model situation is a half-space of photonic crystal or a semi-infinite periodic waveguide; here, the underlying domain is not invariant with respect to integer translations, so it is not clear how to apply Floquet-Bloch theory. In this talk, we give an overview of recent work leading to a new radiation condition for semi-infinite periodic structures and also to representation theorems for solutions of periodic problems in half-spaces.

Ruben Jakob
Universität Tübingen

The „Thread Problem": Its different analytic formulations, classical results and modern methods

The classical, two-dimensional „Thread Problem" (Faden-Problem) $\mathscr{P}(\Gamma, L)$ is the problem to guarantee the existence of some minimal surface X that partially spans some prescribed rectifiable Jordan-arc $\Gamma : [0,1] \longrightarrow \mathbb{R}^3$, the „supporting wire", and has partially free trace Σ, the „thread", whose length is required not to exceed some prescribed real number $L > \mid \Gamma(0) - \Gamma(1) \mid > 0$. Hence, $\mathscr{P}(\Gamma, L)$ is a free boundary problem with a length constraint for the free trace Σ.
At first, the speaker plans to precisely explain this classical, parametric formulation as well as the modern GMT-formulation of the n-dimensional „Thread Problem" $\mathscr{P}(\Gamma, L)$, which is to guarantee the existence of some mass-minimizing integral n-current T within the class of all integral n-currents S on some $\mathbb{R}^{n+k}$ whose free boundaries $\Sigma := \partial S - \Gamma$ have to meet the mass constraint $\mathbf{M}(\Sigma) \leq L$, for some prescribed real value L and some fixed integral $(n-1)$-current Γ on $\mathbb{R}^{n+k}$.
Secondly, the speaker wishes to present the most important existence and (partial) boundary regularity results – concerning the „thread" Σ – about solutions of both types of the „Thread problem", which have been achieved so far, and to compare them to each other with respect to their physical meaning and generality.

Mario Kaip
Universität Konstanz
Mixed order systems and application to parabolic boundary value problems

In this talk we want to present some results on mixed order systems on L^p-spaces and applications to free boundary value problems. Using the H^∞-calculus concept we introduce an functional calculus for the time and space derivatives. After an analysis of the order structure of each component of the mixed order system we can determine mapping properties in a comfortable way. One major aspect of this work is the possibility to consider mixed order systems on spaces of mixed Besov and Bessel scales as ${}_0B_p^{1-1/(2p)}(\mathbb{R}_+, L_p(\mathbb{R}^n)) \cap L_p(\mathbb{R}_+, B_p^{2-1/p}(\mathbb{R}^n))$. Therefore we are able to handle mixed order systems realized on parabolic trace spaces for example.
In L^p theory free boundary value problems are usually reduced to the boundary where the natural spaces are of mixed Besov and Bessel type. With our method we can interpret the reduced problem as a mixed order system and solve this at one stroke. With this approach we can avoid many auxiliary problems which occurs when the problem is solved 'manually'. The method can be applied to the generalized L_p-L_q Stokes problem on $\mathbb{R}^n$, the generalized thermo-elastic plate equations on $\mathbb{R}^n$, the spin-coating process, the two-phase Navier-Stokes with Boussinesq-Scriven surface and gravity, the two phase Stefan problem with Gibbs-Thomson correction, etc.

Literatur

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Prüss, J. and Simonett, G. (2010). On the two-phase Navier-Stokes equations with surface tension. *Interfaces and Free Boundaries. Mathematical Modelling, Analysis and Computation*, **12**, 3, 311-345.

Bernd Kawohl
Universität zu Köln
On an overdetermined boundary value problem

Serrin proved in a well-known paper from 1971 that the overdetermined bvp $-\Delta u = 1$ in Ω, $u = 0$ AND $\partial u/\partial \nu = const.$ on $\partial\Omega$ has a solution u in a bounded connected domain Ω if and only if Ω is a ball. While Serrin's Theorem is valid for fairly general and benign elliptic equations, Weinberger found a much simpler proof for the special case mentioned above. In my lecture I report on related questions for degenerate nonlinear equations, e.g. for $-\Delta_p u = 1$ with $p \in (1,\infty]$. For$p < \infty$ Pohozaev-identities are one ingredient for the proof. For $p = \infty$ it is remarkable that there are other domains than balls, on which (viscosity)-solutions exist. These results were obtained in cooperation with the coauthors listed in the references.

Literatur
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Kawohl, B. (2011) Fragalà, I., Gazzola, F. & Kawohl, B. *Overdetermined problems for the ∞-Laplacian and web functions.* submitted

Hans Knüpfer
Universität Bonn
Propagation of three-phase contact lines - well-posedness and regularity

The propagation of a liquid drop on a plate is characterized by the evolution of the three-phase contact line where air, liquid and solid meet. For thin viscous droplets, the evolution can be decribed by a class of scalar fourth order degenerate parabolic equations, the so called thin-film equations. We consider well-posedness and regularity for these thin-film equations and other fluid models in the presence of a three-phase contact line. Since the considered do not satisfy a maximum principle, the analysis has to be based on the underlying dissipative structure. One important point in the analysis is to find suitable function spaces such that the model is well-posed.

Stefan Krömer
Universität zu Köln
Weak lower semicontinuity of multiple integrals revisited: the role of lower bounds

For integral functionals on $W^{1,p}$, the standard result due to Acerbi and Fusco shows equivalence of quasiconvexity of the integrand and weak lower semincontinuity of the functional. This result relies on an additional assumption, a lower bound for the integrand, which is not purely technical (as a well-known example involving the determinant illustrates), but not optimal either. I will present a less restrictive condition that is also necessary. Interestingly, this optimal condition is weaker than boundary quasiconvexity as defined by Ball and Marsden, although for p-homogeneous integrands, it reduces to the latter.

Matthias Kurzke
Institut für Angewandte Mathematik, Universität Bonn
Motion laws for Ginzburg-Landau type vortices

We discuss some results about the motion of Ginzburg-Landau type vortices. Such vortices appear in various physical models such as superfluids, Bose-Einstein condensates or type II superconductors, and a related model describes vortices in thin ferromagnetic films.
The most natural motion laws for these models are Schrödinger flows and gradient flows and hybrids between these. In the case of ferromagnets, the equation of motion is the Landau-Lifshitz-Gilbert (LLG) equation, a geometric flow that combines Schrödinger map flow and harmonic map heat flow.
I will discuss recent results, obtained in collaborations with C. Melcher (Aachen), R. Moser (Bath) and D. Spirn (Minneapolis). For ferromagnets, I will show the derivation of an ODE (called “Thiele equation” in the physical literature) for the vortex motion from the LLG equation. Our methods are based on a detailed control of the energy and some geometric quantities.
For the model problem of the parabolic Ginzburg-Landau equations without gauge field, I will discuss joint work with D. Spirn on the derivation of motion laws for large numbers of vortices. Using quantitative error bounds, we are able to give a rigorous PDE to mean field PDE limit for dilute Ginzburg-Landau vortex liquids.

Stefan Liebscher
Freie Universität Berlin
Bifurcation without parameters

We study dynamical systems with manifolds of equilibria near points at which normal hyperbolicity of these manifolds is violated. Manifolds of equilibria appear frequently in classical bifurcation theory by continuation of a trivial equilibrium. Here, however, we are interested in manifolds of equilibria which are not caused by additional parameters. In fact we require the absence of any flow-invariant foliation transverse to the manifold of equilibria at the singularity. We therefore call the emerging theory bifurcation without parameters.
Albeit the apparent degeneracy of our setting (of infinite codimension in the space of all smooth vectorfields) there is a surprisingly rich and diverse set of applications ranging from networks of coupled oscillators, viscous and inviscid profiles of stiff hyperbolic balance laws, standing waves in fluids, binary oscillations in numerical discretizations, population dynamics, cosmological models, and many more.
In this lecture we will give an overview of the behavior of flows near bifurcation points without parameters and discuss new results on bifurcations of higher codimension.

Samuel Littig
Technische Universität Dresden
Konvergenz der Eigenwerte des p-Laplace-Operators für p gegen 1

Als Lösung einer Euler-Lagrange-Gleichung sind die Eigenwerte des p-Laplace-Operators per Definition kritische Punkte des zugehörigen Variationsproblems. Im entarteten Fall $p = 1$, für den die Energie nicht mehr differenzierbar ist, definiert man Eigenwerte des 1-Laplace-Operators daher als kritische Punkte im Sinne des *weak slope* des entsprechenden Variationsproblems. Im Fall $p > 1$ lässt sich die Existenz einer unbeschränkten Folge $(\lambda_p^k)_k$ von Eigenwerten des p-Laplace-Operators mittels Minimax-Methoden nachweisen. Die Definition der Minimax-Werte überträgt sich für $p = 1$ und es wurde gezeigt, dass die so definierten $(\lambda_1^k)_k$ ebenfalls eine unbeschränkte Folge von Eigenwerten des 1-Laplace-Operators bilden. Ferner wurde gezeigt, dass die Eigenwerte des p-Laplace-Operators für p gegen 1 gegen die Eigenwerte des 1-Laplace-Operators konvergieren.

Literatur

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S. Littig und F. Schuricht (Preprint, 2011). Convergence of the eigenvalues of the p-Laplace operator as p goes to 1.
Z. Milbers und F. Schuricht (2010). Existence of a sequence of eigensolutions for the 1-Laplace operator. *Journal of the London Mathematical Society*, **82**, 74–88.

Zoja Milbers
Technische Universität Dresden
Notwendige Bedingung für Eigenlösungen des 1-Laplace-Operators mittels innerer Variationen

Eigenfunktionen des p-Laplace-Operators für $p > 1$ sind definiert als kritische Punkte des zugehörigen Variationsproblems. Dies ist äquivalent dazu, dass es Lösungen der zugehörigen Euler-Lagrange-Gleichung sind. Im stark entarteten Grenzfall des 1-Laplace-Operators können die Eigenfunktionen ebenfalls als kritische Punkte eines Variationsproblems definiert werden, wobei man kritische Punkte im Sinne des *weak slope* versteht. Allerdings hat die zugehörige Euler-Lagrange-Gleichung viele Lösungen, die nicht kritische Punkte sind, d. h. die Gleichung kann nicht für eine äquivalente Definition genutzt werden. Wir leiten eine neue notwendige Bedingung für Eigenfunktionen des 1-Laplace-Operators mittels innerer Variationen des Variationsfunktionals her und zeigen damit, dass bestimmte Lösungen der Euler-Lagrange-Gleichung keine Eigenfunktionen sind.

Literatur

Z. Milbers, F. Schuricht (2010). Existence of a sequence of eigensolutions for the 1-Laplace operator. *J. Lond. Math. Soc.* (2) **82**, 74-88.
Z. Milbers, F. Schuricht (2010). Necessary condition for eigensolutions of the 1-Laplace operator by means of inner variations. *TU-Dresden preprint* MATH-AN-01-2010.

Luca Mugnai
Max-Planck-Institut für Mathematik in den Naturwissenschaften, Leipzig
Phase-field approximation of Helfrich-Canham bending energy

I will present some results concerning the approximability via diffuse interfaces of the so-called Helfrich-Canham bending energy, under a constraint on the ratio between the bending rigidity and the Gauss-rigidity

Tobias Nau
Universität Konstanz
Maximal regularity of cylindrical parameter-elliptic boundary value problems

For parameter-elliptic boundary value problems in (smooth) domains $V \subset \mathbb{R}^k$ with compact boundary, $\mathbf{R}$-sectoriality of the related L^p-realizations is known. We make use of this result to show $\mathbf{R}$-sectoriality for the L^p-realizations of a class of boundary value problems in cylindrical domains $W \times V$, where W is either given as the fullspace $\mathbb{R}^n$ or the cube $(0, 2\pi)^n$. Due to a result of L. Weis, this gives maximal regularity for the corresponding Cauchy problem.
The differential operators A under consideration resolve into two parts $A = A_1 + A_2$ such that A_1 acts merely on W and A_2 acts merely on V. Each part is further assumed to be parameter-elliptic. As a strong tool to treat model problems of this kind, continuous and discrete operator-valued Fourier multiplier theorems are used. To some extent this approach allows to treat vector-valued boundary value problems in the above domains.
In the case where W is given as a cube, periodic and antiperiodic boundary conditions can be treated. Combined with reflection techniques, the method applies to the Stokes problem in layers subject to Neumann boundary conditions.
The talk includes joint works with Robert Denk, Konstanz and Jürgen Saal, Darmstadt.

Literatur

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L. Weis, *Operator-valued Fourier multiplier theorems and maximal* L^p*-regularity*, Math. Ann. **319** (2001), 735–758.

Stefan Neukamm
Max-Planck-Institut für Mathematik in den Naturwissenschaften, Leipzig
Homogenization of nonlinearly elastic materials in small strain regimes

The energy associated to a nonlinearly elastic composite is given by a variational integral of the form $\int_\Omega W_\varepsilon(x,\nabla v(x))dx$ where $v:\Omega\to\mathbb{R}^d$ is a sufficiently smooth deformation and $W_\varepsilon(x,F)$ a stored energy function that typically oscillates in x on scale $\varepsilon\ll 1$, and is nonconvex in F. Due to the nonconvexity, the passage to the homogenization limit $\varepsilon\to 0$ is subtle: Buckling phenomena might occur and local stability might be lost. As a consequence, the extraction of qualitative and quantitative properties of the effective behavior is difficult. In this talk, we consider composite materials that have a single, quadratic energy well at the set of rotations. We present two results where homogenization is combined with either linearization or dimension reduction (in the bending regime). We demonstrate that effective properties can rigorously be derived in small strain regimes, based on the local convexity of the stored energy function at $SO(d)$. In particular, we derive (as a Γ-limit from 3d-elasticity) a homogenized, nonlinear bending-torsion theory for rods, and prove the commutativity of homogenization and linearization.

Literatur

S. Müller and S. Neukamm : On the commutability of homogenization and linearization in finite elasticity. *Accepted for publication in Arch. Rat. Mech. Anal.*
A. Gloria and S. Neukamm : Commutability of homogenization and linearization at identity in finite elasticity and applications. *Accepted for publication in Ann. I. H. Poincaré – AN*
S. Neukamm (2010): Homogenization, linearization and dimension reduction in elasticity with variational methods. *Dissertation Technische Universität München*

Enea Parini
CEREMADE - Université Paris-Dauphine
Optimale Konstante für eine Einbettung höherer Ordnung und ein etwas merkwürdiges Eigenwertproblem

Wir betrachten folgendes Problem: man finde die optimale Konstante für die Einbettung des Raumes

$$W^{2,1}_\Delta(\Omega) := \left\{ u\in W^{1,1}_0(\Omega)\,|\,\Delta u\in L^1(\Omega)\right\}$$

in den Raum $L^1(\Omega)$. Dabei ist $\Omega\subset\mathbb{R}^n$ ein beschränktes Gebiet. Dies ist äquivalent dazu, den ersten Eigenwert des 1-biharmonischen Operators

$$\Delta^2_1 u := \Delta\left(\frac{\Delta u}{|\Delta u|}\right)$$

unter (verallgemeinerten) Navier-Randbedingungen zu finden. In diesem Vortrag geben wir eine Interpretation des Eigenwertproblems, wir zeigen eine Ungleichung vom Faber-Krahn Typ, und und für den Fall einer Kugel berechnen wir den ersten Eigenwert und die erste Eigenfunktion explizit. Die Resultate entstanden in Zusammenarbeit mit Bernhard Ruf und Cristina Tarsi (Università degli Studi di Milano).

Ivano Primi
ASML Netherlands B.V. - früher an der Ruprecht-Karls-Universität Heidelberg
Ein zweidimensionales Modell für die durch Propagation von chemischen Signalen entlang Spiralwellen hervorgerufene Zellsortierung

Die in diesem Vortrag vorgestellte Forschungsarbeit, eine Kooperation mit Professor J.J.L. Velazquez und Professor K. Kang, setzt auf Methoden der asymptotischen Analysis. Ihr Ziel ist die Bestimmung der Eigenschaften eines elementaren Modells durch Propagation von chemischen Signalen entlang zweidimensionaler Spiralwellen und durch unterschiedliche chemotaktische Sensitivität hervorgerufene Zellsortierung. Ausgangspunkt ist die spiralische Form der Propagation des cAMP-Signals in der *mound*-Phase der Amöbe *Dictyostelium discoideum*. Vom mathematischen Standpunkt ist das untersuchte Modell eigenartig, da es sich um eine parabolische Gleichung mit Sprungbedingungen entlang einer spiralförmigen Kurve handelt. Bisher hat man die Existenz von stationären Lösungen mit der erwarteten räumlichen Verteilung der Zellpopulation nur im Fall von linearen Sprungbedingungen bewiesen; die Verallgemeinerung der Ergebnisse im nichtlinearen Fall ist künftig zu beweisen.

Philipp Reiter
Universität Freiburg i. Br.
Non-convex anisotropic energies

The study of non-convex anisotropy functionals is typically rather involved as the evolution problem turns out to be ill-posed. To overcome this difficulty we perform a regularization by the Willmore energy. Restricting to the model case of one-dimensional graphs, we consider the energies

$$E_\varepsilon : \quad u \mapsto \int_{\operatorname{graph} u} \gamma(\nu)\,\mathrm{d}s + \varepsilon^2 \int_{\operatorname{graph} u} \kappa^2\,\mathrm{d}s \qquad \text{for } u \in H^{2,2}(0,1),$$

where $\gamma : \mathbb{R}^2 \to [0,\infty)$ characterizes the anisotropy, ν is the normal to the graph, and κ denotes its curvature. We discuss the theoretical background of the stationary case and the evolution and present some numerical experiments.
This is joint work with P. Pozzi (Freiburg).

Armin Schikorra
RWTH Aachen/ ETH Zürich
Regularity Results for Fractional Harmonic Maps

We present regularity results for fractional harmonic maps into manifolds, in the setting where the appropriate Euler-Lagrange equations have a critical structure. Thus, compensation effects in their spirit similar to Wente's inequality are applied.

Anja Schlömerkemper
Universität Würzburg
Uniformly Γ-equivalent theories for nonconvex discrete systems

Within the context of the multiscale analysis I will focus on continuum limits of nonconvex discrete systems. In particular I will present results for a one-dimensional chain of atoms which interact through nearest and next-to-nearest neighbour interactions being nonconvex. The aim is to find a good approximation of the energy functional of this system for a large number of atoms. The method is based on Γ-convergence and moreover on a concept introduced by A. Braides and L. Truskinovsky called uniformly Γ-equivalent theory, which I will recall. Then I will show how this can be applied to the above mentioned system.

Literatur

Braides, A., Truskinovsky, L. (2008). Asymptotic expansions by Γ-convergence. *Continuum Mech. Thermodyn.*, **20**, 21–62.
Scardia, L., Schlömerkemper, A., Zanini, C (2011). Boundary Layer Energies for nonconvex discrete systems. DOI: 10.1142/S0218202511005210. Forthcoming article in *Math. Models Methods Appl. Sci.*

Bernd Schmidt
Universität Augsburg
On discrete-to-continuum limits for brittle fracture

We study a two-dimensional discrete system of atoms which allows for brittle fracture in the continuum limit. In particular, under suitable conditions it is shown that cracks occur along a special cleavage line. As an application, we can e.g. rigorously justify the reduction to a one-dimensional chain model for the investigation of brittle materials. (Joint work with M. Friedrich).

Matthias Schneider
Ruprecht Karls-Universität Heidelberg
Closed magnetic geodesics

We give existence results for closed curves with prescribed geodesic curvature in Riemannian surfaces. Moreover, we will discuss higher dimensional versions, e.g. existence of closed surfaces with prescribed curvature in three dimensional Riemannian manifolds.

Literatur

Rosenberg, H. and Schneider, M. (2011) Embedded constant curvature curves on convex surfaces. *arXiv:1105.1609*.
Rosenberg, H. and Smith, G. (2010) Degree Theory of Immersed Hypersurfaces. *arXiv:1010.1879v1*.
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Felix Schulze
Freie Universität Berlin
Stability results for curvature flows

In the first part of this talk we will present several results, which are joint work with M. Simon and O. Schnürer, concerning long-time behaviour and convergence of the Ricci flow close to the Euclidean and hyperbolic space. The Euclidean and hyperbolic space are examples of so-called 'self-similar' solutions of the Ricci-flow where the geometric shape only changes by scaling.

In the second part we consider the flow of regular networks in the plane under curve shortening flow. We will explain how a similar stability result - in this case for self-similarly expanding solutions - can be applied to prove short-time existence from non-regular initial data. This is joint work with A. Neves and T. Ilmanen.

Tim Seger
Universität Konstanz
Regularity Theory for an Elliptic Parabolic System

In the modeling of Lithium Ion Batteries and Fuel Cells there appears a nonlinear system of one parabolic and two elliptic equations in a bounded domain Ω that describe the evolution of concentration c_e and of the electric potentials ϕ_e and ϕ_s in liquid and solid phase respectively. These equations are coupled by a kinetic expression, that takes the form

$$S(\phi_s - \phi_e, c_e) = c_e^{-1/2} \exp(\phi_s - \phi_e) - c_e^{3/2} \exp(\phi_e - \phi_s), \tag{1}$$

and appears as the right hand side of each of the equations.
Local existence of bounded weak solutions to this system was proved in 2006 by J. Wu, J. Xu and H. Zou. Under slightly stronger hypothesis on the coefficients we prove the local existence of strong solutions in the space $W_p^1(0,T;L_p(\Omega)) \cap L_p(0,T;W_p^2(\Omega))$ for a smooth domain Ω, using results on elliptic regularity and Leray-Schauder theory.

Miles Simon
Universität Magdeburg
Ricci-Fluss von Kegeln mit nichtnegativem Krümmungsoperator

Eine Zusammenarbeit mit Felix Schulze. Es sei C ein Kegel mit nichtnegativem Krümmungs-operator, positiver asymptotischer Volumen-Dichte (*asymptotic volume ratio*) und beschränkter Krümmung. Wir zeigen, dass eine globale Lösung zur Ricci-Fluss Gleichung mit Anfangswert C existiert und, dass die Lösung ein expandierendes Soliton (*expanding soliton*) ist.

George Smyrlis, Nikolaos Papageorgiou, Dimitrios Kravvaritis
Technological Educational Institute of Athens, Department of Mathematics (Smyrlis), National Technical University, Department of Mathematics (Papageorgiou, Kravvaritis)
Multiple solutions for semilinear Neumann problems

Let $\Omega \subseteq \mathbb{R}^N$ $(N \geq 1)$ be a bounded domain with a C^2-boundary $\partial\Omega$. We consider the following nonlinear Neumann problem

$$-\Delta u(z) = f(z,u(z)) \quad \text{a.e. in } \Omega, \quad \frac{\partial u}{\partial \nu} = 0, \quad \text{on } \partial\Omega, \tag{2}$$

where Δ stands for the Laplace differential operator, $f(z,x)$, $z \in \Omega$, $x \in \mathbb{R}$ is of Carathéodory type with linear growth in x, ν is the exterior normal to $\partial\Omega$ and $\frac{\partial u}{\partial \nu}$ is the normal derivative in the direction ν. Under certain hypotheses on the reaction term $f(z,x)$, we derive multiple nontrivial smooth (weak) solutions for the problem (1), possibly of constant sign. Our approach combines variational methods based on the critical point theory, together with techniques from Morse theory.

Christian Stinner
Universität Zürich
Large time behavior in a quasilinear viscous Hamilton-Jacobi equation with degenerate diffusion

The large time behavior of nonnegative solutions to the quasilinear degenerate diffusion equation $\partial_t u - \Delta_p u = |\nabla u|^q$ is investigated for $p > 2$ and $q > 0$ in a bounded domain. Qualitative properties of the solutions vary greatly according to the relative strength of the diffusion and the source term. In particular, we show how the relation between the parameters influences the existence of nontrivial steady states as well as the existence of solutions which are global in time. Moreover, we study the convergence of global solutions towards steady states and characterize the stationary solutions. Part of the presented results were obtained in joint works with G. Barles and Ph. Laurençot.

Eleutherius Symeonidis
Katholische Universität Eichstätt-Ingolstadt
Die Harmonische Deformation ebener Kurven

Sei Ω ein einfach zusammenhängendes Gebiet in der Ebene, $t \mapsto (x_0(t), y_0(t)) \in \Omega$ eine glatte Kurve, die über ein Intervall I parametrisiert ist. Sei ferner J ein Intervall mit $0 \in J$, $J \times I \ni (s,t) \mapsto (x(s,t), y(s,t)) \in \Omega$ eine konforme Abbildung mit $x(0,t) \equiv x_0(t)$, $y(0,t) \equiv y_0(t)$.
Ist h eine harmonische Funktion auf Ω, für die $I \ni t \mapsto h(x_0(t), y_0(t))$ integrierbar ist und

$$\lim_{t \to \inf I} \tilde{h}(x(s,t), y(s,t)) = \lim_{t \to \sup I} \tilde{h}(x(s,t), y(s,t))$$

für alle $s \in J$ gilt, wobei $\tilde{h}$ eine harmonische Konjugierte zu h ist, so gilt

$$\int_I h(x(s,t), y(s,t)) dt = \int_I h(x_0(t), y_0(t)) dt$$

für alle $s \in J$, d. h. dass das Integral von h über die Kurven der Familie $(t \mapsto (x(s,t), y(s,t)))_{s \in J}$ invariant ist. Dies berechtigt, von einer *harmonischen Deformation* der ursprünglichen Kurve zu sprechen. (Die Bedingung an $\tilde{h}$ ist automatisch erfüllt, wenn alle Kurven der obigen J-Familie geschlossen sind und I kompakt ist.)
Des Weiteren wird ein allgemeines Prinzip vorgestellt, nach dem eine konforme Abbildung wie oben aus einem bestimmten „Potential“ ableitbar ist.
Der Vortrag endet mit einer Reihe von Beispielen, in denen auch unbeschränkte Kurven $t \mapsto (x_0(t), y_0(t))$ oder solche mit mehrfachen Punkten vorkommen.

Literatur

Symeonidis, E. (2011). Harmonic Deformation of Planar Curves. *International Journal of Mathematics and Mathematical Sciences, vol. 2011, Article ID 141209, 10 pages, 2011, doi:10.1155/2011/141209.*

László Szekelyhidi
Bonn
Die inkompressiblen Eulergleichungen: Nichteindeutigkeit und Selektionsprinzipien

Sergey Tikhomirov, Sergey Kryzhevich
Frei Universität Berlin, Saint-Petersburg State University
Shadowing in Partially hyperbolic systems

The shadowing problem is related to the following question: under which condition, for any pseudotrajectory (approximate trajectory) of a diffeomorphism there exists a close exact trajectory. The most famous result in shadowing theory is so-called Shadowing Lemma: in a small neighborhood of a hyperbolic set near any pseudotrajectory there exists an exact trajectory. We prove analog of shadowing lemma for partially hyperbolic diffeomorphisms. Let f be a partially hyperbolic diffeomorphism with splitting $E^s \oplus E^c \oplus E^u$. Let us assume that it is dynamically coherent with foliations W^s, W^c, W^u. We say that sequence $\{x_k\}$ is a d-central pseudotrajectory if $\mathrm{dist}(x_{k+1}, f(x_k)) < d$ and x_{k+1} and $f(x_k)$ lies on the same central leaf. We proved that for any $\varepsilon > 0$ there exists $d > 0$ such that any d-pseudotrajectory $\{y_n\}$ can be ε shadowed by a ε-central pseudotrajectory.

Martin Väth
Freie Universität Berlin
Reaktions-Diffusionssysteme mit einseitigen Hindernissen

Es ist bekannt, dass in einem Reaktions-Diffusionssystem die Diffusion durch den sog. Turing-Effekt für Instabilität sorgen und damit in vielen Systemen Musterbildung ermöglichen kann. Dennoch gibt es einen großen Bereich von Parametern, in dem das System trotz der Diffusion stabil ist. Im Vortrag wird diskutiert, weshalb einseitige Hindernisse, etwa Quellen oder Senken, die erst ab einer gewissen Schwelle aktiv werden, auch in diesen Parameterbereichen für Bifurkation sorgen können. Ohne zusätzliche Dirichlet-Randbedingungen war dieses Problem seit fast 30 Jahren offen.

Glen Wheeler
Otto-von-Guericke-Universität Magdeburg
On the curve diffusion flow of planar curves

The curve diffusion flow of a planar curve is the steepest descent gradient flow of the length functional in H^{-1}. We consider the flow of periodic immersed curves with arbitrary winding number and discuss some recent new results on long time existence and exponential convergence for initial data with small 'oscillation of curvature' and isoperimetric ratio close to that of a multiply-covered circle. We also provide an estimate for the measure of the time during which the curvature is not strictly positive, quantifying the extent of the failure of global positivity of curvature. Finally we compare this situation for curves with that of surfaces immersed in $\mathbb{R}^3$ flowing by surface diffusion, and briefly discuss the new difficulties encountered there.

Rico Zacher
Martin-Luther-Universität Halle-Wittenberg
Regularity and long-time behaviour for nonlinear nonlocal in time PDEs

In the first part we discuss several recent results on a priori estimates for weak solutions to linear and quasilinear fractional diffusion equations of time order less than one (boundedness, Hölder continuity and Harnack estimates). Such equations appear e.g. in the modelling of anomalous diffusion (subdiffusion) and dynamic processes in materials with memory. The second part of the talk is devoted to the long-time behaviour of solutions to certain gradient like systems with time fractional dynamics of order less than one or between one and two. We construct suitable Lyapunov functions and use these to prove convergence to equilibrium as $t \to \infty$. As an application we present a result (which is joint work with J. Prüss and V. Vergara) on the global well-posedness and long-time behaviour for the non-isothermal Cahn-Hilliard equation with memory.

Sektion 6

Diskrete Mathematik

Ulrich Faigle (Köln), Rainer Schrader (Köln), Martin Skutella (Berlin)

Montag, 19. September **Hörsaalgebäude, Hörsaal E**

14:00 Frauke Liers (Köln)
An exact approach for a robust network design problem

14:30 Gregor Pardella (Köln)
Maximum flows in grid graphs

15:00 Dominique Stephan Andres (Hagen)
Einige Heuristiken für das binäre Paintshop-Problem

15:30 Winfried Hochstättler (Hagen)
Sind Transversalmatroide dreifärbbar?

Stephan Dominique Andres, Winfried Hochstättler
FernUniversität in Hagen
Einige Heuristiken für das binäre Paintshop-Problem

Motiviert durch ein Anwendungsproblem in der Automobilindustrie führten Epping et al. (2004) das *binäre Paintshop-Problem* ein. Eine Instanz dieses Problems besteht aus einem Wort mit $2n$ Buchstaben aus einem Alphabet mit n Zeichen, bei dem jedes Zeichen genau zwei mal als Buchstabe vorkommt. Dieses Wort soll so mit zwei Farben gefärbt werden, dass jedes Zeichen genau einmal mit jeder Farbe gefärbt wird. Hierbei soll die Anzahl der Farbwechsel zwischen aufeinanderfolgenden Buchstaben minimiert werden. Bonsma et al. (2006) haben gezeigt, dass dieses Optimierungsproblem $\mathscr{APX}$-hart ist. Bislang ist jedoch keine Konstante-Faktor-Approximation für das binäre Paintshop-Problem bekannt. Im Vortrag untersuchen wir drei Heuristiken für das binäre Paintshop-Problem und bestimmen asymptotisch den Erwartungswert ihrer benötigten Farbwechsel in Abhängigkeit von der Alphabetgröße n. So benötigt die Greedy-Heuristik, die das Wort von links nach rechts liest und Farbwechsel nur dann vornimmt, wenn sie nötig sind, asymptotisch im Erwartungswert $n/2$ Farbwechsel. Dieses Ergebnis wurde bereits von Amini et al. (2010) vermutet. Eine andere Heuristik, die Red-First-Heuristik, kommt auf $(2n+1)/3$ Farbwechsel. Die beste Performance liefert eine Modifikation der Greedy-Heuristik, die rekursive Greedy-Heuristik, mit asymptotisch $2n/5$ Farbwechseln.

Literatur

Amini, H., Meunier, F., Michel, H., Mohajeri, A. (2010). Greedy colourings of the binary paintshop problem. *Journal of Discrete Algorithms*, **8**, 8 - 14.
Bonsma, P.S., Epping, T., Hochstättler, W. (2006). Complexity results on restricted instances of a paint shop problem for words. *Discrete Applied Mathematics*, **154**, 1335 - 1343.
Epping, T., Hochstättler, W., Oertel, P. (2004). Complexity results on a paint shop problem. *Discrete Applied Mathematics*, **136**, 217 - 226.

Winfried Hochstättler
FernUniversität in Hagen
Sind Transversalmatroide dreifärbbar?

Hugo Hadwiger vermutete, dass die chromatische Zahl $\chi(G)$ eines Graphen nur dann größer als k sein kann, wenn G einen K_{k+1}-Minor hat. William T. Tutte vermutete, dass ein Graph ohne Petersen-Minor stets einen NZ-4-Fluss hat, und dass jeder Graph einen NZ-5-Fluss hat. Verallgemeinert man die Theorie der NZ-Flüsse auf reguläre Matroide, erkennt man, dass die Vermutungen von Tutte und Hadwiger zusammenfallen, wobei der Petersen-Dual im Falle der 5-Färbbarkeit als verbotener Minor dazu kommt.
Ausgehend von einer Arbeit mit Jaroslav Nešetřil haben wir die Theorie der NZ-Flüsse auf orientierbare Matroide übertragen und u.a. mit Robert Nickel gezeigt, dass bis auf den K_{r+1} ein orientierbares Matroid vom Rang r stets r-färbbar ist. Da uniforme Matroide stets zwei- oder dreifärbbar sind, könnte Hadwigers Vermutung allgemeiner für orientierbare Matroide gelten.
Mit Luis Goddyn untersuchen wir die 3-Färbbarkeit von Matroiden ohne K_4-Minor, insbesondere von Transversalmatroiden und Gammoiden. Wir berichten über Teilergebnisse.

Literatur

Hochstättler W., Nickel R. (2008): On the Chromatic Number of an Oriented Matroid. *Journal of Combinatorial Theory, Series B*, **98**, 698—706.

Frauke Liers, Christoph Buchheim, Laura Sanità
Universität zu Köln, Technische Universität Dortmund, École Polytechnique Fédérale de Lausanne
An exact Algorithm for Robust Network Design with a Discrete Set of Traffic Matrices

Modern life heavily relies on communication networks that operate efficiently. A crucial issue for the design of communication networks is robustness with respect to traffic fluctuations, since they often lead to congestion and traffic bottlenecks. In this paper, we address an NP-hard single commodity robust network design problem, where the traffic demands change over time. For k different times of the day, we are given for each node the amount of single-commodity flow it wants to send or to receive. The task is to determine the minimum-cost edge capacities such that the flow can be routed integrally through the net at all times. We present an exact branch-and-cut algorithm, based on a decomposition into biconnected network components, a clever primal heuristic for generating feasible solutions from the linear-programming relaxation, and a general cutting-plane separation routine that is based on projection and lifting. By presenting extensive experimental results on realistic instances from the literature, we show that a suitable combination of these algorithmic components can solve most of these instances to optimality. Furthermore, cutting-plane separation considerably improves the algorithmic performance.

Literatur

Buchheim, Liers, Sanità (2011). In J. Pahl, T. Reiners and S. Voß (Eds.): INOC 2011, LNCS 6701, pp. 7-17, 2011.

Gregor Pardella, Frauke Liers
Universität zu Köln
Maximum Flows in Grid Graphs

Maximum-flow problems occur in a wide range of applications. Although already well-studied, they are still an area of active research. The fastest available implementations for determining maximum flows in graphs are either based on augmenting-path or on push-relabel algorithms. In this talk, we present two ingredients that, appropriately used, can considerably speed up these methods. On the one hand, we present flow-conserving conditions under which subgraphs can be contracted to a single vertex. These rules are in the same spirit as presented by Padberg and Rinaldi (Math. Programming (47), 1990) for the minimum cut problem in graphs. On the other hand, we propose a two-step max-flow algorithm for solving the problem on instances coming from physics and computer vision. In the two-step algorithm flow is first sent along augmenting paths of restricted lengths only. Starting from this flow, the problem is then solved to optimality using some known max-flow methods. By extensive experiments on instances coming from applications in theoretical physics and in computer vision and on random instances, we show that a suitable combination of the proposed techniques speeds up traditionally used methods.

Literatur

Y. Boykov and V. Kolmogorov (2004). An Experimental Comparison of Min-Cut/Max-Flow Algorithms for Energy Minimization in Vision. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **26(9)**, 1124 – 1137.
A. V. Goldberg and R. E. Tarjan (1988). A New Approach to the Maximum-Flow Problem. *Journal of the Association for Computing Machinery*, **35(4)**, 921 – 940.
M. Padberg and G. Rinaldi (1990). An Efficient Algorithm for the Minimum Capacity Cut Problem. *Mathematical Programming A*, **47(1)**, 19 – 36.

Sektion 7

Mathematische Physik

Martin Zirnbauer (Köln)

Montag, 19. September **Physik, Seminarraum der theoretischen Physik**

14:00 Volker Bach (Braunschweig)
Existence and construction of resonances in minimally coupled nonrelativistic QED

15:00 Michael Baake (Bielefeld)
Kinematic diffraction from a mathematical viewpoint

16:00h – 16:30h Pause

16:30 Benjamin Schlein (Bonn)
The average density of states of hermitian Wigner matrices

17:30 Wojcieck de Roeck (Heidelberg)
Diffusion in Hamiltonian models

Dienstag, 20. September **Physik, Seminarraum der theoretischen Physik**

14:00 Christoph Schweigert (Hamburg)
Higher categories in field theory - an invitation

15:00 Dorothea Bahns (Göttingen)
String theory outside the critical dimension

Mittwoch, 21. September **Physik, Seminarraum der theoretischen Physik**

14:00 Herbert Spohn (München)
The one-dimensional KPZ equation and its universality class

15:00 Leonid Pastur (Kharkiv, Ukraine)
Fluctuation laws of spectral statistics for large random matrices

16:00h – 16:30h Pause

16:30 Manfred Salmhofer (Heidelberg)
Renormalization group analysis of Fermi systems with pointlike singularities

Donnerstag, 22. September **Physik, Seminarraum der theoretischen Physik**

14:00 Rainer Verch (Leipzig)
Quantum fields on non-commutative space: non-commutative potential scattering and Wick rotation

15:00 Sefan Weinzierl (Mainz)
Hidden mathematical beauty in scattering amplitudes

16:00h – 16:30h Pause

16:30 Hanno Gottschalk (Wuppertal)
On the Anti-de-Sitter / conformal field theory conjecture from a Euclidean quantum field standpoint

17:30 Klaus Fredenhagen (Hamburg)
Epstein-Glaser renormalization and Batalin-Vilkovisky formalism

Michael Baake
Universität Bielefeld
Kinematic diffraction from a mathematical viewpoint

Mathematical diffraction theory is concerned with the analysis of the diffraction image of a given structure and the corresponding inverse problem of structure determination. In recent years, the understanding of systems with continuous and mixed spectra has improved considerably, while their relevance has grown in practice as well. Here, the phenomenon of homometry shows various unexpected new facets, particularly so in the presence of disorder. After an introduction to the mathematical tools, we review pure point spectra, based on the Poisson summation formula for lattice Dirac combs, aiming at the diffraction formulas of perfect crystals and quasicrystals. We continue by considering classic deterministic examples with singular or absolutely continuous diffraction spectra, and we recall an isospectral family of structures with continuously varying entropy. We close with a summary of more recent results on the diffraction of dynamical systems of algebraic or stochastic origin.

Literatur

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Baake, M., Birkner, M. and Moody, R.V. (2010). Diffraction of stochastic point sets: Explicitly computable examples, *Commun. Math. Phys.* **293**, 611–660; arXiv:0803.1266.

Volker Bach
Institut für Analysis und Algebra, Technische Universität Braunschweig
Existence and construction of resonances in minimally coupled nonrelativistic QED

An excited eigenvalue of an atom is believed to be unstable and turn into a resonance under a perturbation. In this talk the precise definition of such resonances is given and their existence and construction is outlined in case the atom is minimally coupled to the quantized radiation field. This model is infrared singular and notoriously difficult to treat. We review Sigal's recent construction of resonances based on the "Feshbach map" and present a novel, alternative construction based on "Pizzo's method".

Dorothea Bahns
Universität Göttingen
String theory outside the critical dimension

I will review some recent developments in string theory in a setting initiated by Klaus Pohlmeyer in the 1980s. Here, a Poisson algebra is assigned to surfaces of extremal area immersed in Minkowski space, e.g. to the world sheet of a string. Two deformations of this Poisson algebra (quantization schemes) have been proposed. One is based on the quantization of an auxiliary Lie algebra in terms of its universal enveloping algebra, the other is based on the deformation theory of quasi-Lie-bialgebras. Contrary to the ordinary setting of string theory, which is based on conformal field theory, these two quantization schemes do not require a critical dimension for consistency.

Wojciech de Roeck
Universität Heidelberg
Diffusion in Hamiltonian models

Irreversible phenomena like diffusion and thermalization obviously occur in our world, which is described by deterministic and time-reversible equations (Newton's equations of motion or the Schrödinger equation in quantum mechanics). However, up to today we seem to lack the tools to describe and derive these phenomena rigorously (apart from a few special models). In physics, one usually models them by stochastic evolution equations and the transition from deterministic equations to stochastic ones remains a leap of faith. Our work treats one of the simplest possible models: a quantum particle interacting with a gas of bosons. With the help of a time-dependent renormalization group analysis, we prove diffusion.

Klaus Fredenhagen
Universität Hamburg
Epstein-Glaser renormalization and Batalin-Vilkovisky formalism

The Batalin-Vilkovisky formalism for field theories with gauge symmetries is revisited. It is shown that the step from the classical theory to the quantum theory, which is usually discussed via the path integral, can be performed by the renormalized time ordering operator which is obtained by a generalization of Epstein-Glaser renormalization.

Hanno Gottschalk
Bergische Universität Wuppertal
On the Anti-de-Sitter / conformal field theory conjecture from a Euclidean quantum field standpoint

The symmetry group on the Anti-de-Sitter space acts as conformal group on its boundary. It is shown that quantum fields on Euclidean AdS - when resticted via suitable scaling - indeed fulfill conformal invariance on the boundary. Even in the case of non-interacting fields some new renormalization factors are required. In the case of interacting fields in AdS_2 or fields with cut offs in arbitrary dimensions a new kind an somewhat intriguing infra-red problems arises.
While the approach taken here does not reflect the richness of Maldacena's AdS/CFT conjecture on Supergravity and Yang-Mills theory, the AdS/CFT problem for Euclidean quantum fields allows statement and proof of some rigorous results on the basis of what has been established in Constructive QFT.

Literatur
M. Dütsch, K.-H. Rehren, A comment on the dual field in the AdS-CFT correspondence, Lett. Math. Phys. 62 (2002) 171-184.
Gottschalk, H, Thaler, H. (2008),AdS/CFT correspondence in the Euclidean context, *Commun. Math. Phys.*, **277**, 83 - 100.
E.Witten, Anti-de Sitter space and holography, Adv. Theor.Math. Phys. 2 (1998) 253-291.

Leonid Pastur
Mathematical Division, Institute for Low Temperatures, Kharkiv, Ukraine
Fluctuation laws of spectral statistics for large random matrices

We consider certain functions of eigenvalues and eigenvectors (spectral statistics) of real symmetric and hermitian random matrices of large size. We first show that for these functions an analog of the Law of Large Numbers is valid as the size of matrices tends to infinity. We then discuss the scale and the form for limiting fluctuations laws of the statistics and show that the laws can be standard Gaussian (i.e., analogous to usual Central Limit Theorem for appropriately normalized sums of i.i.d. random variables) in non-standard asymptotic settings, certain non-Gaussian in seemingly standard asymptotic settings, and other non-Gaussian in non-standard asymptotic settings.

Manfred Salmhofer
Universität Heidelberg
Renormalization group analysis of Fermi systems with pointlike singularities

We consider the quantum field theoretical description of quantum many-body systems. In fermionic gases at low densities, and in specific materials of solid-state physics, the Fermi surface becomes small or even degenerates to a point. A multiscale analysis can be used to determine the correlation functions by convergent expansions. In the talk I will discuss models for double-layer graphene and the dilute Fermi gas, and explain the main ideas in the analysis.

Benjamin Schlein
Hausdorff-Zentrum für Mathematik, Bonn
The average density of states of hermitian Wigner matrices

In this talk we will consider the density of states (DOS) of Wigner matrices on very small intervals. In such intervals, the fluctuations of the DOS are important and one cannot expect convergence to the semicircle law to hold in probability. Assuming the entries of the matrices to have a sufficiently regular law, we prove, nevertheless, that the average DOS still converges to the semicircle law, on arbitrarily small intervals.

Christoph Schweigert
Fachbereich Mathematik, Universität Hamburg und Zentrum für mathematische Physik
Higher categories in field theory - an invitation

We explain the notation of a bicategory and its use in topological, classical and quantum field theory.

Herbert Spohn
Zentrum für Mathematik, Technische Universität München
The one-dimensional KPZ equation and its universality class

In 1986 Kardar, Parisi, and Zhang proposed a stochastic PDE for the motion of driven interfaces. Bertini and Giacomin (1997) explained how to approximate the solution to the 1D KPZ equation through the weakly asymmetric simple exclusion process. Based on work of Tracy and Widom on the PASEP, we report a formula for the one-point generating function of the KPZ equation in the case of sharp wedge initial data. The long time limit is given by the Tracy-Widom distribution from GUE random matrices. Of particular interest are the finite time corrections. This is joint work with Tomohiro Sasamoto.

Rainer Verch
Universität Leipzig
Quantum fields on non-commutative space: non-commutative potential scattering and Wick rotation

In this talk, two different strands of quantum field theory on non-commutative space will be presented. First, the scattering of the quantized Dirac field on Minkowski spacetime will be discussed, and it will be explained how this gives rise to observables of the quantized Dirac field on Moyal-deformed Minkowski spacetime. Furthermore, it will be argued that this construction is a model for obtaining a correspondence between more general Lorentzian non-commutative geometries in the sense of spectral geometry and observables of quantum field theories over such non-commutative Lorentzian geometries. In the second strand of the talk, the problem of Wick rotation, i.e. the relation between a quantum field theory on Euclidean space on one hand, and Minkowski spacetime on the other, will be generalized for the Moyal deformations of Euclidean space and Minkowski spacetime. It will be shown that there is a relation if the Moyal deformation leaves the time coordinate untouched. These latter results were obtained in joint work with H. Grosse, G. Lechner and T. Ludwig.

Stefan Weinzierl
Universität Mainz
Hidden mathematical beauty in scattering amplitudes

This talk will be on a topic related to mathematics and (particle) physics. Scattering amplitudes in particle physics are related to the probability with which a certain scattering process occurs. The scattering amplitudes are calculable in perturbation theory. Higher orders in the perturbative expansion are needed for precision predictions for the experiments at the LHC collider. Recent progress in the calculation of scattering amplitudes has shown that these scattering amplitudes have a much simpler structure than previously believed. This simplicity is directly related to mathematical structures hiding underneath. The complexity of scattering amplitudes increases with the number of external legs and with the number of internal loops. Simplicity with respect to the number of external legs is obtained by formulating the theory not in space-time, but in twistor space instead. Simplicity with respect to the number of internal loops is obtained by making use of the algebra of transcendental functions, like the algebra of multiple poly-logarithms. Here, particle physics touches the domain of the theory of motives.

Sektion 8

Numerik

Michael Günther (Wuppertal), Ralf Kornhuber (Berlin), Caren Tischendorf (Köln)

Dienstag, 20. September **Mathematisches Institut, S3**

14:00 Roswitha März (Berlin)
Computational aspects of detecting DAE structures I

14:30 René Lamour (Berlin)
Computational aspects of detecting DAE structures II

15:00 Lennart Jansen (Köln)
Semiexplicit methods for differential-algebraic equations

15:30 Caren Tischendorf (Köln)
DAE index calculation and consistent initialization of multiphysical network models

16:00h – 16:30h Pause

16:30 Michael Matthes (Köln)
Coupled systems as abstract differential-algebraic equations

17:00 Flavius Guias (Dortmund)
A time-adaptive numerical scheme for evolution partial differential equations based on path simulation of Markov jump processes

17:30 Roland Pulch (Wuppertal)
Stochastic Galerkin methods for partial differential equations with random parameters

Donnerstag, 22. September **Seminargebäude, S15**

14:00 Michael Dörfel (Kaiserslautern)
Isogeometrische Schalen für flexible Mehrkörpersysteme

14:30 Sebastian Schöps (Wuppertal)
Mehrskalenverfahren für die Feld-/Netzwerkkopplung

15:00 Tanja Clees (Köln)
Adaptive hierarchical RBF metamodels with industrial applications

15:30 Sascha Baumanns (Köln)
Analysis and simulation of coupled circuit/field problems

Sascha Baumanns
Universität zu Köln
Analysis and simulation of coupled circuit/field problems

Modeling electric circuits that contain electromagnetic (EM) devices leads to a coupled system of differential-algebraic equations (DAEs) and partial-differential equations.
The EM devices within the circuit are modeled by Maxwell's equations and are coupled to the DAE that describes the behavior of the other circuit's elements and its topology.
After spatial discretization of Maxwell's equations, using e.g. finite integration technique, the coupled system leads to a DAE with a properly stated leading term.
For a successful numerical integration of a DAE the characterization of the index plays a vital role. Roughly speaking the index can be seen as a measure of the equations sensitivity to perturbations of the input and numerical difficulties.
We present topological and modelling conditions that guarantee the tractability index of the coupled system to be not greater than two using different gauge conditions. Furthermore, we show some simulation results of the monolithic approach using our self-developed simulator.

Tanja Clees, Nils Hornung, Lialia Nikitina, Georg van Bühren
Fraunhofer Institut für Algorithmen und Wissenschaftliches Rechnen SCAI
Adaptive hierarchical RBF metamodels with industrial applications

Radial basis functions, among other techniques, are used to construct metamodels that approximate multi-objective expensive high-fidelity functions from a finite number of function evaluations (design of experiments, DoE). Radial basis functions can be applied if the DoE covers the parameter space in an arbitrary though uniform manner. Leave-one-out strategies allow for computing tolerance limits. The approximated value and a certain tolerance can be interpreted as expectation and variance of a random experiment. Thus, model improvement as described for Kriging models in the literature can in principal be applied to RBF-based metamodels, too. We describe our adaptive and hierarchical metamodeling approach that deals with the specific problems that such metamodel adaptions pose to RBF-based models. We also briefly discuss implementation details and first industrial test cases.

Flavius Guiaş
TU Dortmund
A time-adaptive numerical scheme for evolution partial differential equations based on path simulation of Markov jump processes

We present a new general scheme of stochastic type for approximating ordinary differential equations, which turns out to be efficient especially for spatially discretized partial differential equations. It is a further development of the method introduced in Guiaş (2010) which is based on the direct simulation of paths of suitable Markov jump processes. This initial explicit scheme turns out to be stable even on non-uniform grids. In this talk we present the results of exploiting further the full path simulation and improve the convergence order by performing periodically Picard iterations and/or Runge-Kutta steps based on the computed trajectories. We apply the method on a model problem where a very precise time resolution is needed (a reaction-diffusion PDE which exhibits steep and fast traveling fronts) and its efficiency turns out to be superior to standard deterministic methods. We use cartesian grids in 1D and 2D and also moving grids for the 1D problem. The mathematical algorithm behind this scheme is simple and flexible and can be formulated for general evolution partial differential equations. The main challenge in improving the efficiency of the method is shifted towards an optimal 'tuning' and to implementation aspects such as sampling, data structures and computational features. By taking the mean over several independent paths this scheme is also suitable for using the facilities of parallel computing.

Literatur

Guiaş, F. (2010). Direct simulation of the infinitesimal dynamics of semi-discrete approximations for convection-diffusion-reaction problems *Math. Comput. Simulation*, **81**, 820 - 836.
Guiaş, F., Eremeev, P. (2011). A time-adaptive numerical scheme for evolution partial differential equations based on path simulation of Markov jump processes (submitted)

Lennart Jansen
Universität zu Köln
Semiexplicit methods for differential-algebraic equations

By their definition differential-algebraic equations (DAEs) are a mixture of differential and algebraic equations. With the help of projector functions the solutions of a DAE can also be seperated into a differential and an algebraic part.
In the case of an ordinary differential equation (ODE) the whole solution belongs to the differential part. Therefore an ODE can be solved with explicit solver methods which may lead to a reduction of the calculation time, because an explicit method does not need to solve a non-linear system in every time step, in contrast to an implicit method.
With the seperation of the solution into differential and algebraic parts, it is possible to formulate an explicit method on the differential solution parts while solving the algebraic ones with an implicit method. For this reason in every time step one has only to solve a non-linear system of the size of the algebraic solution parts.
As an application we will use DAEs generated by a simulation of an electric circuit with electromagnetic (EM) devices. Only one third of the solution components of these DAEs belong to the algebraic part. Simulation results of these electric circuits will be shown.

René Lamour, Roswitha März
Humboldt-Universität zu Berlin
Computational aspects of detecting DAE structures II

A regularity region describes the local characteristics of a Differential-Algebraic Equation (DAE).
We determine regularity regions of DAEs by means of sequences of continuous matrix functions. The matrix sequence is built step-by-step by certains admissible projector functions starting with the Jacobian matrices of the DAE data. For time-dependent and nonlinear DAEs the sequence contains a differentiation of a projector function.
The matrix functions are constructed pointwise. Beside common linear algebra tools such as matrix factorizations and generalized inverses, widely orthogonal projector functions are applied and algorithmic differentiation technices are used to realize the differentiation.
Several constant-ranks of related matrix functions determine the structure of a regularity region. This also allows for the detection of critical points, which marks the border of different regularity regions.
A comparison with other approaches, the discussion of numerical experiments and open problems complete the paper.

Roswitha März, René Lamour
Humboldt-Universität zu Berlin
Computational aspects of detecting DAE structures I

We present a different view on DAEs which relies on the decomposition of the DAE definition domains into several so-called regularity regions. We consider the regularity regions as prior in the analysis against obvious and hidden constraints. Determinig regularity regions we do not suppose any knowledge concerning solutions and constraints. On each regularity region the DAE has uniform structure. The structure may be different on different regions.
The commonly applied understanding of a DAE having index μ corresponds to the specific case if all solutions remain in exact one regularity region. However, more generally, the DAE solutions may shuttle between different regularity regions and stay on borderlines. If solutions cross borders of regularity regions, a critical flow behaviour must be expected. We demonstrate this phenomenon by examples.
We determine regularity regions by means of sequences of continuous matrix functions built with certains admissible projector functions. We benefit from several constant-rank conditions which offer the DAE structures, which is useful also for detecting critical points.

Michael Matthes
Universität zu Köln
Coupled systems as Abstract Differential-Algebraic Equations

We study so called Abstract Differential-Algebraic Equations (ADAEs) which are Differential-Algebraic Equations (DAEs) with operators acting on infinite dimensional Hilbert or Banach spaces. In applications these equations arise when coupling DAEs and partial differential equations (PDEs). Information is shared between these two systems by certain coupling operators. For example specific models in circuit simulation were already studied in the literature in the context of ADAEs or PDAEs.
While theory and numerics of DAEs and PDEs were well developed in the last 20 years there are just a few results for coupled DAE-PDE systems concerning solvability and convergence. We study a general prototype class of a coupled system where the infinite dimensional part of the system is governed by a monotone operator. Investigating especially the coupling terms we give an existence and uniqueness result of this prototype system. Also the Galerkin approach is discussed as it is important for numerical applications.

Roland Pulch
Bergische Universität Wuppertal
Stochastic Galerkin Methods for Partial Differential Equations with Random Parameters

We consider partial differential equations (PDEs) of elliptic, parabolic and hyperbolic type. The PDEs include parameters, which may be uncertain due to measurements or a lack of knowledge. We replace the parameters by random variables to achieve an uncertainty quantification. The resulting stochastic model can be resolved by a Monte-Carlo simulation, for example. Alternatively, we apply a spectral method involving the expansion of the unknown random fields in the generalised polynomial chaos. This expansion is based on orthogonal polynomials defined in the underlying random space. A stochastic Galerkin technique yields a larger coupled system of PDEs satisfied by an approximation of the required coefficient functions. We analyse the structure of the coupled systems in comparison to the original PDEs. The focus is on hyperbolic systems of PDEs, where the coupled system of the stochastic Galerkin method is not necessarily hyperbolic. Sufficient conditions are specified such that the coupled system inherits the hyperbolicity. We present numerical simulations of corresponding test examples.

Literatur

Pulch, R.; van Emmerich, C. (2009). Polynomial chaos for simulating random volatilities. *Math. Comput. Simulat.*, **80**, 245 - 255.
Pulch, R.; Xiu, D. (2011). Generalised polynomial chaos for a class of linear conservation laws. to appear in: *Journal of Scientific Computing*, Springer.
Xiu, D. (2010). Numerical methods for stochastic computations: a spectral method approach. Princeton University Press.

Sebastian Schöps, Michael Günther
Bergische Universität Wuppertal
Mehrskalenverfahren für die Feld-/Netzwerkkopplung

In diesem Vortrag werden Mehrskalenverfahren für die schwachgekoppelte Simulation von räumlichverteilten elektromagnetischen Bauteilen mit elektrischen Netzwerken besprochen. Wir betrachten Bauteile, die durch Maxwell's partielle Differentialgleichungen (PDEs) und einigen zusätzlichen algebraischen Kopplungsgleichungen (AE) beschrieben werden, so dass das resultierende System aus PDAEs besteht (z.B. niederfrequente Bauteile wie Transformatoren oder Motoren gesteuert durch gepulste Signale). Die Struktur, Kopplung und der Index der semidiskreten Systeme werden analysiert und maßgeschneiderte Verfahren vorgestellt. Insbesondere Cosimulation und Bypassing-Verfahren werden diskutiert. Wie zeigen analytisch und numerisch, dass die Methoden stabil und effizient arbeiten.

Bernd Simeon, Michael R. Dörfel, Anmol Goyal
Technische Universität Kaiserslautern
Isogeometrische Schalen für flexible Mehrkörpersysteme

Während es bisher in der klassischen Mehrkörperdynamik genügte, elastische Körper in Form von vorab reduzierten, niederdimensionalen Subsystemen einzubeziehen, erfordern moderne Leichtbauwerkstoffe sowie nichtlineare Kopplungselemente eine grundsätzlich neue Herangehensweise. Ein methodisches Kernstück ist dabei die simultane Kopplung des Mehrkörperformalismus mit Verfahren, die räumlich verteilte Effekte über die Gleichungen der Elastodynamik berechnen. Im Vortrag wird speziell auf den aktuellen Stand bei der Entwicklung eines Schalenmodells eingegangen, das mithilfe von isogeometrischen Finiten Elementen im Ort diskretisiert und in die Zeitsimulation eingebunden wird.

Caren Tischendorf, Sascha Baumanns
Universität zu Köln
DAE index calculation and consistent initialization of multiphysical network models

Multiphysical network models are used in several applications, for instance in circuit simulation, gas transmission or water transmission simulation. Depending on the modeling level we obtain differential-algebraic equations (DAEs) or systems of partial differential equations and differential-algebraic equations (PDAEs). We first explain the common structure of such problems. Whereas the branch elements of the networks are described by dynamic or static relations between the flow (current/gas/water) and the voltage/pressure, the network graph yields algebraic constraints for the flow.
We present a DAE index calculation for such networks basing on the network graph. Furthermore, we introduce an algorithm for computing consistent initial values for the resulting DAE systems exploiting the network structure.

Sektion 9

Stochastik

Achim Klenke (Mainz), Josef G. Steinebach (Köln)

Montag, 19. September **Seminargebäude, S15**

14:00 Mark Podolskij (Heidelberg)
Inference for Brownian semistationary processes

15:00 Andreas Eberle (Bonn)
Mixing times of Metropolis-adjusted Langevin algorithms for log-concave probability measures in high dimensions

15:30 Martin Wendler (Bochum)
Strong invariance principle for the generalized quantile process under dependence

16:00h – 16:30h Pause

16:30 Lutz Mattner (Trier)
On the statistical comparison of diagnostic tests using joint test results

17:00 Stefan Fremdt (Köln)
Page's CUSUM for the detection of changes in linear models

17:30 Hella Timmermann (Köln)
On sequential detection of a gradual change

Dienstag, 20. September **Seminargebäude, S15**

14:00 Wolfgang König (Berlin)
Localisation of the parabolic Anderson model in one island

15:00 Michael Stolz (Münster/Bochum)
Stein's method and multivariate normal approximation for random matrices

15:30 Lothar Breuer (Kent)
New results on Markov-additive processes

16:00h – 16:30h Pause

16:30 Dietmar Pfeifer (Oldenburg)
Bernstein-Copulas: wie man den "Fluch der Dimension" umgeht

17:00 Paul Ressel (Eichstätt-Ingolstadt)
Multivariate distribution functions, classical mean values, and Archimedean copulas

Lothar Breuer
University of Kent, UK
New results on Markov-additive processes

Markov-additive processes (MAPs) are a powerful generalisation of Lévy processes, allowing Markovian regime switching (or Markov-modulation) and additional jumps at the times of regime switching. Let $(\mathscr{X}, \mathscr{J})$ denote a Markov-additive process with phase-type jumps (PH-MAP). Phase-type distributions are (weakly) dense within all distributions of non-negative support, thus PH-MAPs are a fairly general subclass of MAPs. Denote the supremum process of $\mathscr{X}$ by $\mathscr{S}$. For some $a > 0$, let $\tau(a)$ denote the time when the reflected process $\mathscr{Y} := \mathscr{S} - \mathscr{X}$ first surpasses the level a. Further, let $\tau_{-}(a)$ denote the last time before $\tau(a)$ when $\mathscr{X}$ attains its current supremum. In this paper we shall derive the joint distribution of $S_{\tau(a)}$, $\tau_{-}(a)$ and $\tau(a)$, where the latter two are given in terms of their Laplace transforms. This extends recent results for spectrally negative Lévy processes to the class of PH-MAPs. First we recall pertinent results from Jiang and Pistorius (2008) and Breuer (2008), where we show that exit problems for PH-MAPs can be reduced to exit problems for Markov-modulated Brownian motions. Furthermore, we define scale functions for PH-MAPs and remark on some of their properties. The results are of interest to applications such as the dividend problem in insurance mathematics and the buffer overflow problem in queueing theory. Examples will be given for the former.

Literatur

Breuer, L. (2008). First passage times for Markov-additive processes with positive jumps of phase-type. *J. Appl. Prob.*, **45(3)**, 779-799.
Jiang, Z. and Pistorius, M. (2008). On perpetual American put valuation and first-passage in a regime-switching model with jumps. *Finance Stoch.*, **12**, 331-355.

Andreas Eberle
Universität Bonn
Mixing times of Metropolis-adjusted Langevin algorithms in high dimensions

The Metropolis-adjusted Langevin algorithm (MALA) is a Metropolis-Hastings algorithm for approximate sampling from continuous distributions. We derive upper bounds for the distance from equilibrium after a finite number of steps for MALA with semi-implicit Euler proposals applied to perturbations of Gaussian measures. For sufficiently “regular” perturbations, the estimates are dimension-independent in a sense to be specified.

Stefan Fremdt
Universität zu Köln
Page's CUSUM for the detection of changes in linear models

Has there been a change in the growth of plants or animals after an ecological catastrophe? Are certain models for the calculation of asset prices or derivatives still valid after a shock in the market? Those and more questions motivate the work in the field of change-point analysis. In this talk a linear model allowing for certain dependencies in the error terms is considered which can be applied in a whole variety of research fields. We will introduce sequential methods for the detection of abrupt parameter changes in this linear model that are based on an idea of E.S. Page that was already published in 1954 but hasn't been used in this context so far. These procedures are more stable concerning the assumptions on the time of change in contrast to CUSUM-type procedures that have been used so far. As main results the asymptotic distributions under the null hypothesis, the consistency of the procedures and the asymptotic distribution of the stopping times for "early" as well as for relatively "late" changes will be presented. Finally these methods will be compared to already existing CUSUM-approaches in a small simulation study.

Wolfgang König
WIAS Berlin and Technische Universität Berlin
Localisation of the parabolic Anderson model in one island

We consider the random Schrödinger operator on the lattice with i.i.d. potential, which is double-exponentially distributed. In a large box, we look at the lowest eigenvalues, together with the location of the centering of the corresponding eigenfunction, and derive a Poisson process limit law, after suitable rescaling and shifting, towards an explicit Poisson point process. This is a strong form of Anderson localisation at the bottom of the spectrum. Since the potential is unbounded, also the eigenvalues are, and it turns out that the gaps between them are much larger than of inverse volume order. We explain an application to concentration properties of the corresponding Cauchy problem, the parabolic Anderson model. In fact, it will turn out that the total mass of the solution comes from just one island, asymptotically for large times. This is joint work in progress with Marek Biskup (Los Angeles and Budweis).

Lutz Mattner, Frauke Mattner
Universität Trier, Kliniken der Stadt Köln
On the statistical comparison of diagnostic tests using joint test results

We consider the common problem of estimating or comparing sensitivities or specificities of (dichotomous) diagnostic tests, with the available data consisting of joint test results from the whole population, without true state determinations. Assuming the plausible latent class model of Gart and Buck (1966), it is well known that interesting inferences are possible only under not always plausible additional assumptions, most notoriously the one of conditional independence of results of different tests given the true state, as discussed and criticized in, for example, the book of Pepe (2003). We suggest to impose additional assumptions only if they are plausible in a given application, even if this leads to nonidentifiability of the parameters of interest and hence to, say, only upper confidence bounds instead of two-sided confidence intervals.

A detailed example in the talk will be the case of two diagnostic tests with the second at least as specific as the first. An application where this specificity assumption seems plausible is the comparison of two competing tests for diagnosing toxigenic Clostridium difficile from stool samples, applying an enzyme-immuno-assay either directly or after culturing (possibly nontoxigenic) Clostridium difficile. We derive confidence bounds good enough to refute the direct test.

The talk will be aimed at mathematicians without prior knowledge of diagnostic tests.

Dietmar Pfeifer
Karl von Ossietzky Universität Oldenburg
Bernstein-Copulas: wie man den 'Fluch der Dimension' umgeht

Der Modellierung und Simulation von stochastischen Abhängigkeiten versicherungstechnischer Risiken kommt insbesondere im Licht von Solvency II eine wachsende Bedeutung zu. Für die Konzeption und Implementierung interner Risikomodelle ist sie praktisch unverzichtbar. In dem Vortrag wird eine Möglichkeit auf der Basis von Bernstein- und anderen konstruktiven Copula-Ansätzen vorgestellt, die insbesondere das Problem des 'Fluchs der Dimension' umgehen. In dem Vortrag wird auch ein konkretes Anwendungsbeispiel vorgestellt.

Mark Podolskij
Universität Heidelberg
Inference for Brownian semistationary processes

We introduce a new class of continuous stochastic processes called Brownian semistationary processes (BSS). We derive limit theorems for functionals of high frequency observations of BSS processes and apply them for the estimation of the scaling parameter of the unobserved path. Furthermore, we present the link to turbulence modelling. This talk is based on the joint work with Ole Barndorff-Nielsen and Jose Manuel Corcuera.

Literatur

O. E. Barndorff-Nielsen, J. M. Corcuera and M. Podolskij (2010). Multipower variation for Brownian semi-stationary processes. *To appear in Bernoulli*.
O. E. Barndorff-Nielsen, J. M. Corcuera and M. Podolskij (2010). Limit theorems for functionals of higher order differences of Brownian semi-stationary processes. *Working paper*.

Paul Ressel
Katholische Universität Eichstätt-Ingolstadt
Multivariate distribution functions, classical mean values, and Archimedean copulas

Functions operating on multivariate distribution and survival functions are characterized, based on a theorem of Morillas, for which a new proof is presented. These results are applied to determine those classical mean values on $[0,1]^n$ which are distribution functions of probability measures on $[0,1]^n$. As it turns out, the arithmetic mean plays a universal rôle for the characterization of distribution as well as survival functions. Another consequence is a far reaching generalisation of Kimberling's theorem, tightly connected to Archimedean copulas.

Michael Stolz
Westfälische Wilhelms-Universität Münster/ Ruhr-Universität Bochum
Stein's method and multivariate normal approximation for random matrices

Let M_n be a random element of the unitary, special orthogonal, or unitary symplectic groups, distributed according to Haar measure. By a classical result of Diaconis and Shahshahani, for large matrix size n, the vector $(\mathrm{Tr}(M_n), \mathrm{Tr}(M_n^2), \ldots, \mathrm{Tr}(M_n^d))$ tends to a vector of independent, (real or complex) Gaussian random variables. Recently, Jason Fulman has demonstrated that for a single power j (which may grow with n), a speed of convergence result may be obtained via Stein's method of exchangeable pairs. In this talk, I will discuss a multivariate version of Fulman's result, which is based on joint work with Christian Döbler (Bochum).

Literatur

Döbler, C. / Stolz, M. (2010), Stein's method and the multivariate CLT for traces of powers on the compact classical groups, arXiv:1012.3730
Fulman, J. (2010), Stein's method, heat kernel, and traces of powers of elements of compact Lie groups, arXiv:1005.1306

Hella Timmermann
Universität zu Köln
On sequential detection of a gradual change

We will describe and analyze some sequential monitoring procedures for detecting a gradual change in the drift parameter of a general stochastic process satisfying a certain (weak) invariance principle. It is shown that the tests can be constructed such that the false alarm rate attains a prescribed level and that the tests have asymptotic power one. A more precise analysis of the procedures under the alternative proves that the stopping times, suitably normalized, have a standard normal limit distribution. A few results from a small simulation study are also presented in order to give an idea of the finite sample behavior of the suggested procedures.

Literatur

Steinebach, J. and Timmermann, H. (2011). Sequential testing of gradual changes in the drift of a stochastic process. *Journal of Statistical Planning and Inference*, **141**, 2682-2699.

Martin Wendler
Ruhr-Universität Bochum
Strong invariance principle for the generalized quantile process under dependence

A strong invariance principle for the empirical distribution function (the approximation by a Kiefer-Müller process) has been established by Berkes and Philipp (1977) for dependent data. We extend this results to the empirical U-process (the empirical process of the values $h(X_i, X_i)$ for a bivariate, symmetric function h). With the help of a generalized Bahadur representation, it follows that such a strong invariance principle also holds for the empirical U-quantile process and consequently for GL-statistics (linear combination of U-quantiles). GL-statistics have applications in robust estimation and robust change point detection. We obtain the functional central limit theorem and the functional law of the iterated logarithm for GL-statistics under dependence as straightforward corollaries.

Sektion 10

Geometrie und Topologie

Christian Bär (Potsdam), Hansjörg Geiges (Köln)

Montag, 19. September **Seminargebäude, S01**

14:00 Wolfgang Lück (Bonn)
On the Farrell-Jones conjecture

15:00 Thomas Schick (Göttingen)
Metrics of positive scalar curvature: existence and classification

Dienstag, 20. September **Seminargebäude, Hörsaal S01**

14:00 Ruth Kellerhals (Fribourg)
Small hyperbolic orbifolds, scissors congruence and arithmetic

15:00 Andreas Thom (Leipzig)
L^2-invariants for groups and manifolds

16:00h – 16:30h Pause

16:30 Felix Schlenk (Neuchâtel)
From symplectic geometry to number theory?

17:30 Ines Kath (Greifswald)
Indefinite extrinsic symmetric spaces

Mittwoch, 21. September **Seminargebäude, S01**

14:00 Rolf Sulanke (Berlin)
Möbius Geometrie mit Mathematica

14:30 Christian Becker (Potsdam)
Fiber integration for Cheeger-Simons differential characters

15:00 Ivan Izmestiev (Berlin)
Infinitesimal rigidity of convex surfaces and variations of the Hilbert-Einstein functional

15:30 Rolfdieter Frank (Koblenz-Landau)
Eine einfache Formel für das Volumen beliebiger Hyperebenenschnitte des n-dimensionalen Würfels

16:00h – 16:30h Pause

16:30 Stefan Müller (Seoul)
Continuous Hamiltonian and contact dynamics

17:00 Frank Pfäffle (Potsdam)
On torsion, gravity and the spectral action principle

Donnerstag, 22. September **Seminargebäude, S01**

14:00 Christoph Böhm (Münster)
Ricci flow in higher dimensions

15:00 Bernhard Hanke (Augsburg)
Positive scalar curvature, K-area and essentialness

Christian Becker
Universität Potsdam
Fiber integration for Cheeger-Simons differential characters

The group of differential characters fits into several short exact sequences relating it to smooth singular cohomology and differential forms. On a smooth fiber bundle with compact oriented fibers there are natural fiber integration maps for differential forms and smooth singular cohomology. We prove existence and uniqueness of the fiber integration for differential characters, both for fiber bundles with closed fibers and for fibers with boundary. The fiber integration commutes with the exact sequences. As an application, we construct the transgression to loop spaces and more general mapping spaces.

Ruth Kellerhals
University of Fribourg
Small hyperbolic orbifolds, scissors congruence and arithmetic

We give a survey about hyperbolic orbifolds realising minimal volume and discuss the problem and results about how to detect and characterise them. In the focus are the combinatorial and arithmetical properties in the 5-dimensional case. We report about ongoing work together with Vincent Emery.

Rolfdieter Frank
Universität Koblenz-Landau
Eine einfache Formel für das Volumen beliebiger Hyperebenenschnitte des n-dimensionalen Würfels

Im Vortrag geht es um den folgenden Satz, den ich gemeinsam mit Harald Riede bewiesen habe: Ist $C_n = [-1,1]^n$ ein n-dimensionaler Würfel, $a = (a_1, \ldots, a_n) \in (\mathbb{R} \setminus \{0\})^n$, $b \in \mathbb{R}$ und $H = \{x \in \mathbb{R}^n \,|\, a \cdot x = b\}$, so gilt

$$Vol(C_n \cap H) = \frac{|a|}{2(n-1)!} \cdot \prod_{k=1}^{n} a_k^{-1} \cdot \sum_{w \in \{1,-1\}^n} (a \cdot w + b)^{n-1} \cdot sgn(a \cdot w + b) \cdot \prod_{k=1}^{n} w_k \,.$$

Zum Beispiel ist $C_5 \cap H$ mit $H = \{x \in \mathbb{R}^5 \,|\, x_1 + x_2 + x_3 + x_4 + x_5 = 0\}$ ein vierdimensionales archimedisches Polytop. Unser Satz liefert $Vol(C_5 \cap H) = \frac{115}{12}\sqrt{5}$ und dieses Ergebnis lässt sich geometrisch bestätigen.

Bernd Hanke
Universität Augsburg
Positive scalar curvature, K-area and essentialness

We discuss several largeness properties of closed smooth manifolds and point out their geometric and topological implications.

Ivan Izmestiev
Technische Universität Berlin
Infinitesimal rigidity of convex surfaces and variations of the Hilbert-Einstein functional

Infinitesimal rigidity of smooth strictly convex surfaces is a classical result proved by Liebmann, Blaschke, and Weyl about 100 years ago. We give a new proof of it by studying the second variation of the Hilbert-Einstein functional on a class of warped product metrics. We also discuss some perspectives concerning a new approach to the Weyl problem and infinitesimal rigidity of Einstein manifolds with boundary.

Literatur

Izmestiev, I. (2011). Infinitesimal rigidity of convex surfaces through the second derivative of the Hilbert-Einstein functional II: Smooth case. arXiv:1105.5067

Ines Kath
Greifswald
Indefinite extrinsic symmetric spaces

We will study symmetric submanifolds of pseudo-Euclidean spaces. A non-degenerate submanifold of a pseudo-Euclidean space is called symmetric submanifold or extrinsic symmetric space if it is invariant under the reflection at each of its affine normal spaces. In particular, each extrinsic symmetric space is an ordinary (abstract) symmetric space. Another characterisation can be obtained in terms of the second fundamental form. Extrinsic symmetric spaces are exactly those connected complete submanifolds whose second fundamental form is parallel.
While a nice construction found by Ferus provides a classification of all extrinsic symmetric spaces in Euclidean ambient spaces, the pseudo-Riemannian situation is much more involved.
We will give a description of extrinsic symmetric spaces in pseudo-Euclidean spaces in terms of the corresponding infinitesimal objects and discuss the classification problem for these objects.

Christoph Böhm
Universität Münster
Ricci flow in higher dimensions

The long-time behavior of the Ricci flow in dimension three is described very well by the work of Hamilton and Perelman. In this talk we address on the one hand which corresponding results are known in higher dimensions, but point out on the other hand limitations of such a programme.

Wolfgang Lück
Universität Bonn
On the Farrell-Jones Conjecture

We give an introduction to the Farrell-Jones Conjecture and its applications. We give a status report. In particular we will mention the recent result of Bartels-Lück-Reich-Rüping that the conjecture holds for $\mathrm{GL}(n,\mathbb{Z})$ and, more generally, for arithmetic groups over algebraic number fields.

Stefan Müller
Korea Institute for Advanced Study
Continuous Hamiltonian and contact dynamics

Continuous Hamiltonian and contact dynamics is an extension of smooth Hamiltonian and contact dynamics to continuous flows with nonsmooth 'generating' Hamiltonian functions. Although there does no longer exist a vector field linking a flow to its Hamiltonian, each continuous flow possesses a unique Hamiltonian in the appropriate sense, and vice versa. Moreover, the usual transformation laws continue to hold, and in fact, many other fundamental properties of smooth dynamics unexpectedly persist in this continuous framework.
This survey will introduce the main players of the theory together with their most important properties, followed by a selection of interesting applications. As much as time permits, the initial motivation for this approach to some of the known C^0-phenomena in symplectic topology will be explained. The talk is based on joint work with Peter Spaeth, earlier joint work with Yong-Geun Oh, and work of Augustin Banyaga and Spaeth.

Frank Pfäffle
Universität Potsdam
On torsion, gravity and the spectral action principle

In this talk closed Riemannian manifolds equipped with orthogonal connections (with torsion) will be considered. First, I will review the classical Einstein-Cartan-Hilbert theory. Then, I will consider Dirac operators which are induced by orthogonal connections. By Connes' spectral action principle all physically relevant actions should be deducible from the spectral data of a suitable Dirac operator. The Chamseddine-Connes action is motivated by eigenvalue counting, and it predicts the right form of the Lagrangian of the standard model of particle physics. I will present a formula for the Chamseddine-Connes action in presence of torsion and discuss critical points. This project is joint work with Christoph Stephan.

Thomas Schick
Universität Göttingen
Metrics of positive scalar curvature: existence and classification

Fix a compact smooth manifold without boundary. Does it admit a Riemannian metric with positive scalar curvature? The index of the Dirac operator and the (non)-existence of harmonic spinors, as well as many "higher" refinements give rise to obstructions. On the other hand, it there are Riemannian metrics of positive scalar curvature, how does the space of all such metrics look like? What are its homotopy groups? In the talk, we will present new developments concerning obstructions. The focus, however will be on the construction and detection of interetsting topological features of the space of metrics of positive scalar curvature and of its moduli space.

Felix Schlenk
Universität Neuchâtel
From symplectic geometry to number theory?

It has been known since 1985 by work of Gromov, Ekeland-Hofer, Hofer-Zehnder and others that symplectic mappings are much more special than volume preserving mappings. For instance, Gromov's famous nonsqueezing theorem states that a ball $B^{2n}(r)$ in $\mathbb{R}^{2n}$ symplectically embeds into the cylinder $B^2(R)\times\mathbb{R}^{2n-2}$ only if $r\leq R$. In recent work with Dusa McDuff we have studied a 1-parameter family of symplectic embedding problems, namely finding for each r the smallest 4-ball into which the ellipsoid $E(1,r)$ symplectically embeds. The resulting function $f(r)$ is surprisingly complicated. This indicates the intricate structure of symplectic rigidity.

Rolf Sulanke
Humboldt Universität zu Berlin
Möbius Geometrie mit Mathematica

Moderne computer-algebraische Programme bieten die Möglichkeit, umfangreiche numerische und symbolische Rechnungen effizient auszuführen. Ich habe mich in den letzten Jahren bemüht, nicht nur einzelne Aufgaben mit Wolframs Mathematica zu lösen, sondern auch mehr und mehr Erweiterungen dieses Systems in Form von Packages zu konstruieren, die es gestatten, Teilgebiete der elementaren und der Differentialgeometrie begrifflich und rechnerisch in diesem Programm zu bearbeiten. Ein wesentlicher Vorteil dieser Methode ist die Möglichkeit, die Ergebnisse nicht nur symbolisch oder numerisch, sondern in den Dimensionen zwei und drei auch grafisch darstellen zu können. Hierzu bietet Wolframs Mathematica recht geeignete und vielseitige grafische Werkzeuge. Die Ergebnisse meiner Arbeit findet man mit knappen Kommentaren auf meiner Homepage http://www-irm.mathematik.hu-berlin.de/˜ sulanke, von der die Packages und erläuternde Notebooks herunter geladen werden können. In diesem kurzen Vortrag kann ich nur einige Beispiele vorstellen. Diese sind: 1. Pseudo-euklidische lineare Algebra mit einem Orthogonalisierungsverfahren, 2. die Herleitung von zwei zur konform-invarianten Coxeter-Entfernung zweier Hypersphären analoge Ausdrücke für Paare von räumlichen Kreisen und 3. die Klassifikation und Darstellung der Kurven konstanter Konformkrümmungen.

Andreas Thom
Universität Leipzig
L^2-Invariants for groups and manifolds

I want to review some applications of L^2-invariants to groups and manifolds. In particular, I want to report about some progress in understanding the Hopf conjecture about the sign of the Euler characteristic of aspherical manifolds and mention structure results about groups with positive first l_2-Betti number.

Minisymposium 1

Algorithmische Algebra

Jürgen Müller (Aachen), Gabriele Nebe (Aachen)

Montag, 19. September **Seminargebäude, S21**

14:00 Bettina Eick (Braunschweig)
Das Burnside Problem für Algebren

14:55 Stanislav Bulygin (Darmstadt)
Algebraische Kryptoanalyse von PRINTCipher

15:30 Thomas Feulner (Bayreuth)
Isometrie und Automorphismen von Constant Dimension Codes

16:00h – 16:30h Pause

16:30 Max Horn (Braunschweig)
Polyzyklische Quotienten und nicht-kommutative Gröbner-Basen

17:10 Viktor Levandovskyy (Aachen)
Quanten-Analogon zur graduierten Hecke-Algebra

17:50 Daniel Robertz (Aachen)
Differentialelimination für analytische Funktionen

Dienstag, 20. September **Seminargebäude, S21**

14:00 Claus Fieker (Sydney)
Working in the multiplicative group of a number field

14:55 Jan Jongen (Aachen)
Rational forms of finite groups

15:30 Markus Kirschmer (Aachen)
Bestimmen von Idealklassen in Quaternionenalgebren

16:00h – 16:30h Pause

16:30 Michael Pleger (Kaiserslautern)
Konstruktion von Darstellungen einfacher algebraischer Gruppen

17:10 Sebastian Jambor (Aachen)
An L3-U3-quotient algorithm

17:50 Lukas Maas (Duisburg-Essen)
A construction of the basic spin representations of symmetric groups

Stanislav Bulygin
Center of Advanced Security Research Darmstadt
Algebraische Kryptoanalyse von PRINTCipher

In diesem Vortrag werden wir zeigen wie man mit algebraischen Methoden wichtige kryptographische Verfahren, Blockchiffren, analysieren kann. Als konkretes Beispiel benutzen wir die Blockchiffre PRINTCipher, die im Jahr 2010 für Integrated-Circuits-Printing vorgeschlagen worden ist. Wir konzentrieren uns auf kryptoanalytische Methoden, sowie dazu benötigte algebraische Methoden und Werkzeuge, wie Gröbner-Basen und SAT-Solving.

Bettina Eick
Technische Universität Braunschweig
Das Burnside-Problem für Algebren

Das Analogon des Burnside-Problems für Algebren fragt, ob jede Algebra, in der jedes Element eine Polynomgleichung erfüllt, endlich-dimensional ist. In dem Vortrag werden Methoden zur Untersuchung des Problems vorgestellt.

Thomas Feulner, Anna-Lena Trautmann
Universität Bayreuth, Universität Zürich
Isometrie und Automorphismen von Constant-Dimension-Codes

Constant-Dimension-Codes finden Anwendung bei der Nachrichtenübertragung über Netzwerken. Sie werden definiert als Teilmengen $\mathscr{C} = \{\mathscr{U}_1, \ldots, \mathscr{U}_m\}$ der k-dimensionalen Untervektorräume in $\mathrm{GF}(q)^n$. Die zugrundeliegende Metrik ist $\mathrm{d}(U,V) := \dim(U) + \dim(V) - 2\dim(U \cap V)$. Zwei Constant-Dimension-Codes $\mathscr{C}, \mathscr{C}'$ sind *isometrisch*, falls es eine Matrix $A \in \mathrm{GL}_n(q)$ und einen Körperautomorphismus α gibt mit $\{\alpha(\mathscr{U}_1)A, \ldots, \alpha(\mathscr{U}_m)A\} = \mathscr{C}'$.
Aus Sicht der Codierungstheorie ist man nur an *Repräsentanten* der Isometrieklassen interessiert. In diesem Vortrag soll nun ein Algorithmus beschrieben werden, welcher zu gegebenen $\mathscr{C}$ einen eindeutigen Repräsentanten seiner Isometrieklasse berechnet. Außerdem ist es mit Hilfe des Algorithmus möglich, die Automorphismengruppe des Codes zu bestimmen.
Wie viele andere Algorithmen zur Berechnung kanonischer Formen (z.B. von Graphen) basiert unsere Methode auf einem Backtracking-Verfahren, welches im wesentlichen die Elemente der operierenden Gruppe durchläuft. Um möglichst große Teile des zu durchlaufenden Baums abschneiden zu können, nutzt man Homomorphismen von Gruppenoperationen und die Automorphismen des Codes.

Literatur

Feulner, T. (2009). The automorphism groups of linear codes and canonical representatives of their semilinear isometry classes. *Adv. Math. Commun.* **3**, 363 - 383.
Kötter, R. und Kschischang, F. R. (2008). Coding for Errors and Erasures in Random Network Coding. *IEEE Trans. Inf. Theory*, **54**, 3579–3591.
McKay, B. D., Practical graph isomorphism. *Congr. Numer.*, **30**, 45–87.

Claus Fieker
University of Sydney
Working in the multiplicative group of a number field

The multiplicative group of a number field is rather large and difficult to work in on a computer: we clearly do not have a finitely generated $\mathbb{Z}$-module structure that can be used. Therefore to use the multiplicative group in applications, one frequently starts by creating a finitely generated sub-group that is large enough to contain a solution but small enough to allow effective manipulation. Apart from the finite generation, a second problem comes from the (neccessary) use of logarithms to linearize the structure, it implies that the linear structure is only approximated and not exactly represented. In this context there are a few important problems to solve:

- given a finite number of non-zero number field elements, can we compute the $\mathbb{Z}$-module structure?
- given a tentative sub-group, can we enlarge it systematically?
- given a particular problem, can we find an effective set of generators for the part that we are interested in?
- given an element in the finitely generated group, can we find nicer representatives?

Examples here are the computation of the class group, S-unit group, solution of norm equations, splitting of co-cycles in cohomology groups and p-Selmer group computations. I will indicate algorithmic solutions to some of the problems, classical solutions as well as new ones based on p-adic techniques.

Max Horn
Technische Universität Braunschweig
Polyzyklische Quotienten und nicht-kommutative Gröbner-Basen

Wir beschreiben, wie man polyzyklische Quotienten von (endlich) präsentierten Gruppen algorithmisch berechnen kann, und stellen unsere Implementierung in GAP vor. Zentral dafür sind Methoden, um verallgemeinerte Gröbner-Basen in integralen Gruppenringen von polyzyklischen Gruppen zu berechnen; diese Ringe sind dabei im allgemeinen nicht kommutativ. Zum Ende geben wir ein paar Beispiele und weitere Anwendungen dieser Gröbnerbasenmethoden an.

Sebastian Jambor
RWTH Aachen
An L_3-U_3-quotient algorithm

Given a finitely presented group G on two generators, the L_3-U_3-quotient algorithm enumerates all normal subgroups $N \trianglelefteq G$ such that G/N is isomorphic to $\mathrm{PSL}(3,q)$ or $\mathrm{PSU}(3,q)$. This is done simultaneously for any q, and even works if G has infinitely many factor groups isomorphic to $\mathrm{PSL}(3,q)$ or $\mathrm{PSU}(3,q)$ (in particular, this gives a proof that G is infinite, in this case).
The algorithm uses methods from representation theory and from commutative algebra. In the talk, I will present some of the ideas of the algorithm and give a demonstration with several examples.

Jan Jongen
RWTH Aachen
Rational forms of finite groups

In this talk we will discuss the following descent question coming form invariant theory of finite groups: Let k be a perfect field and G be a finite subgroup of $\mathrm{GL}_n(\bar{k})$. Is it possible to find a subgroup of $\mathrm{GL}_n(\bar{k})$, conjugate to G, with a set of fundamental polynomial invariants whose coefficients lie in the field k?
If G is irreducible we will use the theory of central simple U-algebras (algebras equipped with an action of a finite group U) to treat this question. Algorithmically this involves Galois cohomology and number theory.

Markus Kirschmer
RWTH Aachen
Bestimmen von Idealklassen in Quaternionenalgebren

Sei K ein Zahlkörper oder aber $F_q[t]$ mit einer ungeraden Primzahlpotenz q. Eine Quaternionenalgebra A über K besitzt nur endlich viele Konjugiertenklassen von Maximalordnungen. Weiter besitzt jede solche Ordnung nur endlich viele Isomorphieklassen von Rechtsidealen.
Die Methoden zum Bestimmen von Vertretersystemen der Konjugationsklassen von Maximalordnungen bzw. von Rechtsidealklassen einer gegebenen Ordnung hängen stark von der Algebra A ab. Erfüllt A die sogenannte Eichlerbedingung, ist also an mindestens einer unendlichen Stelle unverzweigt, so lassen sich diese Fragen auf das Rechnen in (einer Strahlklassengruppe von) K zurückführen.
Anderenfalls ist die Normform von A positiv definit und solche Vertretersysteme lassen sich mit Hilfe von definiten Gittern und Maßformeln algorithmisch bestimmen. Dieser Fall soll im Vortrag behandelt werden.

Viktor Levandovskyy, Anne V. Shepler
RWTH Aachen/University of Northern Texas
Quanten-Analogon zur graduierten Hecke-Algebra

Sei K ein Körper und V ein K-Vektorraum mit Basis $v_1,\dots,v_n$. Sei weiterhin $G \subset \mathbb{GL}(V)$ eine endliche Gruppe. Betrachten wir eine assoziative K-Algebra A_κ, die von Elementen $\{t_g | g \in G\} \cup \{v_1,\dots,v_n\}$ erzeugt ist, so dass die folgenden Relationen erfüllt sind:

1. $t_g \cdot t_h = t_{gh}$ für alle $g,h \in G$ (d.h. KG ist eine Unteralgebra),
2. $t_g \cdot v = g(v) \cdot t_g$ für alle $g \in G$ und $v \in V$, wobei $g(v)$ die Wirkung von $g \in G$ auf $v \in V$ bezeichnet,
3. $v_j \cdot v_i = q_{ij} \cdot v_i \cdot v_j + \kappa(v_i, v_j)$ für $1 \leq i,j \leq n$, wobei $q_{ij} \in K^*$ und $\kappa(v_i,v_j) \in KG$.

A_κ wird das **Quanten-Analogon zur graduierten Hecke-Algebra** genannt, falls $\{v_1^{\alpha_1} \dots v_n^{\alpha_n} t_g \mid \alpha_i \in \mathbb{N}_0,\ g \in G\}$ eine K-Basis (auch Poincaré-Birkhoff-Witt-Basis genannt) von A_κ ist.
Wir präsentieren notwendige und hinreichende Bedingungen an q_{ij} und $\kappa(v_i,v_j)$, so dass A_κ zu einem Quanten-Analogon zur graduierten Hecke-Algebra wird. Wir untersuchen die Eigenschaften von solchen Algebren und deren assoziierten graduierten bzgl. $\mathbb{N}_0$-Filtrierung. Wir beweisen, dass diese Algebren noethersch sind und rechnen sowohl ihre Gel'fand-Kirillov-Dimension als auch ihre globale homologische Dimension explizit aus. Es gibt interessante Zusammenspiele zwischen Quanten-Analoga zu graduierten Hecke-Algebren, Deformationstheorie und Invariantentheorie.

Lukas Maas
Universität Duisburg-Essen
A construction of the basic spin representations of symmetric groups

Basic spin representations are the smallest faithful representations of the double covering groups of symmetric groups in odd characteristic. We present an inductive method for constructing these representations.

Michael Pleger
Technische Universität Kaiserslautern
Konstruktion von Darstellungen einfacher algebraischer Gruppen

Thema des Vortags ist die Bestimmung der irreduziblen Darstellungen einfacher algebraischer Gruppen mit Bahnen kleiner Kodimension. Bei der Untersuchung dieser Darstellungen ist es in manchen Fällen hilfreich, die jeweiligen Matrixdarstellungen zu kennen. Durch die Konstruktion zweier Darstellungen der symplektischen Gruppe Sp_4 konnte in diesen Darstellungen die minimale Kodimension einer Bahn bestimmt werden. Neben einer kurzen Einführung in die Theorie der algebraischen Gruppen und deren Darstellungstheorie wird erläutert, wie Matrixdarstellungen mit Hilfe des Computers berechnet werden können.

Daniel Robertz
RWTH Aachen
Differentialelimination für analytische Funktionen

Für eine Menge S von (komplex-)analytischen Funktionen, welche in einer gewissen parametrisierten Form gegeben ist, werden die folgenden Probleme mit Hilfe von Computer-Algebra behandelt:

1. (Erkennung) Entscheide, ob eine gegebene analytische Funktion in S liegt.
2. (Explizite Erkennung) Bestimme ggf. Parameter, welche die gegebene Funktion als Element der Menge S realisieren.
3. (Implizite Beschreibung) Entscheide, ob es ein System partieller Differentialgleichungen gibt, dessen Lösungsmenge S ist, und finde ggf. eines.

Der Fall von Mengen S, die durch gewisse lineare Parametrisierungen gegeben sind, ist gemeinsame Arbeit mit W. Plesken. In diesem Vortrag gebe ich einen Überblick über diese Resultate und präsentiere neue Ergebnisse für bilineare Parametrisierungen. Dabei werden Methoden der Differentialalgebra, z. B. der Janet-Algorithmus zum Lösen von Problemen der Differentialelimination, verwendet.

Minisymposium 2

Analysis und Simulation von Nanostrukturen

Wolfgang Reichel (Karlsruhe), Christian Wieners (Karlsruhe)

Montag, 19. September **Seminargebäude, S26**

14:00 Guido Schneider (Stuttgart)
The mKdV equation as a model for short pulses

14:30 Christian Engström (Zürich)
Spectral approximation of operator functions with periodic coefficients

15:00 Wolfgang Reichel (Karlsruhe)
Ground states for the nonlinear Schroedinger-equation with interface

15:30 Abdullah Demirel (Karlsruhe)
Exponentielle Mehrschrittverfahren und deren Anwendung zur Simulation optischer Resonatoren

Dienstag, 20. September **Seminargebäude, S26**

14:00 Kersten Schmidt (TU Berlin)
Modelling of photonic crystal wave-guides modes

14:30 Sven Heumann (Karlsruhe)
Inverse Streuprobleme in chiralen Medien

15:00 Christian Wieners (Karlsruhe)
Parallel computation of photonic band gaps

15:30 Markus Richter (Karlsruhe)
Optimierung photonischer Bandstrukturen

Abdullah Demirel
Karlsruhe Institut für Technologie
Exponentielle Mehrschrittverfahren und deren Anwendung zur Simulation optischer Resonatoren

In der Physik treten häufig Anwendungen auf, deren Modellierung auf zeitabhängige partielle Differentialgleichungen führen, bei denen nur in einem kleinen Teil des Rechengebiets eine Ortsdiskretisierung mit sehr kleinen Elementen (Dreiecke, Tetraeder, etc.) benötigt wird. Diese kleinen Elemente erfordern jedoch bei der Zeitintegration mit expliziten Verfahren die Verwendung von sehr kleinen Zeitschrittweiten und machen damit Standardverfahren ineffizient.
In diesem Vortrag erläutern wir die Konstruktion spezieller exponentieller Mehrschritt-Verfahren, mit denen eine effiziente Simulation optischer Ringresonatoren möglich ist. Unsere Implementierung basiert auf einem Multiple-Time-Stepping Ansatz und kommt ohne die Berechnung von Produkten von Matrixfunktionen mit Vektoren aus, wie sie üblicherweise bei exponentiellen Integratoren benötigt werden. Der Vortrag basiert auf gemeinsamer Arbeit mit Kurt Busch, Jens Niegemann und Marlis Hochbruck im Rahmen des DFG Graduiertenkollegs 1294.

Kersten Schmidt, Willy Dörfler
TU Berlin
Modelling of photonic crystal wave-guides modes

In this project we study appearing modes in photonic crystal wave-guides of finite width and infinite periodicity in the other direction. The TE and TM modes for a given frequency ω are determined by a quadratic eigenvalue problem in the quasi-momentum k in the unit cell even if the material is frequency-dependent. The unit cell is an infinite strip. Truncating the strip and using Dirichlet-to-Neumann maps as absorbing boundary conditions would destroy the structure of the eigenvalue problem. We compare different ways to model the behaviour at infinity where the eigenvalue problem remains quadratic. For a highly accurate discretisation we use the *p*-version of the finite element method on meshes with curved cells.

Christian Engström
ETH Zürich
Spectral approximation of operator functions with periodic coefficients

A large number of processes are accurately described by operator functions with a nonlinear dependence of a spectral parameter, but a linear dependence on the field. Problems involving operator functions result from many important applications in fluid dynamics, acoustics, quantum mechanics, and electromagnetic field theory. In this talk, I focus on Galerkin spectral approximation theory for operator functions with periodic coefficients. The main applications are metallic photonic crystals and metamaterials, which are promising materials for controlling and manipulating electromagnetic waves. We show basic properties of the spectrum and use high-order finite element methods with curvilinear elements to discretize the nonlinear eigenvalue problem. The resulting matrix problems are transformed into linear eigenvalue problems and approximate eigenpairs are computed with a Krylov space method. Two different linearization techniques for rational eigenvalue problems will be discussed.

Sven Heumann
Karlsruher Institut für Technologie
Inverse Streuprobleme in chiralen Medien

Ein Objekt heißt CHIRAL, wenn es nicht identisch mit seinem Spiegelbild ist. In der Chemie bezieht sich der Begriff auf Moleküle. Chirales Material ist optisch aktiv: die Polarisation linear polarisierten Lichts wird gedreht. Linksdrehend und rechtsdrehend zirkulär polarisierte Wellen breiten sich mit unterschiedlicher Geschwindigkeit aus. Wir betrachten folgende Situation. Ein beschränktes chirales Objekt Ω in Vakuum wird durch eine zeitharmonische elektro–magnetische Welle getroffen. Die einfallende Welle dringt einerseits in das Objekt ein. Andererseits wird sie gestreut. Wir formulieren dieses (direkte) Streuproblem variationell und untersuchen es auf Existenz und Eindeutigkeit mit Hilfe einer Integralgleichungsmethode. Das asymptotische Verhalten einer ausstrahlenden Lösung ist durch ihr Fernfeld charakterisiert. Ist das Fernfeld gegeben, besteht das inverse Problem darin, Ω zu lokalisieren. Dies wird mit der Faktorisierungsmethode von A. Kirsch gelöst: Definiere den Fernfeldoperator F, der das einfallende Feld auf das erzeugte Fernfeld abbildet. Wir zeigen die Faktorisierung $F = H^*TH$ mit speziellen Operatoren H, T und beweisen, dass Ω durch das Bild des adjungierten Operators H^* charakterisiert ist. Ferner existiert ein Zusammenhang zwischen dem als bekannt vorausgesetzten Bild von F und dem von H^*. Als numerisches Beispiel betrachten wir ein zylindrisches Streuproblem.

Wolfgang Reichel
Karlsruhe Institut für Technologie
Ground states for the nonlinear Schroedinger-equation with interface

We are interested in ground states for the nonlinear Schrödinger-equation (NLS) with an interface between two purely periodic media. This means that the coefficients in the NLS are modelling two different periodic media in each halfspace. The resulting problem no longer has a periodic structure. Using variational methods we give conditions on the coefficients such that ground states are created/prevented by the interface. These ground states appear as solitary waves in optical waveguides (joint work with Michael Plum and Tomas Dohnal).

Markus Richter
Karlsruher Institut für Technologie (KIT)
Optimierung photonischer Bandstrukturen

Unter einem photonischen Kristall versteht man einen Nichtleiter, dessen Materialstruktur eine räumliche Periodizität aufweist. Die Periodenlängen betragen dabei typischerweise nur wenige Hundert Nanometer. Durch ein geeignetes mathematisches Modell für die Lichtausbreitung in periodischen Medien, kann jedem photonischen Kristall eine so genannte photonische Bandstruktur zugeordnet werden. Aus einer solchen Bandstruktur lassen sich bestimmte optische Eigenschaften des photonischen Kristalls ablesen. Für technische Anwendungen ist es vorteilhaft, bestimmte Kenngrößen der Bandstruktur zu maximieren. Da die Bandstruktur letztlich eine Funktion der Materialstruktur eines photonischen Kristalls ist, kann man ein solches Problem als Form- oder Topologieoptimierungsproblem formulieren. Der Vortrag stellt das zugrunde liegende mathematische Modell sowie einige numerische Algorithmen vor, mit denen Probleme der Bandstrukturoptimierung gelöst werden können.

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Guido Schneider
Universität Stuttgart
The mKdV equation as a model for short pulses

We consider a lattice model for the evolution of electro magnetic waves in homogeneous and periodic media. With a multiple scaling ansatz a mKdV equation can be derived. We prove an approximation theorem showing that solutions of the original system behave as predicted by the modulation equation. Our approach allows the description of short and ultra short light pulses.

Christian Wieners
Karlsruhe Institut für Technologie
Parallel computation of photonic band gaps

We investigate photonic crystals, modeled by a spectral problem for Maxwell's equations with periodic electric permittivity. By Floquet-Bloch theory, the spectrum has band-gap structure, and the bands are characterized by families of eigenvalue problems on a periodicity cell, depending on a parameter k varying in the Brillouin zone K. The numerical approximation of a band gap requires the accurate computation of several eigenvalues for sufficiently many parameters k. We introduce a parallel multgrid method for Maxwell's equations discretized with suitable modified finite elements in order to handle the quasi-periodic boundary conditions (depending on the parameter k which introduces a complex shift along periodically identified boundaries). This is used as a preconditioner in the iterative eigenvalue solver LOBPC. Here, it is required to modify the LOBPC method by including a projection onto the divergence free vector fields in every iteration step. Again, this projection is realized by a parallel multigrid method. We demonstrate the efficiency of this method by several examples.

Minisymposium 3

Approximierungsmethoden und schnelle Algorithmen

Ralf Hielscher (Chemnitz), Stefan Kunis (Osnabrück)

Mittwoch, 21. September **Seminargebäude, S26**

16:30 Antje Vollrath (Braunschweig)
A new algorithm for fast Fourier transforms on the rotation group

17:00 Michael Pippig (Chemnitz)
Parallel fast Fourier transforms and their application to particle simulation

17:30 Brigitte Forster (München)
Polyzyklische Quotienten und nicht-kommutative Gröbner-Basen

18:00 Jürgen Prestin (Lübeck)
Quadrature Rules for Scattered Data on Spherical Triangles

Donnerstag, 22. September **Seminargebäude, S26**

14:00 Holger Rauhut (Bonn)
Recovery of functions in high dimensions via compressive sensing

14:30 Frank Filbir (München)
Approximation on Manifolds

15:00 Jan Hamaekers (St. Augustin)
HCFFT: A fast Fourier transformation software library for general hyperbolic cross/sparse grid spaces

15:30 Lutz Kämmerer (Chemnitz)
Stable interpolation of hyperbolic cross trigonometric polynomials

16:00h – 16:30h Pause

16:30 Bastian Harrach (München)
Fast shape-reconstruction in electrical impedance tomography

17:00 Florian Boßmann (Göttingen)
Model based image pattern recognition in ultrasonic non destructive testing

17:30 Sören Häuser (Kaiserslautern)
Shearlet Coorbit Spaces: Traces and Embeddings

18:00 Jürgen Frikel (München)
A new framework for tomographic reconstruction at a limited angular range

Florian Boßmann
Universität Göttingen
Model based image pattern recognition in ultrasonic non destructive testing

Ultrasonic non destructive testing methods have achieved rapidly gaining prominence as reli-able techniques for tube inspection. Its use as inspection tool brings into light the challenge of developing fast and reliable data processing methods in order to be able to characterize flaws in the material. In particular, the determination of precise positions and dimensions of flaws is a complicated task due to the huge amount of data. Moreover, the obtained data contains strong noise caused e.g. by (multiple) reflections from mode converted signals.
In our group a new simplified physical model for the problem of tube inspection by ultrasound waves has been developed. Using this model we are able to solve the inverse problem of defect reconstruction in two steps. In particular, we use the sparsity of this problem: Normally the number and size of defects will be small compared to the tube size. This means only a small number of reflections generates the measured data. In a first step we compute the position and amplitude of those reflections by solving a sparse representation problem. Taking this information we can solve the inverse problem of our model.
In this talk, the model and some basic ideas of its inversion will be summarized. First numerical results can be shown. This is joined work with my supervisor Gerlind Plonka-Hoch (Göttingen).

Brigitte Forster
Technische Universität München
Interpolation with fundamental splines of fractional order

Fractional B-splines B_σ, $\sigma \geq 1$, are piecewise polynomials of fractional degree that interpolate the classical Schoenberg splines B_n, $n \in \mathbb{N}$, with respect to the degree. As the Schoenberg splines of order ≥ 3, they in general do not satisfy the interpolation property $B_\sigma(n-k) = \delta_{n,k}$, $n,k \in \mathbb{Z}$. However, the application of the interpolation filter $1/\sum_{k\in\mathbb{Z}} \widehat{B}_\sigma(\omega - 2\pi k)$—if well-defined—in the frequency domain yields a fundamental spline of fractional order that does satisfy the interpolation property. We handle the ambiguity of the complex exponential function appearing in the denominator of the interpolation filter, and relate the filter to interesting properties of the Hurwitz zeta function. Finally, we show that the fundamental splines of fractional order fits into the setting of Kramer's Lemma and allows for a family of sampling, resp., interpolation series. This is joint work with Peter Massopust, Helmholtz Zentrum München.

Jürgen Frikel
Institut für Biomathematik und Biometrie, Helmholtz Zentrum München
A new framework for tomographic reconstruction at a limited angular range

We investigate the reconstruction problem for limited angle tomography. Such problems arise naturally in applications like digital breast tomosynthesis, dental tomography, etc. Since the acquired tomographic data is highly incomplete, the reconstruction problem is severely ill-posed and the traditional reconstruction methods, as filtered backprojection (FBP), do not perform well in such situations. Our approach is based on the observation that for a given acquisition geometry only a few (visible) structures of the unknown object can be reconstructed using a limited angle data set. By formulating the problem in the curvelet domain, we can characterize those curvelet coefficients, which correspond to visible structures in the image domain. The integration of this a-priori information into the reconstruction problem leads to a considerable dimensionality reduction in the transform domain and, thus, accelerates the corresponding reconstruction algorithms.

Jan Hamaekers
Fraunhofer SCAI, Sankt Augustin
HCFFT: A fast Fourier transformation software library for general hyperbolic cross/sparse grid spaces

In this talk, we will present our software library HCFFT for fast Fourier transformations on general sparse grid approximation spaces. The curse of dimension limits the application of standard full grid spaces to low dimensional approximation problems and thus limits also the application of the conventional multi-dimensional fast Fourier transformation method. For functions which fulfill certain additional regularity assumptions, sparse grid spaces allows us to circumvent the curse of dimension at least to some extend. Our library HCFFT enables us to perform a fast Fourier transformation on these spaces. In particular, this includes optimized sparse grid approximation spaces, e.g. energy-norm sparse grid like spaces, and also dimension-adaptive sparse grid approximation spaces. We will discuss costs, accuracy, convergence rates, and some implementational details and applications.

Bastian Harrach
Technische Universität München
Fast shape-reconstruction in electrical impedance tomography

The mathematical problem behind electrical impedance tomography (EIT) is how to reconstruct the coefficient $\sigma(x)$ in the elliptic partial differential equation

$$\nabla \cdot \sigma(x) \nabla u(x) = 0, \quad x \in \Omega, \tag{3}$$

from knowledge of the Neumann-to-Dirichlet operator

$$\Lambda(\sigma) : \; g \mapsto u|_{\partial\Omega}, \quad u \text{ solves (3).}$$

We concentrate on the following anomaly detection (or shape detection) problem in EIT. Assume that σ differs from a known reference conductivity σ_0 only in a (possibly disconnected) open subset D with $\overline{D} \subset \Omega$,

$$\sigma(x) = \sigma_0 + \sigma_D(x)\chi_D(x),$$

where $\chi_D(x)$ denotes the characteristic function of D. Our goal is to locate the conductivity anomalies D from $\Lambda(\sigma)$.
Somewhat surprisingly, linearizing the inverse problem of EIT does not lead to shape errors (Harrach/Seo, 2010). Based on this result, we will derive fast shape reconstruction methods in this talk.

Literatur

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Sören Häuser
Technische Universität, Kaiserslautern
Shearlet coorbit spaces: traces and embeddings

In recent years it has turned out that shearlets have the potential to retrieve directional information so that they became interesting for many applications. Moreover the shearlet transform has the outstanding property to stem from a square integrable group representation. This remarkable fact provides the opportunity to design associated canonical smoothness spaces, so-called shearlet coorbit spaces by applying the general coorbit theory derived by Feichtinger and Gröchenig. However, once these abstract smoothness space are established some natural questions arise. Of course one would like to know how these spaces look like and how they are related to other known classical smoothness spaces such as Besov or Triebel-Lizorkin spaces. Moreover, one would like to understand the structure of these new spaces. That is, it would be desirable to know how these new scales of shearlet coorbit spaces behave under embeddings and trace operations.
In this talk we examine structural properties of shearlet coorbit spaces in higher dimensions. We prove embedding theorems for subspaces of shearlet coorbit spaces resembling shearlets on the cone in three dimensions into Besov spaces. The results are based on general atomic decompositions of Besov spaces. Furthermore, we establish trace results for these subspaces with respect to the coordinate planes. It turns out that in many cases these traces are contained in lower dimensional shearlet coorbit spaces. To prove these results we apply the concept of coorbit molecules recently developed by Gröchenig and Piotrowski.

Joint work with S. Dahlke (Philipps-Universität Marburg), G. Steidl (Technische Universität Kaiserslautern) and G. Teschke (Hochschule Neubrandenburg).

Lutz Kämmerer
Technische Universität Chemnitz
Stable interpolation of hyperbolic cross trigonometric polynomials

A straightforward discretisation of high-dimensional problems often leads to an exponential growth in the number of degrees of freedom. So, computational costs of even efficient algorithms like the fast Fourier transform increase similar.
Trigonometric polynomials with frequencies only supported by hyperbolic crosses allow for a good approximation of functions of appropriate smoothness and decrease the number of used Fourier coefficients strongly. As a matter of course, an important issue is the customisation of efficient algorithms to these thinner discretisations.
Sparse grids are the natural discretisations in the spatial domain. The corresponding Fourier transform suffers from stability problems. For that reason we consider sets produced by multiples of a so-called generating vector as spatial discretisations. Therewith an easy and fast evaluation of trigonometric polynomials at the grid nodes is guaranteed. Some additional assumptions ensure even stability and besides the fast reconstruction of trigonometric polynomials from the function values. We discuss necessary and sufficient conditions allowing for the stable reconstruction.

Frank Filbir
Institut für Biomathematik und Biometrie, Helmholtz Zentrum München
Approximation on manifolds

In many practical applications, for example document analysis, semi-supervised learning, and inverse problems one is confronted with functions defined on a (Riemannian) manifold M imbedded in a high dimensional ambient space. These functions have to be approximated by using sample values of the function. Due to several restrictions like experimental setup etc. we can hardly assume that the sampling nodes are located on a regular grid. This means we have to come up with an approximation process which can, on the one hand, work with scattered data and, on the other hand, has sufficiently good approximation rate. We consider approximation processes of the form

$$\sigma_L f(x) = \sum_{j=0}^{\infty} H\Big(\frac{\ell_j}{L}\Big)\langle f, \phi_j\rangle \phi_j(x),$$

where H is a suitable filter function and $\{\phi_j\}$ is an orthonormal function system on the manifold M. In order to get an approximation process which has the aforementioned properties it is necessary to construct quadrature formulas with certain degree of exactness. In this talk we will address this problem and we will show how this is related to the problem of constructing well localized kernels on M. This talk is based on joint work with Hrushikesh N. Mhaskar, Department of Mathematics, California State University, U.S.A.

Michael Pippig
Technische Universität Chemnitz
Parallel fast fourier transforms and their application to particle simulation

The direct computation of Coulomb interactions in large particle systems is a computational demanding problem. For periodic boundary conditions, Ewald proposed to split the interactions into two fast converging parts. While the first part is short ranged and includes the singularity, the long ranged and smooth part converts fast in Fourier domain. Using nonequispaced fast Fourier transforms, the calculation of the smooth part can be further sped up. This leads to a fast algorithm comparable to the particle-particle particle-mesh method. During this talk, we develop an algorithm for the massively parallel computation of the equispaced fast Fourier transform, generalize it to the nonequispaced case and apply it to parallelize the fast Ewald summation. The resulting algorithm will be compared to other algorithms for the fast computation of Coulomb interactions.

Jürgen Prestin
Universität Lübeck
Quadrature rules for scattered data on spherical triangles

In this talk we present the construction of quadrature rules on arbitrary triangulations of the sphere which are exact for polynomials of some fixed degree. In the first part we study quadrature on some preassigned nodes so that we are able to compute integrals over triangles for arbitrary polynomials. In a second part we apply Cholesky decomposition methods to obtain the weights for scattered data. For our numerical tests we used Mathematica where we carried out all calculations in high accuracy or even with exact numbers. So we were able to overcome a lot of instability problems particularly for very small and thin triangles. Finally, we compare our local quadrature rules on triangulations and some small polynomial degree of exactness with global formulas on the whole sphere and high degree of polynomial exactness. Particularly, for clustered data the local methods seem to be better. This is joint work with Judith Beckmann (University of Lübeck) and Hrushikesh N. Mhaskar (California State University).

Holger Rauhut
Universität Bonn
Recovery of functions in high dimensions via compressive sensing

Compressive sensing predicts that sparse vectors can be recovered efficiently from highly undersampled measurements. It is known in particular that multivariate sparse trigonometric polynomials can be recovered from a small number of random samples. Classical methods for recovering functions in high spatial dimensions usually suffer the curse of dimension, that is, the number of samples scales exponentially in the dimension (the number of variables of the function). We introduce a new model of functions in high dimensions that uses “sparsity with respect to dimensions”. More precisely, we assume that the function is very smooth in most of the variables, and is allowed to be rather rough in only a small but unknown set of variables. This translates into a certain sparsity model on the Fourier coefficients. Using techniques from compressive sensing, we are able to recover functions in this model class efficiently from a small number of samples. In particular, this number scales only logarithmically in the spatial dimension - in contrast to the exponential scaling in classical methods.

Antje Vollrath
Technische Universität Braunschweig
A new algorithm for fast Fourier transforms on the rotation group

We will discuss an approximate fast algorithm to calculate the discrete Fourier transform on the rotation group SO(3). The algorithms to compute such transforms are based on evaluating the so-called Wigner-D functions D_ℓ^{mn} that yield an orthogonal basis of $L^2(\mathrm{SO}(3))$. Using these basis functions, our method needs $\mathcal{O}(L^3 \log L + Q)$ arithmetic operations for a degree-L transform at Q nodes free of choice, with the desired accuracy, instead of $\mathcal{O}(L^3 Q)$ in a naive approach.
This acceleration, is achieved by exploiting the tensor product character of the Wigner-D functions. With this decomposition arises a set of orthogonal polynomials closely related to Jacobi polynomials - the Wigner-d functions.
The talk will focus on a new efficient method to calculate a particular linear transformation that allows us to replace Wigner-d functions of arbitrary orders with those of low orders and eventually with Chebyshev polynomials. Based on the differential equations, whose solutions are the Wigner-d functions, we show that the linear mapping for these conversions appears as the eigenvector matrix of certain semiseparable matrices. This enables us to employ a known divide-and-conquer algorithm for symmetric semiseparable eigenproblems together with the fast multipole method to calculate the desired change of basis.
Finally by replacing the Chebyshev expansions by expansions of complex exponentials we can employ the well-analysed nonequispaced fast Fourier transform algorithm for the computations.

Minisymposium 4

Biostatistik: Multiplizität und hochdimensionale Daten

Helmut Finner (Düsseldorf), Arnold Janssen (Düsseldorf)

Mittwoch, 21. September **Seminargebäude, S15**

14:00 Begrüßung

14:10 Edgar Brunner (Göttingen)
Hochdimensionale Globaltests

15:00 Elmar Diederichs (Berlin)
Modellselektion durch semidefinite Relaxation

15:30 Alexander Meister (Rostock)
Nichtparametrische Regressionsanalyse für gruppierte Daten

16:00h – 16:30h Pause

16:30 Christian Gieger (München)
The role of genetically determined metabotypes in the genetics of complex traits and polygenic disorders

17:20 Sandra Landwehr (Düsseldorf)
Signifikanz und Abhängigkeit bei Genexpressionsanalysen

Donnerstag, 22. September **Seminargebäude, S16**

14:00 Jörg Rahnenführer (Dortmund)
Vorhersage von Progression und Therapieantwort bei Krebspatienten: Sind hochdimensionale genomische Daten ein Segen oder ein Fluch?

14:45 Marsel Scheer (Düsseldorf)
Die erwartete Anzahl falscher Ablehnungen als Fehlerkriterium

15:30 Werner Brannath (Bremen)
Shortcuts for locally consonant closed test procedures

16:00h – 16:30h Pause

16:30 Korbinian Strimmer (Leipzig)
Higher Criticism versus False Discovery Rates

17:00 Veronika Gontscharuk (Düsseldorf)
Plug-in Schätzer für die Anzahl wahrer Nullhypothesen bei multiplen Testproblemen

17:30 Thorsten Dickhaus (Berlin/Clausthal)
Über die effektive Anzahl an Tests in genetischen Assoziationsanalysen

18:00 Frank Konietschke (Göttingen)
Simultane Konfidenzintervalle für Multiple Kontraste in Repeated Measures Designs

Werner Brannath, Frank Bretz
Universität Bremen und Novatis Pharma AG
Shortcuts for locally consonant closed test procedures

The closed testing principle provides a general and simple framework to construct powerful multiple test procedures for k elementary null hypotheses while controlling the familywise error rate in the strong sense. However, the closed testing principle has the disadvantage of leading to the evaluation of $\mathcal{O}(2^k)$ intersection hypotheses. Multiple test procedures based on the closed testing principle may thus require substantial computational efforts. Consonant closed test procedures for unrestricted hypotheses have the advantage of rejecting at least one elementary null hypothesis whenever the global null hypothesis is rejected and thus admit shortcuts of size k. If the elementary hypotheses are restricted by logical constraints, the closure of common tests, like max-t or min-p tests, may not be consonant and no shortcut may be available. In this paper we introduce a weaker consonance property, denoted as local consonance, and show that many closed test procedures with restricted hypotheses satisfy this condition. We describe a general algorithm to construct related shortcuts and illustrate the results with several applications.

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Edgar Brunner
Universität Göttingen
Hochdimensionale Globaltests

Multivariate oder Repeated-Measures Daten heißen hochdimensional, wenn die Dimension d größer ist als die Anzahl der unabhängigen Beobachtungsvektoren. Der Vortrag gibt einen kurzen Überblick vom Beginn der Entwicklung beginned mit Box (1954), Geisser und Greenhouse (1958) und Dempster (1958) bis zum derzeitigen Stand Srivastava und Du (2008), Brunner (2009) und Chen und Qin (2010). Dabei werden insbesondere die folgenden Gesichtpunkte diskutiert:

- verschiedene Methoden, das Box'sche ε zu schätzen
- der Unterschied zwischen multivariaten Daten und Repeated-Measures Daten
- die Annahme der multivariaten Normalverteilung
- die unterschiedliche Asymptotik: n, d fest oder $\to \infty$.

Wegen der Fülle der bisher unter den verschiedenen Gesichtspunkten entwickelten Verfahren ist es nicht möglich in der Kürze der Zeit auf alle Verfahren einzugehen. Es werden einige neuere Verfahren vorgestellt, insbesondere wird das Problem der Annahme gleicher Kovarianzmatrizen im hochdimensionalen Fall diskutiert.

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Thorsten Dickhaus
Humboldt-Universität zu Berlin, derzeit: Technische Universität Clausthal
Über die effektive Anzahl an Tests in genetischen Assoziationsanalysen

Wir studieren exakte Tests für Kontingenztafeln, insbesondere exakte Chi-Quadrat Tests und exakte Tests vom Fisher-Typ. In der Praxis werden solche Tests typischerweise ohne Randomisierung ausgeführt, was zu reproduzierbaren Ergebnissen führt, jedoch das Signifikanzniveau nicht voll ausschöpft. Wir demonstrieren, dass dies zu methodischen und praktischen Schwierigkeiten führen kann, wenn, wie in genetischen Assoziationsstudien, viele Tafeln gleichzeitig zu analysieren sind, vgl. dazu auch Finner et al. (2010). Der dort vorgeschlagene Lösungsansatz, die Verwendung von realisierten randomisierten p-Werten, erweist sich als besonders nützlich für daten-adaptive plug-in Prozeduren aus der modernen Theorie multipler Tests.
Darüber hinaus bearbeiten wir das Problem positiv korrelierter marginaler p-Werte in Assoziationsanalysen und gehen auf Techniken zur Multiplizitätsreduktion ein, die von der Korrelationsstruktur (beschrieben durch Kopplungsungleichgewichte, englisch: linkage disequilibrium, LD) genetischer Marker Gebrauch machen. Durch Kombination von (i) Verwendung realisierter randomisierter p-Werte, (ii) Schätzen des Anteils informativer Marker und (iii) Ausnutzung der LD-Struktur kommen wir zu einer Methode, die „effektive Anzahl an Tests“ zu bestimmen.
Anhand von Realdatenbeispielen zeigen wir die Stärken der Methode in der Praxis auf.

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Elmar Diederichs, Vladimir Spokoiny
Weierstraß Institut für angewandte Analysis und Stochastik Berlin

Modellselektion durch Semidefinite Relaxation

Modellselektion durch Minimierung des um einen Strafterm für Modelkomplexität penalisierten empirischen Risikos hat aufgrund der überlegenen performance inzwischen die traditionellen Kriterien zur Modellselektion nach Akaike und Schwarz abgelöst. Das mathematische design des Strafterms für Modellkomplexität ist für die Entscheidung zwischen zwei Modellen dabei zentral. Leider fehlte bisher eine mathematische Theorie für dessen Rechtfertigung. Der Vortrag berichtet über neue Konzentrationseigenschaften des empirischen Risikos, die die Betrachtung von Differenzen von Straftermen und deren mathematisches design motivieren. Die Minimierung des auf diese Weise neu formulierten, bivariaten, empirischen Risikos führt auf das diskretes Optimierungsproblem der Berechnung eines Sattelpunktes. Gezeigt wird, dass sich dieses Problem auf ein semidefinites Optimierungsproblem relaxieren und sich auch in hohen Dimensionen effizient lösen lässt.

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Christian Gieger
Institute of Genetic Epidemiology, Helmholtz Zentrum München, Neuherberg, Germany

The role of genetically determined metabotypes in the genetics of complex traits and polygenic disorders

Metabolite concentrations provide a direct readout of biological processes in the human body, and are associated with disorders such as cardiovascular and metabolic diseases. We have identified common genetic polymorphisms that alter an individual's metabolic capacities. Knowledge of these genetically determined metabotypes in the human population is key to identify the contributions and interactions of genetic and environmental factors in the etiology of complex diseases. I will present a genome-wide association study with 163 metabolic traits, covering a biologically relevant panel of amino acids, sugars, acylcarnitines, and phospholipids, using 1809 participants from the KORA population. Most often, the genetic variant is located in or near enzyme or solute carrier coding genes, where the associating metabolic traits match the proteins' function. The analysis of such a dataset is a major computational effort. We calculated more than 26,000 separate genome-wide association studies, in which we associated 500,000 single nucleotide polymorphisms with 163 metabolite concentrations as well as all possible 26,406 metabolite concentration ratios. Statistical modelling is not trivial as metabolite concentrations are highly correlated due to common and connected metabolic pathways. In summary, this study allowed us to draw a systemic perspective of the genetic variation that is found in metabolism.

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Veronika Gontscharuk, Helmut Finner
Deutsches Diabetes-Zentrum an der Heinrich-Heine-Universität Düsseldorf, Leibniz-Zentrum für Diabetes-Forschung, Institut für Biometrie und Epidemiologie

Plug-in Schätzer für die Anzahl wahrer Nullhypothesen bei multiplen Testproblemen

Einige multiple Testverfahren, die ein Fehlerkriterium kontrollieren, werden konservativer, wenn der Anteil wahrer Nullhypothesen kleiner wird. Manchmal kann man die Güte solcher Tests verbessern, indem die Anzahl aller Tests durch die geschätzte Anzahl n_0 wahrer Nullhypothesen bei der Berechnung kritischer Werte ersetzt wird. Beispielsweise haben Schweder und Spjøtvoll (1982) die Anwendung von Schätzern für n_0 im Falle des klassischen Bonferroni Tests vorgeschlagen. Kürzlich haben Finner und Gontscharuk (2009) und Guo (2009) bewiesen, dass solche Bonferroni plug-in (BPI) Testprozeduren die FWER unter geeigneten Annahmen kontrollieren. Darüber hinaus werden plug-in Schätzer auch bei FDR kontrollierenden Testprozeduren eingesetzt. Zum Beispiel für die FDR Kontrolle bei speziellen linearen schrittweisen Tests hat Sarkar (2008) eine schöne Bedingung an plug-in Schätzer gestellt.
In diesem Vortrag betrachten wir einige Klassen von plug-in Schätzern für n_0. Oft ist es ausreichend, die Kontrolle der zugrunde liegenden Fehlerrate für sogenannte Dirac-Uniform Konfigurationen nachzuweisen. Dies liefert exakte Formeln und obere Schranken für z.B. FWER und FDR für sowohl unabhängige als auch austauschbare Teststatistiken. Auch für eine Reihe von abhängigen Teststatistiken lässt sich asymptotische Fehlerkontrolle bei plug-in Tests zeigen.

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Frank Konietschke
Universitätsmedizin Göttingen - Abteilung Medizinische Statistik
Simultane Konfidenzintervalle für Multiple Kontraste in Repeated Measures Designs

Bretz, Genz und Hothorn (2001) entwickeln für unabhängige Beobachtungen parametrische multiple Kontrasttests und simultane Konfidenzintervalle für lineare Kontraste (z.B. multiple Vergleiche gegen eine Kontrollgruppe, Tukey-type All-Pairs Vergleiche, Changepoint, etc.). Diese Verfahren können auf beliebige Fragen der Anwender adaptiert werden und basieren auf der exakten multivariaten t-Verteilung verschiedener Teststatistiken zur Überprüfung der Teilhypothesen. In vielen Versuchen und Studien werden Messungen allerdings an unabhängigen Subjekten zu mehreren Zeitpunkten erhoben. Das einfachste *Repeated Measures Design* ist das verbundene Zwei-Stichprobenproblem, bei dem n Versuchseinheiten unter zwei verschiedenen Bedingungen (Zeitpunkten) wiederholt gemessen werden. Die Daten am selben Subjekt sind nicht notwendigerweise unabhängig und die Modellierung der Kovarianzstruktur der Repeated Measures stellt in vielen Versuchen eine Schwierigkeit dar. In diesem Vortrag werden wir die Verfahren von Bretz et al. (2001) auf Repeated Measures Designs verallgemeinern. Speziell für Compound-Symmetry Modelle können exakte multiple Kontrasttests und simultane Konfidenzintervalle angegeben werden. Für den Fall unstrukturierter Kovarianzmatrizen werden Bootstrap-Methoden vorgeschlagen. Erste Untersuchungen zeigen, dass die Bootstrap-Algorithmen auch für den Fall *hochdimensionaler* Daten einsetzbar sind.

Literatur

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Sandra Landwehr, Helmut Finner, Veronika Gontscharuk
Deutsches Diabetes-Zentrum, Leibniz Zentrum für Diabetesforschung an der
Heinrich-Heine-Universität Düsseldorf, Institut für Biometrie und Epidemiologie
Signifikanz und Abhängigkeit bei Genexpressionsanalysen

Multiple Testmethoden nehmen seit Jahrzehnten bei der Untersuchung von Fragestellungen in vielen Disziplinen der biomedizinischen Forschung einen wichtigen Stellenwert ein. Wird zum Beispiel nach Genvarianten, Expressionsmustern und Biomarkern gesucht, die für Prädiktion, Pathogenese und Prävention von Erkrankungen relevant sein könnten, sind durch die Vielzahl zu testender Hypothesen besondere Methoden gefragt. Dies gilt beispielsweise für genomweite Studien zur Analyse von Genexpressionen, bei denen der Einfluss von Genexpressionsprofilen auf die Entstehung von Typ-2-Diabetes untersucht wird. Dabei ist es von Interesse, Gene bzw. RNA-Transkripte zu identifizieren, die differentiell exprimiert sind. Generell stellt sich die Frage, ob die durch einen multiplen Test als signifikant erkannten Unterschiede zwischen RNA-Transkripten verschiedener Gruppen tatsächlich signifikant sind, oder aber von Abhängigkeiten zwischen Teststatistiken herrühren. Auch falsche Verteilungsannahmen können Probleme bereiten. Im Vortrag werden anhand von Microarraydaten aus einer großen populationsbasierten Studie einige Ansätze vorgestellt, mit Hilfe derer sich mögliche Modellabweichungen aufdecken lassen.

Alexander Meister
Universität Rostock
Nichtparametrische Regressionsanalyse für gruppierte Daten

Wir betrachten ein Regressionsmodell, in dem die binären Antwortvariablen nicht für jede zugehörige erklärende Variable beobachtet werden, sondern nur die Maxima der Antworten über heterogene Datengruppen. Anwendung finden solche Modelle zum Beispiel bei der Auswertung von vermischten Blut- oder Wasserproben. Wir führen einen nichtparametrischen Schätzer der gesuchten Regressionsfunktion ein, welche sich in den genannten Beispielen als bedingte Wahrscheinlichkeit für eine Infektion bzw. Verschmutzung gegeben die erklärende Variable ergibt. Wir untersuchen die asymptotischen Eigenschaften dieses Schätzers sowie seine Qualität bei endlichen Stichprobenumfängen durch numerische Simulationen. Ferner diskutieren wir Ausweitungen unseres Verfahrens für ungenaue Probenuntersuchung sowie fehlerhaft gemessene oder mehrdimensionale erklärende Variable. Dieser Vortrag stützt sich auf eine gemeinsame Arbeit mit Aurore Delaigle.

Literatur

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Jörg Rahnenführer
Technische Universität Dortmund
Vorhersage von Progression und Therapieantwort bei Krebspatienten: Sind hochdimensionale genomische Daten ein Segen oder ein Fluch?

In den letzten Jahren ist in der Krebsforschung die Sammlung hochdimensionaler Daten aus dem Tumormaterial von Patienten in Mode gekommen. Die gleichzeitige Messung tausender Gene in Bezug auf Expression und/oder DNA-Varianten birgt das Versprechen einer verbesserten individualisierten Therapie. Der Fluch der Dimension führt jedoch oft zur Überschätzung der Vorhersagequalität von Methoden, die derartige Daten verwenden. In diesem Vortrag erläutern wir zunächst, wie dennoch genomweite Messungen verwendet werden können, um prognostische Signaturen zur Unterscheidung von Krebskohorten zu identifizieren. Nach einem allgemeinen Überblick stellen wir eigene neue Ergebnisse vor.
(i) Wir identifizieren Gene, deren Expressionverteilung eine charakteristische Form besitzt, etwa bimodal ist oder viele Ausreißer enthält. In solchen Fällen können die Patienten in natürlicher Weise in Kategorien unterteilt werden.
(ii) Wir verwenden penalisierte Likelihood-Ansätze für die Variablenselektion bei der Konstruktion von Cox-Modellen mit Genen und Gengruppen als Kovariablen.
(iii) Wir entwickeln Methoden zur Schätzung von differentiellen genregulatorischen Netzwerken.

Marsel Scheer, Helmut Finner
Deutsches Diabetes-Zentrum, Leibniz Zentrum für Diabetesforschung an der Heinrich-Heine-Universität Düsseldorf, Institut für Biometrie und Epidemiologie
Die erwartete Anzahl falscher Ablehnungen als Fehlerkriterium

Die erwartete Anzahl falscher Ablehnungen, kurz ENFR (expected number of false rejections), ist eine interessante und wichtige Kenngröße für multiple Testprozeduren. Bereits 1972 führte Spjøtvoll ein Kriterium zur Kontrolle der ENFR ein, welches sehr restriktiv ist und wohl nicht zuletzt deshalb wenig Beachtung gefunden hat. Wesentlich populärer und umfassender erforscht sind die familywise error rate (FWER) und die false discovery rate (FDR). In diesem Vortrag wird ein neues auf der ENFR beruhendes Kriterium vorgestellt, dass deutlich flexibler als Spjøtvoll's Ansatz ist. Unter entsprechenden Unabhängigkeitsannahmen wird gezeigt, dass eine in einem gewissen Sinne die ENFR-kontrollierende Prozedur auch die FDR zu einem wohlbestimmten Niveau kontrolliert. In einem Spezialfall gilt sogar die Umkehrung. Bei fehlenden Unabhängigkeitsannahmen können sich die Verhältnisse jedoch drastisch ändern. So kann zum Beispiel für eine die FWER kontrollierende Testprozedur für alle Paarvergleiche bei wachsender Hypothesenanzahl die ENFR gegen unendlich streben.

Korbinian Strimmer, Bernd Klaus
University of Leipzig
Higher Criticism versus False Discovery Rates

In the last decade, multiple testing based on estimation and control of false discovery rates (FDR) have become standard in high-dimensional data analysis problems. Recently, Donoho and Jin (2004, 2009) have (re)-introduced and strongly advocated Tukey's "higher criticism"(HC) approach to multiple testing. In our talk we will shed light on the mutual relationship of the FDR and HC method. Furthermore, we assess claims by Donoho and Jin concerning the superiority of HC over FDR and other competing approaches to multiple testing by revisiting the so-called "rare-weak"model and the associated optimal phase diagram.

Literatur

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Minisymposium 5

Darstellungstheorie von Lie-Superalgebren

Alexander Alldridge (Köln), Maria Gorelik (Weizmann Institute)

Montag, 19. September **Philosophikum, S91**

14:00 Paolo Papi (Università di Roma “La Sapienza”)
Denominator identities for finite-dimensional Lie superalgebras

15:00 Pierluigi Möseneder Frajria (Politecnico die Milano)
Superalgebras and Theta correspondence over the real numbers

16:00h – 16:30h Pause

16:30 Hadi Salmasian (University of Ottawa)
An analytic approach to unitary representations of Lie supergroups

17:30 Fabio Gavarini (Università degli Studi die Roma “Tor Vergata”)
Algebraic supergroups associated to simple Lie superalgebras

Dienstag, 20. September **Philosophikum, S91**

14:00 Volodymyr Mazorchuk (Uppsala University)
Serre functors for Lie superalgebras

15:00 Joris Van der Jeugt (Gent University)
Wigner quantization and representations of Lie superalgebras

16:00h – 16:30h Pause

16:30 Shun-Jen Cheng (Academia Sinica, Taiwan)
Kostant homology formula for oscillator representations of classical Lie superalgebras

17:30 Weiqiang Wang (University of Virginia)
A super duality approach to the representation theory of Lie superalgebras

Mittwoch, 21. September **Philosophikum, S91**

14:00 Vera Serganova (University of California at Berkeley)
Borel-Weil-Bott theorem and Bernstein-Gelfand-Gelfand reciprocity for classical supergroups

15:00 Catharina Stroppel (Universität Bonn)
t.b.a.

Shun-Jen Cheng
Academia Sinica, Taiwan
Kostant homology formula for oscillator representations of classical Lie superalgebras

Pierluigi Möseneder Frajria
Politecnico di Milano
Superalgebras and Theta correspondence over the real numbers

The odd part of the super denominator of a basic classical Lie superalgebra is the character of the oscillator representation of the odd part of the superalgebra. It is then natural to use superalgebra techniques to study this representation. In particular, we will show how the generalized denominator formulas for basic classical Lie superalgebras can be used to derive the Theta correspondence between representations of a compact dual pair.

Fabio Gavarini
Università degli Studi di Roma “Tor Vergata”
Algebraic supergroups associated to simple Lie superalgebras

For any finite dimensional (complex) simple Lie superalgebra I provide an explicit recipe to construct an algebraic supergroupe G (defined via its functor of points) whose tangent Lie superalgebra is $\mathfrak{g}$ itself.To do that, I generalise the classical Chevalley method, which constructs a (semi-) simple algebraic group starting from any complex, f. d. (semi-) simple Lie algebra $\mathfrak{g}$ and from a faithful f. d. $\mathfrak{g}$-module V: the basic ingredient to make use of is the datum of a so-called “Chevalley basis”. I shall show that one can do the same when $\mathfrak{g}$ is replaced with a simple Lie *super*algebra: one introduces then a notion of “Chevalley basis”, one proves the existence of the latter, and then one essentially implements the same method (with many new aspects to deal with, of course). A remarkable fact is that this strategy is succesful both with the (simple) Lie superalgebras of classical type and with those of Cartan type—somehow extending the range of application of Chevalley’s original idea.
Besides this “existence” result, I shall present also a “uniqueness” one: every connected algebraic supergroup whose Lie superalgebra be (f.d.) simple is isomorphic to one of the supergroups that I just constructed. Thus one eventually finds a complete classification of such supergroups.

Literatur

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Gavarini, F. Algebraic supergroups of Cartan type, in preparation.

Volodymyr Mazorchuk
Uppsala University
Serre functors for Lie superalgebras

In this talk I will try to show how one can use Harish-Chandra bimodules to describe Serre functors on the BGG category O for certain finite dimensional Lie (super)algebras. Although there are various descriptions of Serre functors for Lie algebras, our description using Harish-Chandra bimodules is new even in this classical case. As a consequence, we show that in "good"cases the algebra describing the category of finite dimensional modules for a Lie superalgebra is symmetric. (Joint work with Vanessa Miemietz.)

Paolo Papi
Università di Roma “La Sapienza”
Denominator identities for finite-dimensional Lie superalgebras

This is a joint work with M. Gorelik, P. Moseneder Frajria and V. Kac. We provide formulas for the denominator and superdenominator of a basic classical type Lie superalgebra for any set of positive roots. I’ll try to explain the motivations which led us to deal with this problem (related to my previous work, joint with Moseneder and Kac, on Dirac operators), and the combinatorial setting for its solution.

Hadi Salmasian
University of Ottawa
An analytic approach to unitary representations of Lie supergroups

In this talk I will present an overview of recent progress on the classification of unitary representations of finite and infinite dimensional Lie supergroups. In the finite dimensional case, we can show that under natural conditions all unitary representations are highest weight modules in the appropriate sense. I will also describe an analogue of the classical orbit method which applies to nilpotent Lie supergroups. In the case of infinite dimensional Lie supergroups, I will introduce a category of representations which is closed under restriction, and also contains natural modules such as the oscillator representation. Part of this talk is based on joint work with Karl-Hermann Neeb.

Vera Serganova
University of California at Berkeley
Borel-Weil-Bott theorem and Bernstein-Gelfand-Gelfand reciprocity for classical supergroups

In 2003 J. Brundan found remarkable connections between the category F of finite-dimensional representations of $GL(m,n)$ and tensor representations of $GL(\infty)$. In the recent paper Brundan and Stroppel develop this idea further using a categorification approach and construct a certain Koszul algebra which completely describes the structure of the category F. The important ingredient of this approach is the Bernstein-Gelfand-Gelfand reciprocity law which relates projective and simple objects in F via so called Kac modules. The characters of Kac modules are easy to compute, hence knowing of multiplicities of Kac modules in projective modules allows one to obtain the character of a simple module. Unfortunately, Kac modules do not exist for other classical supergroups. We will show that BGG reciprocity holds if in place of a Kac module one takes a virtual module given by the Euler characteristic of a line bundle on a flag supermanifold. We give a combinatorial algorithm for decomposition of a projective module into a sum of these virtual modules for the orthosymplectic supergroup and explore connections with representations of $GL(\infty)$ on this case. This talk is based on a joint work with C. Gruson.

Catharina Stroppel
Universität Bonn
t.b.a.

Joris Van der Jeugt
Gent University
Wigner quantization and representations of Lie superalgebras

For many quantum systems described by a Hamiltonian involving oscillators or oscillator-like interactions, the technique of Wigner quantization leads to algebraic compatibility conditions between operators. These conditions can be solved in terms of Lie superalgebra generators, in particular in terms of the Lie superalgebras $\mathfrak{osp}(1|2n)$ and $\mathfrak{gl}(1|n)$. This implies that the (unitary) representations of these Lie superalgebras are important in order to describe some physical quantities of these systems (position spectrum, energy, angular momentum contents).
We shall focus on some examples where interesting representation theoretic questions appear. For $\mathfrak{osp}(1|2n)$ this involves the characters (and a character formula) of a class of infinite-dimensional lowest weight representations, and the decomposition of these representations with respect to (physically relevant) subalgebras. For $\mathfrak{gl}(1|n)$, this involves finite-dimensional representations (with known characters, e.g. in terms of Schur functions), and here we present some generating function techniques to describe decompositions with respect to subalgebras. In doing so, we use various computational results from the field of symmetric and supersymmetric Schur functions.

Weiqiang Wang
University of Virginia
A super duality approach to the representation theory of Lie superalgebras

Minisymposium 6

Diskrete Geometrie und Diskrete Topologie

Martin Henk (Magdeburg), Frank Lutz (Berlin)

Dienstag, 20. September **Hörsaalgebäude, HS E**

14:00 Günter M. Ziegler (Berlin)
Polytopes with Few Degrees of Freedom

15:00 Karim Adiprasito (Berlin)
Inducing Discrete Morse Functions and Collapsibility of Spaces of Bounded Curvature

15:30 Andreas Paffenholz (Darmstadt)
Permutation Polytopes

16:00h – 16:30h Pause

16:30 Thorsten Theobald (Frankfurt)
Combinatorial Aspects of Tropical Intersections and Self-Intersections

17:30 Maria Hernandez Cifre (Murcia)
Coverings and compressed lattices

18:00 Barbara Langfeld (Kiel)
Are Planar Lattice-Convex Sets Determined by Their Covariogram?

Mittwoch, 21. September **Hörsaalgebäude, HS E**

14:00 Pavle Blagojević (Berlin)
On the Trail of Topological Tverberg Conjecture

15:00 Jonathan Spreer (Stuttgart)
Slicings of Combinatorial 3-Manifolds

15:30 Matthias Henze (Magdeburg)
Blichfeldt-Type Inequalities and Central Symmetry

16:00h – 16:30h Pause

16:30 Raman Sanyal (Berkeley)
Deciding Polyhedrality of Spectraheda

17:30 Tim Netzer (Leipzig)
Spectrahedra

18:00 Hartwig Bosse (Frankfurt)
t.b.a.

Donnerstag, 22. September **Hörsaalgebäude, HS E**

14:00 Gennadiy Averkov (Magdeburg)
Compact Polynomial Representations of Special Semialgebraic Sets

15:00 René Brandenberg (München)
k-Center, Core-Sets, and Successive Radii – Dimension Reduction in Computational Discrete Geometry

15:30 Margarita Spirova (Chemnitz)
Translative Coverings of Convex Bodies

16:00h – 16:30h Pause

16:30 Christian Haase (Frankfurt)
Computing Toric Ideals of Integrally Closed Polytopes

17:30 Eva Linke (Magdeburg)
Rational Ehrhart Quasi-Polynomials

18:00 Christian Wagner (Zürich)
Maximal Lattice-Free Polyhedra in Mixed-Integer Cutting Plane Theory

Karim Adiprasito
Freie Universität Berlin
Inducing Discrete Morse Functions and Collapsibility of Spaces of Bounded Curvature

We present a new way to induce a Morse matching given a polyhedral complex and a real function on it. This procedure comes with a natural formula for critical points, and implies strong collapsibility results for spaces of curvature bounded above.

(Joint work with Bruno Benedetti.)

Maria Hernandez Cifre
Universität Murcia
Coverings and compressed lattices

Pavle V. M. Blagojević
Freie Universität Berlin
On the Trail of Topological Tverberg Conjecture

The topological Tverberg conjecture, posed by Bárány, Shlosman and Szücs in 1981, still open in the case of non prime powers, is one of the most challenging and resistent open problems in the Geometric Combinatorics. In this talk, seeking the proof of the topological Tverberg conjecture, we reveal hidden ideas and open problems standing behind recent results of Blagojević, Matschke and Ziegler.

Hartwig Bosse
Goethe-Universität Frankfurt am Main
t.b.a.

René Brandenberg
Technische Universität München
k-Center, Core-Sets, and Successive Radii – Dimension Reduction in Computational Discrete Geometry

In recent years new techniques in solving euclidean k-center problems were obtained. We present some positive and negative results for the general problem. The latter using some new geometric inequalities in the line of Jung's theorem.

Thorsten Theobald
Goethe-Universität Frankfurt am Main
Combinatorial Aspects of Tropical Intersections and Self-Intersections

In this talk we consider two foundational combinatorial questions on the intersection of tropical hypersurfaces. Given tropical polynomials $g_1,\ldots,g_k$ in n variables with Newton polytopes $P_1,\ldots,P_k$, we first study the f-vector, the number of unbounded faces and (in case of a curve) the genus. For the case of curves, the second question is concerned with the (unweighted) number of self-intersection points under linear projections onto the plane.

Along studying these questions, we meet some intriguing connections between certain mixed volumes and alternating sums of integer points in Minkowski sums of polytopes, a mixed version of Ehrhart theory, as well as mixed fiber polytopes. While for the first problem, our characterizations are exact, for the second question our main results are bounds as well as constructions with many self-intersections.

(Partially based on joint work with Kerstin Hept and with Reinhard Steffens.)

Christian Haase
Goethe-Universität Frankfurt am Main
Computing Toric Ideals of Integrally Closed Polytopes

A lattice polytope is the convex hull of finitely many points in the integer lattice. The toric ideal of such a polytope P is an ideal in a polynomial ring which encodes affine dependencies among the lattice points in P.

Generating sets for these toric ideals have been used in integer programming, algebraic statistics, and many other mathematical fields. In this talk, I want to present a novel approach to compute the toric ideal of P and report on experiments with a first implementation of the algorithm.

It works best under the (checkable) additional assumption that P be integrally closed. That is, we want that every lattice point in a dilation kP of P can be written as the sum of k lattice points in P.

An extension of the algorithm has the potential to compute higher Betti numbers of toric ideals.

(This is joint work in progress with Benjamin Lorenz.)

Matthias Henze
Otto-von-Guericke-Universität Magdeburg
Blichfeldt-Type Inequalities and Central Symmetry

A classical result of Blichfeldt, which dates back to 1921, gives a sharp lower bound on the volume of a convex body K whose lattice points span the whole space in terms of the lattice point enumerator $\#(K\cap\mathbb{Z}^n)$. We are interested in a version of this inequality on the set of centrally symmetric convex bodies. Our motivation to study this problem comes from a lack of methods that exploit the symmetry assumption in problems of a similar kind and where central symmetry is a natural condition.

We report upon first results for special families of centrally symmetric convex bodies.

(This is joint ongoing work with Martin Henk.)

Barbara Langfeld
Christian-Albrechts-Universität zu Kiel
Are Planar Lattice-Convex Sets Determined by Their Covariogram?

A finite subset K of $\mathbb{Z}^d$ is said to be lattice-convex if K is the intersection of $\mathbb{Z}^d$ with a convex set. The covariogram g_K of $K \subseteq \mathbb{Z}^d$ is the function associating to each $u \in \mathbb{Z}^d$ the cardinality of $K \cap (K+u)$. Daurat, Gérard, and Nivat and independently Gardner, Gronchi, and Zong raised the problem on the reconstruction of lattice-convex sets K from g_K. We provide a partial positive answer to this problem by showing that for $d = 2$ and under mild extra assumptions, g_K determines K up to translations and reflections. As a complement to the theorem on reconstruction we also extend the known counterexamples (i.e., planar lattice-convex sets which are not reconstructible, up to translations and reflections) to an infinite family of counterexamples.

(This is joint work with Gennadiy Averkov.)

Eva Linke
Otto-von-Guericke-Universität Magdeburg
Rational Ehrhart Quasi-Polynomials

Ehrhart's famous theorem states that the number of integral points in a rational polytope is a quasi-polynomial in the integral dilation factor. We study the case of rational dilation factors. It turns out that the number of integral points can still be written as a rational quasi-polynomial, that is, a polynomial function, whose coefficients are themselves periodic functions. Furthermore, the coefficients of this rational quasi-polynomial are piecewise polynomial functions and related to each other by derivation. In a special setting, the minimal periods of these coefficients are monotonically decreasing. This is not true in the integral case, and thus we suspect that the rational quasi-polynomial preserves more of the geometric structure of a polytope than the integral one.

Tim Netzer
Universität Leipzig
Spectrahedra

Spectrahedra are generalizations of polyhedra. They occur naturally as feasible sets, when one passes from linear programming to semidefinite programming. Spectrahedra form a most interesting class of sets. Most work on them is quite recent, and there are still many unsolved problems. I will give a short introduction to the topic, and explain some of the underlying algebra.

Andreas Paffenholz
Technische Universität Darmstadt
Permutation Polytopes

A permutation polytope is the convex hull of the permutation matrices of a subgroup of S_n. These polytopes are a special class of 0/1-polytopes. A well-known example is the Birkhoff polytope of all doubly-stochastic matrices. This polytope is defined by the full symmetric group S_n. Much less is known for general groups.

I will introduce basic properties of permutation polytopes, characterize faces, and discuss connections between the group and the polytope. The main focus of my presentation will be on recent results for permutation polytopes defined by cyclic groups. Their face structure depends on the cycle structure of the generator, and I will describe exponential families of facets. The class of cyclic permutation polytopes contains the class of marginal polytopes.

(This is joint work with Barbara Baumeister, Christian Haase, and Benjamin Nill.)

Raman Sanyal
University of California, Berkeley
Deciding Polyhedrality of Spectrahedra

Spectrahedra are to semidefinite programming what polyhedra are to linear programming. Spectrahedra form a rich class of convex bodies with many of the favorable properties of polyhedra. It is a theoretical interesting and practically relevant question to decide when a spectrahedron is a polyhedron. In this talk I will discuss an algorithm for doing that which requires a good understanding of the geometry of spectrahedra and some linear algebra. Only knowledge of the latter will be assumed.

(This is joint work with Avinash Bhardwaj and Philipp Rostalski.)

Margarita Spirova
Technische Universität Chemnitz
Translative Coverings of Convex Bodies

We discuss arrangements of proper translates of a convex body K in $\mathbb{R}^n$ sufficient to cover this body. We call such an arrangement a *t-covering* (a covering by translates) of K. First we investigate relations between t-coverings of the whole of K and t-coverings of only its boundary. Refining the notion of t-covering in several ways, we discuss, particularly for centrally symmetric convex bodies and $n = 2$, how such coverings relate to the classical theorems of Ţiţeica and Miquel as well as to notions like Voronoi regions. We also compare t-coverings with coverings in the spirit of Hadwiger, using smaller homothetical copies of K instead of proper translates. Finally we give upper bounds on the cardinalities of t-coverings.

(The talk is based on a joint work with Marek Lassak and Horst Martini.)

Jonathan Spreer
Universität Stuttgart
Slicings of Combinatorial 3-Manifolds

We investigate slicings of combinatorial manifolds as properly embedded co-dimension 1 submanifolds. Focus is given to the case of dimension 3, where slicings are (discrete) normal surfaces. The talk will be about three particular questions:
1. Is there a connection between the number of quadrilaterals of a slicing and its genus?
2. Which weakly neighborly polyhedral maps can be embedded into combinatorial 3-manifolds?
3. How can we use slicings to construct combinatorial 3-manifolds with a transitive automorphism group?

Gennadiy Averkov
Otto-von-Guericke-Universität Magdeburg
Compact Polynomial Representations of Special Semialgebraic Sets

Bosse, Grötschel and Henk conjectured that every d-dimensional polytope in $\mathbb{R}^d$ can be determined by a system of d nonstrict polynomial inequalities. Recently this conjecture has been confirmed in a joint work with Ludwig Bröcker. We also present further results on compact polynomial descriptions of special classes of semialgebraic sets.

Christian Wagner
Eidgenössische Technische Hochschule Zürich
Maximal Lattice-Free Polyhedra in Mixed-Integer Cutting Plane Theory

A polyhedron with non-empty interior is maximal lattice-free if it is inclusion-maximal with respect to the property of not containing integer points in its interior. In this talk, I will explain the relation between maximal lattice-free polyhedra and cutting plane generation in mixed-integer linear optimization.

Günter M. Ziegler
Freie Universität Berlin
Polytopes with Few Degrees of Freedom

Minisymposium 7

Fragen der Information und Kommunikation in der Mathematik

Wolfram Sperber (Karlsruhe)

Mittwoch, 21. September **Seminargebäude, S13**

14:00 Michael Kohlhase (Bremen)
Formelretrieval in mathematischen Publikationen - on the road

15:00 Bernd Wegner (Berlin)
Profildienste und Rankingangebote bei Referenzdatenbanken I. Grundsätzliche Erwägungen und Probleme

15:30 Olaf Teschke (Berlin)
Profildienste und Rankingangebote bei Referenzdatenbanken II. Implementierung bei ZB-MATH

16:00h – 16:30h Pause

16:30 Wolfram Sperber (Berlin)
MSC, Keywords und automatische Texterschließung

17:00 Michael Jost (Berlin)
Was macht die Digitale Mathematische Bibliothek - Halbzeit im EuDML-Projekt

Donnerstag, 22. September **Seminargebäude, S13**

14:45 Judith Plümer (Osnabrüeck)
Repositories und ihre Einbindung in die wissenschaftliche Infrastruktur

15:30 Sebastian Bönisch (Berlin)
Aufbau einer Open-Access-Datenbank zur Referenzierung mathematischer Software

16:15 Hagen Chrapary (Berlin)
Erste Ansätze und Erfahrungen beim Aufbau einer Datenbank für mathematische Software

Sebastian Bönisch, Michael Brickenstein, Hagen Chrapary, Gert-Martin Greuel, Wolfram Sperber
Mathematisches Forschungsinstutut Oberwolfach (Brickenstein, Greuel), Zentralblatt für Mathematik / FIZ Karlsruhe (Bönisch, Chrapary, Sperber)

Aufbau einer Open-Access-Datenbank zur Referenzierung mathematischer Software

Die Bedeutung mathematischer Software als Werkzeug in Forschung, Lehre und Anwendungen hat in den letzten drei Jahrzehnten stetig zugenommen. In vielen Teilbereichen der Mathematik und vor allem auch im Anwendungsbereich hat sie inzwischen einen Stellenwert erhalten, der mit dem mathematischer Literatur vergleichbar ist. Im Gegensatz zur systematischen Sammlung und Referenzierung mathematischer Literatur existiert etwas Vergleichbares für mathematische Software allerdings bisher nur in Ansätzen.

Ziel des von der Leibniz-Gemeinschaft geförderten Projektes „SMATH“ ist der Aufbau einer umfassenden Open-Access-Datenbank zur Referenzierung mathematischer Software und die Verknüpfung dieser Datenbank mit existierenden Informationsdiensten. Beim Aufbau einer Soft-ware-Datenbank kommt folgenden Problemkomplexen eine zentrale Bedeutung zu:

- Identifikation von Software, möglichst umfassende Abdeckung existierender Software
- Inhaltliche Erschließung identifizierter Software (Metadaten)
- Sicherstellen von Relevanz, Qualität und Aktualität der referenzierten Software

Der innovative Ansatz des SMATH-Projekts zum Umgang mit diesen Problemen besteht in der Verknüpfung mathematischer Software mit denjenigen mathematischen Publikationen, die diese Software zitieren. Hierzu kann unter anderem auf den umfangreichen Datenbestand des Zentralblatts für Mathematik zurückgegriffen werden. Ein wesentlicher Vorteil des publikationsbasierten Ansatzes besteht darin, dass der Peer-Review-Prozess für eine Publikation automatisch auch für die darin zitierte Software ein Mindestmaß an Qualität und Relevanz impliziert.

Das SMATH-Projekt hat Anfang dieses Jahres begonnen. Im Projekt sollen Methoden und Werkzeuge für die Erstellung und eine weitgehend automatisierte Pflege der Datenbank für mathematische Software entwickelt und implementiert werden.

Hagen Chrapary, Sebastian Bönisch, Michael Brickenstein, Gert-Martin Greuel, Wolfram Sperber
Mathematisches Forschungsinstitut Oberwolfach (Brickenstein, Greuel), Zentralblatt für Mathematik / FIZ Karlsruhe (Bönisch, Chrapary, Sperber)
Erste Ansätze und Erfahrungen beim Aufbau einer Datenbank für mathematische Software

Der Aufbau der Datenbank „SMATH“ für mathematische Software ist eine konzeptionelle und technische Herausforderung. Einerseits ist die Beschreibung mathematischer Software wesentlich komplexer als für wissenschaftliche Publikationen und kaum standardisiert. Andererseits ist es Ziel des Projektes, einen nachhaltigen Informationsdienst aufzubauen, wofür eine maschinelle Unterstützung der Pflege der Datenbank wichtig ist.
Dafür müssen im SMATH-Projekt Verfahren und Werkzeuge entwickelt werden, insbesondere für:

- die Identifizierung mathematischer Software in der Datenbank ZBMATH und in Publikationen
- die formale und inhaltliche Erschließung der Software
- die Suche und den Zugang zu mathematischer Software

Der Vortrag stellt die ersten Ansätze und Erfahrungen bei der Identifizierung mathematischer Software und den Aufbau eines Prototyps der SMATH-Datenbank vor und zeigt die vielfältigen Schwierigkeiten bei der Suche und Analyse mathematischer Software.

Michael Jost
Zentralblatt für Mathematik / FIZ Karlsruhe
Was macht die Digitale Mathematische Bibliothek? – Halbzeit im EuDML-Projekt

Im Februar 2010 ist das Projekt ”The European Digital Mathematics Library” (EuDML) gestartet. Dieses von der EU im Bereich CIP-ICT PSP geförderte Projekt mit 14 europäischen Partnern bringt während einer Laufzeit von 3 Jahren die verschiedenen Digitalisierungsinitiativen im Bereich Mathematik in Europa zusammen und erstellt eine kooperative Digital Library, die die verteilten und heterogenen Inhalte der verschiedenen Provider umfasst. Als ”single access point” macht der Dienst dem Nutzer das Netzwerk der zusammengeführten, angereicherten und untereinander verbundenen Literatur verfügbar. Dieser Vortrag wird über den Halbzeitstand im Projekt, die verfügbaren Bestände, technische Ansätze und Features, sowie über die weitere Projektplanung berichten.

Michael Kohlhase
Jacobs University Bremen
Formelretrieval in mathematischen Publikationen – on the road

Die Suche nach und in mathematischen Publikationen beschränkt sich bis heute auf den Text. Einen wesentlichen Teil des Inhalts mathematischer Publikationen machen aber Formeln aus, die bisher aber maschinell noch nicht analysiert werden. Mit der Entwicklung von XML und der entsprechenden Spezifikationen für die Mathematik, hier seien etwa MathML, OpenMATH und OMDOC genannt, sind neue Sprachen entwickelt worden, um mathematische Formeln im Web darzustellen und zu verarbeiten. In dem Vortrag werden Ansätze und Konzepte für die semantische Analyse und Suche von mathematischen Formeln vorgestellt.
Mathematiker erstellen heute ihre Manuskripte am Computer und benutzen dafür das TEX-Format. Dieses Format ist für die Autoren einfach handhabbar, flexibel und nahezu perfekt für den Druck der Publikation. Semantische Informationen sind aber im TEX-Code nur bedingt enthalten.
Für die Formelsuche wird der TEX-Code in XML-Code transformiert (dafür stehen mittlerweile im Web leistungsfähige Programme zur Verfügung) und die mathematischen Symbole und Formeln werden aus der Publikation extrahiert. Die eigentliche Herausforderung besteht darin, die Formeln semantisch zu analysieren. In der Mathematik ist es wie in der natürlichen Sprache, Symbole und Formeln, im Folgenden als Formel zusammengefasst, sind nicht eindeutig. In verschiedenen Zusammenhängen werden sie in unterschiedlicher Bedeutung verwendet, und es gibt in der Regel mehr als eine Formel, um einen bestimmten mathematischen Zusammenhang auszudrücken. Man muss für die Analyse den Kontext der Formel (Text und Formeln der Publikation oder das Umfeld der Publikation) untersuchen, um semantische Annotationen über die Formel machen zu können. Die Analyse wird häufig nicht zu einer eindeutigen semantischen Interpretation der Formel führen, man wird stattdessen eine Menge möglicher Interpretationen erhalten. Erste Erfahrungen mit prototypischen Suchmaschinen für mathematische Formeln zeigen, dass die Suche in mathematischen Publikationen wesentlich verbessert werden kann.

Judith Plümer
Universität Osnabrück
Repositories und ihre Einbindung in die wissenschaftliche Infrastruktur

Open Access ist in den letzten Jahren zu einem festen Bestandteil des wissenschaftlichen Publikationswesens geworden. Die Veröffentlichung wissenschaftlicher OA-Publikationen geschieht in der Regel in Repositories, die von Institutionen oder von der Community betrieben werden. Über Portale oder Suchmaschinen werden die dort gespeicherten Publikationen dann zugänglich gemacht. Klassische Informationsdienste, wie etwa die bibliographische Datenbank ZBMATH erfassen im Wesentlichen nur die Veröffentlichungen der traditionellen wissenschaftlichen Publikationswelt. Wer nach relevanter Literatur für die Lösung eines Problems sucht, findet einen heterogenen Datenraum vor. Er muss in der Regel unterschiedlich erschlossene Informationsquellen benutzen. Ob Klassifikationen, Metadaten oder Volltexte zur Erschließung genutzt wurden, bleibt dem Nutzer oft verborgen. Mit einer parallelen Suche in den OA Repositories und den bibliografischen Fachdatenbanken ist es nicht getan. Es bedarf einer semantischen Verknüpfung und Harmonisierung der inhaltlichen Erschließung von OA Publikationen und bibliografischen Datenbanken, um den Nutzern einen wirklichen Mehrwert zu bieten. Der Vortrag stellt die Probleme sowie erste Konzepte und Ansätze für die Verknüpfung beider Publikationswelten vor.

Wolfram Sperber, Bernd Wegner
Zentralblatt für Mathematik / FIZ Karlsruhe
MSC, Keywords und automatische Texterschließung

Klassifikation ist auch heute noch von zentraler Bedeutung für die wissenschaftliche Forschung und die Suche nach Informationen. In der Mathematik ist die Mathematical Subject Classification (MSC) heute das am meisten verbreitete Klassifikationsschema für mathematische Publikationen. Die Klassifizierung der gesamten mathematischen Literatur mittels MSC ist eine der wesentlichen Facetten der inhaltlichen Erschließung in den weltweit führenden bibliographischen Datenbanken ZBMATH und MathSciNet.
Im Zeitalter der elektronischen Information haben sich auch die Anforderungen an die MSC und deren Nutzung wesentlich geändert. Basis sind die Ansätze und Werkzeuge des Semantic Web: Resource Description Framework (RDF), RDF Schema, Ontology Web Language (OWL) und insbesondere Simple Knowledge Organization System (SKOS). Diese Techniken gestatten es, die MSC in einer maschinenauswertbaren Form bereitzustellen, die MSC mit weiteren Informationen anzureichern, z.B. die Klassen durch relevante Schlagwörter zu beschreiben, und Werkzeuge für das automatische Klassifizieren zu entwickeln.
In einem ersten Schritt wurde eine SKOS-Implementierung für die MSC entwickelt, die die Klassen der MSC und die Relationen zwischen den Klassen auf der Basis des SKOS-Vokabulars präsentiert. Im Vortrag wird dieser Ansatz vorgestellt und die weitere Vorgehensweise diskutiert.

Olaf Teschke
Zentralblatt für Mathematik / FIZ Karlsruhe
Profildienste und Rankingangebote bei Referenzdatenbanken II: Implementierung in ZBMATH

Aus wissenschaftlichen Datenbanken können abgeleitete Informationen wie Autorenprofile, Zeitschriftenprofile oder Zitierungsanalysen generiert werden, die einen erheblichen Mehrwert an Information darstellen - wenn sie mit einem nötigen Maß an Sorgfalt erzeugt und *genutzt* werden. Erst der Blick auf die Details verrät, welche Daten oder Reihenfolgen man sinnvoll ableiten kann und welche genuin mit einer hohen Ungenauigkeit behaftet sind. Wir veranschaulichen dies anhand der in ZBMATH implementierten Autorenprofile und geben einige Fallbeispiele zu abgeleiteten Daten aus Zitierungsanalysen in Referaten und Zeitschriften.

Bernd Wegner
Zentralblatt für Mathematik / FIZ Karlsruhe
Profildienste und Rankingangebote bei Referenzdatenbanken I: Grundsätzliche Erwägungen

Referenzdatenbanken wie ZBMATH werden mehr und mehr dafür konzipiert, sekundäre Dienste wie Autorenprofile, Kooperationsstatistiken, Impact-Informationen etc. anzubieten. Dabei entstehen Probleme im Inputbereich, in der Auswertung der Daten, bei den Anforderungen an solche Angebote seitens der Nutzer und bei den Erwartungen, die solche Angebote prinzipiell erfüllen können. Der Vortrag soll die wichtigsten Probleme in diesen Bereichen ansprechen und ein differenziertes Verständnis dafür erwecken, was von solchen Angeboten in der Regel erwartet werden kann.

Minisymposium 8

Geomathematik

Volker Michel (Siegen)

Mittwoch, 21. September **Seminargebäude, S25**

14:15 Volker Michel (Siegen)
Opening

14:30 Willi Freeden (Kaiserslautern)
Spherical Discrepancies

15:00 Katrin Bentel (Ås)
Point Grid Positions for Radial Base Functions and Their Effect in Regional Gravity Field Representations

15:30 Roger Telschow (Siegen)
Nonlinear Approximation of Spherical Functions with Dictionaries

16:00h – 16:30h Pause

16:30 Doreen Fischer (Siegen)
Sparse Regularization of an Inversion of Gravitational Data and Normal Mode Anomalies

17:00 Kamil S. Kazimierski (Bremen)
Efficiency of Iterative Regularization Methods Using Banach Space Norms

17:30 Sergei Pereverzev (Linz)
Multiparameter Regularization in Geodetic Data Processing

18:00 Robert Plato (Siegen)
The Regularizing Properties of Some Quadrature Methods for Linear Weakly Singular Volterra Integral Equations of the First Kind

Donnerstag, 22. September **Seminargebäude, S25**

14:30 Isabel Ostermann (Kaiserslautern)
Modeling Heat Transport in Deep Geothermal Systems by Radial Basis Functions

15:00 Jörn Behrens (Hamburg)
A Practical Application of Uncertainty Propagation for Tsunami Early Warning

15:30 Roland Potthast (Offenbach)
Convergence Criteria on Ensembles for Local Ensemble Filters and Their Use for Ensemble Control

16:00h – 16:30h Pause

16:30 Johannes Wicht (Katlenburg-Lindau)
Towards Realistic Planetary Dynamo Simulations

17:00 Christian Gerhards (Kaiserslautern)
Multiscale Methods in Geomagnetic Modeling

17:30 Roelof Rietbroek (Bonn)
The Use of GRACE Gravimetry and Altimetry to Separate Sea Level Contributions

18:00 Zdenek Martinec (Dublin)
The Adjoint Sensitivity Method of Global Electromagnetic Induction for CHAMP Magnetic Data

18:30 Volker Michel (Siegen)
Conclusions

Jörn Behrens
Universität Hamburg, KlimaCampus
A Practical Application of Uncertainty Propagation for Tsunami Early Warning

The challenge of near-field tsunami early warning is to assess the situation precisely within a few minutes, limited by few and uncertain measurements of key indicators. In other words, in a short timeframe only limited information is available, but this information has to be interpreted in such a way, that false warnings are minimized. This challenge had not been addressed in existing tsunami early warning systems until recently and still leads to a large number of false positive (to be on the save side) tsunami warning messages world wide. In the course of development of the German Indonesian Tsunami Early Warning System (GITEWS), operational since 2008 in Jakarta, Indonesia, a new method to assess the situation has been developed [Behrens et al., 2010]. This method utilizes a simple, yet effective uncertainty propagation model, which leads to more robust and accurate situation assessments under the large uncertainty of the first few minutes after an earthquake event. The system is designed as an analog forecasting system, based on pre-computed scenarios. This allows for a forecast within seconds after measurements are available. In this presentation the basic design of the system is introduced. Examples for the high sensitivity and uncertainty of the forecasting problem are given and an analysis with a simple uncertainty propagation model is given. Based on the analysis, a new method that decreases uncertainties in a robust way, is derived. Finally, examples of successful application of the new method are given.

Literatur

Behrens, J., A. Androsov, A. Y. Babeyko, S. Harig, F. Klaschka, L. Mentrup. (2010). A new multi-sensor approach to simulation assisted tsunami early warning. *Nat. Hazards Earth Syst. Sci.*, **10**, 1085 - 1100.

Katrin Bentel, Gabriel Goebel, Michael Schmidt, Christian Gerlach
Norwegian University of Life Sciences, Deutsches Geodätisches Forschungsinstitut (DGFI), Bavarian Academy of Sciences and Humanities
Point grid positions for radial base functions and their effect in regional gravity field representations

Global gravity fields are most common represented in spherical harmonic base functions. However, the main drawback of this representation is that regional signals are not necessarily represented in an optimal way. Spherical harmonics have global support, thus, the gravity models are globally optimized best-fit solutions. That means, it is difficult to represent small spatial details, they can even be masked in the solutions.
To represent a gravity signal in a specified region on a sphere appropriately, we use localizing radial base functions for regional gravity field modeling. The distribution of these individual base functions follows a predefined point grid. The type of grid, number of points, area boundaries, point density, and other parameters play a very important role in the representation of a signal. Depending on the type of grid and its characteristics, artificial structures occur in the estimation of gravity field parameters. In this study we present some of these typical structures and investigate in detail various effects of different point grid parameters in the representation of a regional gravity field.

Doreen Fischer
University of Siegen
Sparse Regularization of an Inversion of Gravitational Data and Normal Mode Anomalies

To recover the density of the Earth we invert Newton's gravitational potential which is an ill-posed problem. Thus, we need to develop a regularization method to solve it appropriately.
We apply the idea of a Matching Pursuit to recover a solution stepwise. At step $n+1$, the expansion function d_{n+1} and the weight α_{n+1} are selected to best match the data structure. However, all kinds of different functions may be taken into account to improve the solution stepwise. Moreover, this new approach generates models with a resolution that is adapted to the data density as well as the detail density of the solution.
For the area of South America, we present an extensive case study to investigate the performance and behavior of the new algorithm. Furthermore, we research the mass transport in the area of the Amazon where the proposed method shows great potential for further ecological studies, i.e. to reconstruct the mass loss of Greenland or Antarctica.
However, from gravitational data alone it is only possible to recover the harmonic part of the density. To get information about the anharmonic part as well, we need to be able to include other data types, e.g. seismic data in the form of normal mode anomalies. We present a new model of the density distribution of the whole Earth as the result of such an inversion.

Literatur

Berkel, P., Fischer, D. and Michel, V. (2011). Spline multiresolution and numerical results for joint gravitation and normal mode inversion with an outlook on sparse regularisation. *GEM*, **1**, 167 - 204.
Fischer, D. and Michel, V. (2011). Sparse regularization of inverse gravimetry — case study: spatial and temporal mass variations in South America. Preprint.

Willi Freeden
TU Kaiserslautern
Spherical Discrepancies

Of practical importance in geomathematics is the problem of generating equidistributed point sets on the sphere. In this respect, the concept of spherical discrepancy, which involves the Laplace-Beltrami operator to give a quantifying criterion for equidistributed point sets, is of great interest. In this lecture, an explicit formula in terms of elementary functions is developed for the spherical discrepancy. Several promising ways are considered to generate point sets on the sphere such that the discrepancy becomes small.

Christian Gerhards
TU Kaiserslautern
Multiscale Methods in Geomagnetic Modeling

With the upcome of high quality satellite magnetic field data from past missions like MAGSAT, Ørsted, CHAMP and future missions like Swarm, it becomes of more and more interest to have adequate mathematical tools at hand for geomagnetic modeling. We present multiscale methods for the modeling of different aspects of the Earth's magnetic field. A special focus is set to the construction of locally supported wavelets for the treated problems, e.g., the reconstruction of radial current densities and the separation of the magnetic field with respect to the sources. Furthermore, some applications to real data sets are presented.

Kamil S. Kazimierski
Universität Bremen
Efficiency of iterative regularization methods using Banach space norms

In this talk we want do discuss several, recently developed methods for iterative regularization with sparsity constraints. In particular: Landweber-regularization of linear and non-linear operators (with sparsity constraints); conjugate gradient like regularization of linear operators (with sparsity constraints). We will present theoretical results concerning regularization properties, convergence rates. We will also discuss numerical properties. Especially, we will show that iterative methods are a viable alternative to the variational approach of Tikhonov.
The presented results are joint work with Torsten Hein, Matheon, Berlin.

Zdeněk Martinec
Dublin Institute for Advanced Studies, 5 Merrion Square, Dublin
The adjoint sensitivity method of global electromagnetic induction for CHAMP magnetic data

Martinec and McCreadie (2004) developed a time-domain spectral-finite element approach for the forward modelling of electromagnetic induction vector data as measured by the CHAMP satellite. Here, we present a new method of computing the sensitivity of the CHAMP electromagnetic induction data on the Earth's mantle electrical conductivity, which we term the adjoint sensitivity method. The forward and adjoint initial boundary-value problems, both solved in the time domain, are identical, except for the specification of prescribed boundary conditions. The respective boundary-value data at the satellite's altitude are the X magnetic component measured by the CHAMP vector magnetometer along satellite tracks for the forward method and the difference between the measured and predicted Z magnetic component for the adjoint method. The squares of these differences summed up over all CHAMP tracks determine the misfit. The sensitivity of the CHAMP data, that is the partial derivatives of the misfit function with respect to mantle conductivity parameters, are then determined by the scalar product of the forward and adjoint solutions, multiplied by the gradient of the conductivity and integrated over all CHAMP tracks. Such exactly determined sensitivities are checked against numerical differentiation of the misfit, and very good agreement is obtained.

Literatur

Martinec, Z. and McCreadie, H. (2004). Electromagnetic induction modelling based on satellite magnetic vector data. *Geophys. J. Int.*, **157**, 1045 - 1060.

Isabel Ostermann
Fraunhofer ITWM Kaiserslautern
Modeling Heat Transport in Deep Geothermal Systems by Radial Basis Functions

Geothermal power uses the intrinsic heat which is stored in the accessible part of the Earth's crust. Its importance among the renewable energy resources originates from the almost unlimited energy supply of the Earth and its independence from external influences such as seasonal or even daily climatic variability. Nevertheless, there are risks which have to be assessed. In particular, local depletion poses a significant risk during the industrial utilization of deep geothermal reservoirs. In order to reduce this risk, reliable techniques to predict the heat transport and the production temperature are required. To this end, a 3D-model to simulate the heat transport in hydrothermal systems is developed which is based on a transient advection-diffusion-equation for a 2-phase porous medium.
The existence, uniqueness, and continuity of the weak solution of the resulting initial boundary value problem is verified. For the numerical realization, a linear Galerkin scheme is introduced on the basis of scalar kernels. Exemplary applications of this method are investigated for the biharmonic kernel as well as appropriate geometric representations of a hydrothermal reservoir. Moreover, numerical integration methods on geoscientifically relevant bounded regions in 3D are introduced and tested for the considered geometries.

Sergei Pereverzev
Johann Radon Institute for Computational and Applied Mathematics, Austrian Academy of Sciences, Linz
Multiparameter Regularization in Geodetic Data Processing

We are going to discuss recent developments in multiparameter regularization. The need in this approach becomes apparent when several model uncertainties affect data processing. Focusing on the context of satellite geodesy we discuss theoretical and computational aspects of some multiparameter regularization schemes. Numerical illustrations with synthetic data will be also presented.

Literatur

Lu, S. and Pereverzev, S. (2010). Multiparameter Regularization in Downward Continuation of Satellite Data. *Handbook of Geomathematics, Springer*, 813 - 832, Chapter 27.

Robert Plato
Universität Siegen
The regularizing properties of some quadrature methods for linear weakly singular Volterra integral equations of the first kind

The subject of this talk is the stable quadrature of the following class of linear weakly singular Volterra integral equations of the first kind:

$$\int_0^x (x-y)^{-(1-\alpha)} k(x,y)u(y)dy = f(x) \quad \text{for } 0 \le x \le 1,$$

with some parameter $0 < \alpha < 1$ and a sufficiently smooth kernel function $k : [0,1] \times [0,1] \to \mathbb{R}$. In addition, $f : [0,1] \to \mathbb{R}$ denotes a given function, and $u : [0,1] \to \mathbb{R}$ is the unknown function. Problems of this kind arise, e.g., in the inversion of seismic flat-earth travel times.
The quadrature methods under consideration are the composite trapezoidal scheme and the composite midpoint rule. In the present talk we consider their regularizing properties, i. e., we discuss appropriate choices of the step size as a function of the noise level for the right-hand side of the considered equation. Different smoothness assumptions on the involved functions are taken into account. Finally some numerical results are presented.

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Roland Potthast
University of Reading / Deutscher Wetterdienst / Universität Göttingen
Convergence Criteria on Ensembles for Local Ensemble Filters and their Use for Ensemble Control

The goal of data assimilation is to construct the state of some dynamical system from in-situ or remote measurements. It is used for example for numerical weather prediction. Ensemble data assimilation systems are very popular for many applications. They provide a flexible alternative to large-scale variational approaches. Many different versions of ensemble filters have been suggested and tested over the last years, including local ensemble transform Kalman filters (LETKF) and sequential importance resampling (SIR). However, one key question of current research is the setup and control of the ensembles which are used for assimilation and prediction. Here, we will provide some mathematical analysis for the local convergence of such filters and derive mathematical criteria on the ensemble which have the potential to be used for ensemble setup and control.

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Roelof Rietbroek
Institut für Geodäsie und Geoinformation, Universität Bonn
The use of GRACE gravimetry and altimetry to separate sea level contributions

In order to fully understand present and future sea level rise a separation of different sea level contributors is a necessity. Major ice sheets and smaller glaciers contribute to sea level rise, while steric expansion due to thermal and salinity changes play an equally important role. On top of that, the ongoing viscoelastic adjustment of the Earth to former ice loads, may not be neglected. Ocean modeling provides valuable information on the ocean response to melting. While on the other hand, absolute quantification and monitoring of sea level changes require actual observations.
In this study, we take complementary data from GRACE gravimetry data and Jason-1 altimetry and estimate time varying scales associated with predefined sea level patterns. The patterns represent non-uniform gravitationally sea level responses to melting and hydrological loading. Additionally, the steric sea level patterns are obtained from the Finite element Sea-Ice model. We discuss accuracy and separability of the estimation method and provide results in the spatial and time domain.

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Roger Telschow
University of Siegen
Nonlinear Approximation of Spherical Functions with Dictionaries

A nonlinear method using a dictionary to approximate functions on the sphere is to be derived. The elements of the dictionary added to the approximation are chosen with a matching pursuit algorithm while the dictionary consists of spherical harmonics of low degrees, to approximate global structures, and several radial basis functions such as the Abel-Poisson kernel to be added in areas with more details. The method, therefore, yields a representation of the function to be approximated which is not only sparse but also adapts to the solution, i.e. chooses more basis functions in areas where the function is structured more heavily, which also provides the possibility to easily add more finely resolved data of certain areas to the approximation. Numerical results are presented for both benchmark functions as well as practical applications.

Johannes Wicht
Max-Planck-Institut für Sonnensystemforschung
Towards realistic planetary dynamo simulations

The last years have witnessed an impressive growth in the number and quality of numerical dynamo simulations. These models successfully describe many aspects of the geomagnetic and other planetary magnetic fields. The success is somewhat surprising since numerical limitation force dynamo modelers to run their computations at unrealistic parameters. In particular the Ekman number, a measure for the relative importance of viscous diffusion, is many orders of magnitude too large. We discuss the fundamental dynamo regimes and address the question how well the modern models reproduce the geomagnetic field. First-level properties like the dipole dominance, realistic magnetic field strength, convective flow vigor, and an Earth-like reversal behavior are already captured by larger Ekman number simulations. However, low Ekman numbers are required for successfully modeling features like the low latitude field and torsional oscillations which are thought to be an important part of the decadal geomagnetic field variations. Only low Ekman number models also retain the huge dipole dominance of the geomagnetic field in combination with magnetic field reversals.

Minisymposium 9

Geometrische Gruppentheorie

Oleg Bogopolski (Düsseldorf)

Montag, 19. September 2011 **Seminargebäude, S16**

14:00 Gabriela Weitze-Schmithüsen (Karlsruhe)
Origami-Teichmüllerkreisscheiben im Culler-Vogtmann-Outerspace

15:00 Richard Weidmann (Kiel)
Nielsen equivalence in graphs of groups

16:00h – 16:30h Pause

16:30 Abderezak Ould Houcine (Lyon)
Algebraic and definable closure in free groups

17:30 Andreas Zastrow (Gdansk)
The homology group of a space, where every closed path is homotopic to an infinite commutator products of loops

Dienstag, 20. September **Seminargebäude, S16**

14:00 Kai-Uwe Bux (Bielefeld)
Subgroup conjugacy separability of surface groups

15:00 Oleg Bogopolski (Düsseldorf)
Generalized presentations of in nite groups, in particular of $Aut(Fw)$

16:00h – 16:30h Pause

16:30 Ahmed Elsawy (Düsseldorf)
Subgroup conjugacy separability property for free products of groups

17:30 Christopher Voll (Southhampton)
Representation zeta functions of arithmetic groups

Mittwoch, 21. September **Seminargebäude, S16**

14:00 Ralf Köhl (Gießen)
Endlichkeitseigenschaften von S-arithmetischen Untergruppen fasteinfacher algebraischer Gruppen über globalen Funktionen-körpern

15:00 Jörg Lehnert (Frankfurt am Main)
Quasi-automorphisms of colored graphs

Oleg Bogopolski
Universität Düsseldorf
Generalized presentations of infinite groups, in particular of $\mathrm{Aut}(F_\omega)$.

A very common way to describe a group G is by specifying generators and relations for G, with other words, by finding a set Λ and a subset R of the free group $F(\Lambda)$ such that G is isomorphic to the quotient of $F(\Lambda)$ by the normal closure $\langle\langle R\rangle\rangle$ of R. Unfortunately, for certain groups G, it is difficult to find such a presentation.
For example, take an infinite set X and look at the symmetric group $\Sigma(X)$ of all permutations of X. It is obvious that the set of transpositions does not generate $\Sigma(X)$. However, it is easy to see that each element of $\Sigma(X)$ is, in a certain sense, an infinite product of transpositions. In the present paper, we are going to develop the concept of a generalized presentation of a group G. In the case of $\Sigma(X)$, generalized generators are just the transpositions, and generalized relations are exactly the relations familiar from the finite symmetric groups Σ_n.
An important ingredient of a generalized presentation is the notion of a big free group $\mathrm{BF}(\Lambda)$. If Λ is countably infinite, the group $\mathrm{BF}(\Lambda)$ was first studied by Higman in 1952; it is isomorphic to the fundamental group of the Hawaiian earrings. Whereas subgroups of free groups are again free, subgroups of big free groups need not be big free groups. Therefore we have to introduce the concept of *generalized free groups*; these are certain subgroups of big free groups.
A generalized presentation of a group G consists, then, of a generalized free group $\mathscr{F}$ and of a subset R of $\mathscr{F}$ such that G is isomorphic, not simply to $\mathscr{F}/\langle\langle R\rangle\rangle$, but to the quotient of $\mathscr{F}$ by the closure of $\langle\langle R\rangle\rangle$ with respect to an appropriate topology on the group $\mathscr{F}$.
We give generalized presentations of the symmetric group $\Sigma(X)$ and of the automorphism group of the free group of infinite countable rank, $\mathrm{Aut}(F_\omega)$. This is a joint work with Wilhelm Singhof.

Kai-Uwe Bux
Universität Bielefeld
Subgroup conjugacy separability of surface groups

Let G be a group. We call two elements g and h conjugacy separated if there is a finite quotient Q of G where g and h have non-conjugate images. We say that G is conjugacy separable if any two non-conjugate elements are conjugacy separated. Taking $h = 1$, we see that conjugacy separability implies residual finiteness.
Similarly, we call subgroups H and H' of G conjugacy separated if there is a finite quotient Q of G where H and H' have non-conjugate images; and we say that G is subgroup conjugacy separable (SCS) if any two non-conjugate finitely generated subgroups are conjugacy separated. This property can be viewed as the subgroup-analogue of conjugacy separability very much in the same spirit as LERF is a subgroup-analogue of residual finiteness.
Bogopolski and Grunewald have shown that free groups of finite rank are SCS. We show that fundamental groups of closed orientable surfaces are SCS. We conjecture that limit groups are SCS (they have been shown to be LERF).
In the talk, I shall outline the proof for fundamental groups of genus at least 2. In particular, I want to stress how the hyperbolic metric that such a surface admits enters the picture. This is a joint work with Oleg Bogopolski.

Ahmed Elsawy
Universität Düsseldorf
Subgroup conjugacy separability for free products of groups

By definition, a group G is subgroup conjugacy separable (abbreviated SCS) if for any two non-conjugate finitely generated subgroups H_1, H_2 of G, there exists a finite quotient of G, where the images of H_1, H_2 are non-conjugate. A group G is called locally extended residually finite (LERF) if for any finitely generated subgroup H of G and for any element $g \in G \setminus H$, there exists a finite index subgroup of G, which contains H and does not contain g. We prove that if A and B are both SCS and LERF, then their free product $A * B$ is SCS. This is a joint work with Oleg Bogopolski.

Ralf Köhl
Universität Gießen
Endlichkeitseigenschaften von S-arithmetischen Untergruppen fasteinfacher algebraischer Gruppen über globalen Funktionenkörpern

Eine Gruppe ist vom Typ F_m, wenn sie einen klassifizierenden Raum mit endlichem m-Skelett besitzt; F_1 ist äquivalent dazu, dass die Gruppe endlich erzeugt ist, F_2 dazu, dass sie endlich präsentiert ist.
Nach Borel-Serre ist eine S-arithmetische Untergruppe einer fasteinfachen algebraischen Gruppe über einem Zahlkörper vom Typ F_m für alle $m \in \mathbb{N}$. Nach einer Beobachtung von Nagao ist dies im Funktionenkörperfall anders; Serre und Stuhler zeigten Ende der 1970er, wie Hardersche Reduktionstheorie genutzt werden kann, um die Endlichkeitseigenschaften von S-arithmetischen Gruppen zu bestimmen, die auf (Produkten von) Bäumen wirken. Später wurden die Endlichkeitseigenschaften durch Bux und Wortman für S-arithmetische Untergruppen von Gruppen von globalem Rang 1 bestimmt, sowie eine allgemein gültige obere Schranke für die Endlichkeitseigenschaften angegeben, abhängig von der euklidischen Dimension des zugrundeliegenden Produkts von affinen Gebäuden.
In meinem Vortrag möchte ich die allgemeine Situation betrachten und den von Bux, Witzel und mir bewiesenen Satz diskutieren, dass im Funktionenkörperfall eine solche S-arithmetische Gruppe vom Typ F_{l-1}, aber nicht vom Typ F_l ist, wobei l die euklidische Dimension des Produktes von affinen Gebäuden ist, auf welchen die S-arithmetische Gruppe natürlicherweise wirkt. Die von Bux und Wortman bestimmte obere Schranke ist somit scharf.

Jörg Lehnert
Universität Frankfurt am Main
Quasi-automorphisms of colored graphs

A quasi-automorphism of a colored graph is a bijection of the set of vertices with the property, that both, the bijection and its inverse, respect all but finitely many colored edges of each color. Thus the set of all quasi-automorphisms of a fixed graph forms a subgroup of the group of all permutations of the set of vertices. We will discuss some interesting examples of graphs and the corresponding groups. The first class of colored graphs a group theorist has in mind might be the class of Cayley graphs. We will discuss the relation between groups and the quasi-automrophism groups of their Cayley graphs. We will also discuss the group of quasi-automorphisms of the rooted binary tree, a group which is strongly related to Richard Thompson's groups F and V.

Abderezak Ould Houcine
University Lyon
Algebraic and definable closure in free groups

We prove that if F is a free group of finite rank and A is a nonabelian subgroup of F such that F is freely indecomposable with respect to A, then $acl(A)$ coincides with the vertex group in the generalized cyclic JSJ-decomposition of F with respect to A. We show that $dcl(A)$ is a free factor of $acl(A)$ and in particular they coincide in a free group of rank 2. In the general case, we show that a free group whose rank is greater than 4 contains a subgroup A such that $acl(A) \neq dcl(A)$. This answers a question of Z. Sela. This is a joint work with D. Vallino.

Christopher Voll
Universität Bielefeld
Representation zeta functions of arithmetic groups

A group is called (representation) rigid if it has, for each n, only finitely many irreducible complex representations of dimension n. The representation growth of rigid groups is the study of arithmetic and asymptotic properties of the number of such representations, as n tends to infinity. If these numbers grow at most polynomially, a profitable approach to their study is to encode them in a Dirichlet generating series – the group's representation zeta function. Under additional assumptions, such zeta functions have Euler products indexed by places in algebraic number fields. The factors of such Euler products can be studied using a wealth of methods from geometry and combinatorics. Major questions regarding representation zeta functions of groups ask about properties of the Euler factors, such as rationality, and local and global abscissae of convergence.

Richard Weidmann
Universität Kiel
Nielsen equivalence in graphs of groups

We discuss how Nielsen classes of (generating) tuples of fundamental groups of graphs of groups can (sometimes) be distinguished.

Gabriela Weitze-Schmithüsen
Universität Karlsruhe
Origami-Teichmullerkreisscheiben im Culler-Vogtmann-Outerspace

Origamis sind Überlagerungen des Torus, die über höchstens einem Punkt verzweigen. Variation der komplexen Struktur auf dem Torus induziert eine Familie von komplexen Strukturen auf der überlagernden Fläche. Diese bilden eine geodätische Kreisscheibe im zugehörigen Teichmüllerraum T_g. Das Bild im Modulraum M_g ist eine komplexe algebraische Kurve. Diese ist bis auf endlich viele Punkte durch ihre Veech-Gruppe bestimmt, eine Gruppe, die gleichzeitig als Matrizengruppe in $\mathrm{GL}(2,\mathbb{R})$ und als Untergruppe der zu M_g passenden Abbildungsklassengruppe aufgefasst werden kann. In dem Vortrag wird eine analoge Konstruktion im Culler-Vogtmann Outerspace CV_n, dem Teichmüllerraum für metrische Graphen von Geschlecht n, und im zugehörigen Modulraum vorgestellt. Mit Hilfe dieser können Rückschlüsse auf die ursprüngliche Teichmüllerkurve C gezogen werden.

Andreas Zastrow
University of Gdansk
The homology group of a space, where every closed path is homotopic to an infinite commutator product of loops

In 1986, Umed Karimov constructed a space as a one-point compactified CW-complex, where the relations built into the CW-Complex were chosen so that every path would be homotopic to an infinite commutator product of loops. In 2002, Karimov already conjectured that the first homology group of this space is huge and asked in private conversation, whether this could be proven. The main subject of this talk will be about how to answer Karimov's question. Due to the one-point compactification the one-skeleton of Karimov's space is homotopy equivalent to the Hawaiian Earrings, hence the fundamental and first homology groups are factor groups of the fundamental group of the Hawaiian Earrings. The talk will also outline the authors' concept of describing the fundamental group of the Hawaiian Earrings by tame words, and some corollaries that could be drawn from this method such as the discovarage subgroups isomorphic to the rationals in the fundamental group of Griffiths' space and what might be interpreted as an infinitary version of the solution of the word problem for this fundamental group and the first homology group of the Hawaiian Earrings and of Griffiths' space. This is a joint work with Oleg Bogopolski.

Minisymposium 10

Modellierung und Analyse neuraler Netzwerke zum Verständnis sensorischer Reizverarbeitungsstörungen

Tassilo Küpper (Köln)

In the first part of this minisymposium results obtained through the project SSensory disorders of irritant processing appearing at schizophrenia - Mathematical modelling of neuronal networks based on time-frequency-analysis and analysis of EEGßponsored by the Walter and Marga Boll foundation will be presented: The second part is devoted to neural aspects of networks, specially a system modelling motions of an insect leg and results describing effects of plasticity in a neural model.

Dienstag, 20. September **Seminargebäude, S25**

14:00 Tassilo Küpper (Köln)
Begrüßung

14:15 Svitlana Popovych (Köln)
Mathematical modelling of dysfunction of the thalamo-cortical loops in schizophrenia

14:40 Ann-Katrin Becher (Köln)
Phase Synchronization in a network of inhibitory and excitatory coupled oscillators

15:10 Sevda Çağırıcı (Köln)
Amplitude Dynamics in the Model of Two Nonlinear Coupled Oscillators

15:30 Ralf Müller (Köln)
Modelling coupled network oscillations to study structures in real electroencephalogram (EEG) data as part of a multifaceted approach for the detection of psychiatric diseases

16:00h – 16:30h Pause

16:15 Silvia Daun–Gruhn (Köln)
A model of the levator-depressor neuro-mechanical system of the stick insect leg

17:15 Veera Katharina Menz (Göttingen)
Modelling of Synaptic STDP and Analysis in a Two-Neuron Model

Ann-Katrin Becher
Universität zu Köln
Phase Synchronization in a network of inhibitory and excitatory coupled oscillators

The phenomenon of phase synchronization plays a crucial role in many systems of biology, physics and neurosciences which can be modelled by phase coupled oscillators. One popular model that exhibits phase synchronization is the Kuramoto system.
In this talk a similar model of phase coupled oscillators is introduced describing a network with both excitatory and inhibitory interactions. The phase dynamics are modelled by a Kuramoto-like system without symmetries with regard to coupling. The coexistence of inhibitory and excitatory interactions and the asymmetry of coupling give rise to several different scenarios of synchronization. Excitatory coupling can result in “in phase” oscillations. In contrast inhibitory coupled oscillators tend to oscillate “anti-phase”. Therefore a combination of both types of coupling can lead to transitional states or coexistence of stable in phase and anti-phase oscillations. In the talk the phase model is introduced and some of the results concerning the excitatory-inhibitory-synchronization behavior are presented.

Sevda Çağırıcı
Mathematical Institute, University of Cologne
Amplitude Dynamics in the Model of Two Nonlinear Coupled Oscillators

We analyse a system of two nonlinear coupled oscillators describing amplitude and phase dynamics, which can be seen as a four dimensional model of two neurons. The major point of our investigations is to study the influence of the inhibitory synaptic coupling between neurons upon the amplitude dynamics. In addition we show some results of our model with external stimulus which corresponding to real EEG-Data from auditory processing in shizophrenia.

Silvia Daun–Gruhn, Tibor I. Tóth
Emmy-Noether Research Group, Zoological Institute, University of Cologne
A model of the levator-depressor neuro-mechanical system of the stick insect leg

It has been established experimentally that each joint in the stick insect leg is associated with its own rhythm generating neural network (CPG), which is responsible for driving the motoneurons (MNs) that innervate antagonistic muscle pairs [1]. This arrangement ensures large flexibility of the leg movements in these animals. But how exactly do these CPG-MN-muscles systems function? And how is sensory information integrated to produce functional stepping?
To tackle these questions, we developed a mathematical model of the levator-depressor neuro-mechanical system, which consists of a half-center oscillator [2] that controls the MN activity via inhibitory interneurons [3]. A sensory pathway to the CPG, conveying information on the loading of the leg, is included as well. The core of the mechanical model is the equation of motion of the femur. The muscles are modeled as nonlinear springs with variable elasticity modules and with viscous damping parallel to the springs. Finally, the neural and the muscle systems are coupled by a linear, 1st order synapse model [4]. Our model successfully reproduces the MN activities, as well as the angular movement of the femur as recorded during straightforward locomotion. Furthermore, our simulations provide strong evidence for a high behavioral flexibility of the model under various peripheral or central influences.

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Veera Katharina Menz
Deutsches Primaten Zentrum Göttingen
Modelling of Synaptic STDP and Analysis in a Two-Neuron Model

Synapses as the connecting elements between two brain cells are crucial in transmitting electrical signals from one neuron to another. Donald Hebb postulated in 1949 that the transmission of signals between two cells can be improved due to synaptic modification when both cells are active at the same time or shortly after each other. Additionally, Bi and Poo detected in 1998 that the strength of transmitting signals can also decrease, depending on the relative spike-timing of the connected cells (*spike-timing-dependent plasticity*, short *STDP*).
We will discuss a mathematical model which describes the behaviour of spiking neurons and synaptic weight change of connecting synapses in terms of spike-timing-dependent plasticity. By combining an integrate-and-fire equation with a system of differential equations as a modification of a model of STDP by Gorchetchnikov, Versace, and Hasselmo (2005) an STDP-curve is produced similar to the one found experimentally by Bi and Poo (1998). This mathematical model is applied to two coupled neurons stimulated by a constant external current and examined for long time periods both for permanent external stimulation as well as short initial stimulation. The results are compared to data of *in vivo* and *in vitro* neurons.

Literatur

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Ralf Müller
Department of Psychiatry and Psychotherapy, University of Cologne
Modelling coupled network oscillations to study structures in real electroencephalogram (EEG) data as part of a multifaceted approach for the detection of psychiatric diseases

In medical science, the electroencephalogram (EEG) gives an impression of the dynamics of cortical brain functions in humans and is used to investigate neurological and psychiatric diseases. Diverse mathematical methods, e.g. time-frequency methods, are very helpful in disentangling the complexity of the EEG data and thereby contribute to a better understanding of neurobiological differences between diseases. Since microscopic and macroscopic neuronal circuits play a key role in understanding complex psychiatric diseases, e.g. schizophrenia, different approaches in the field of mathematical modelling are applied. We describe, how analyses and simulations of our neurophysiologically based coupled phase oscillator model allow new insights into temporal dynamics of sensory processing, which can be detected in real EEG data in humans.

Svitlana Popovych
Mathematical Institute, University of Cologne
Mathematical modelling of dysfunction of the thalamo-cortical loops in schizophrenia

Recent results suggest that disturbances of information processing within the thalamo-cortical circuit are central in the schizophrenia disease. We will derive a phenomenologically mathematical model based on coupled phase oscillators to describe the neural activity of the thalamo-cortical loop. Depending on parameters of coupling our model can demonstrate various states of phase locking between different brain areas, which correspond to disturbances in sensory processing. We compare the numerical simulations for our model with experimental data obtained by EEG measurements for schizophrenia patients.

Minisymposium 11

Nichtglatte dynamische Systeme

Tassilo Küpper (Köln)

Many results in the theory of dynamical systems are based on smoothness requirements, which do not always hold in applications: As typical examples we mention switches in electrical circuits, effects caused by dry friction or by sudden state dependent impacts: Present research is concerned with the question if and to what extent results of the classical theory can be carried over to nonsmooth system: A central point refers to the reduction to invariant manifolds: The concept of invariant cones-like objects has turned out as an appropriate generalization of the notion of center manifolds for example.

Montag, 19. September **Seminargebäude, S25**

14:00 Tassilo Küpper (Köln)
Bifurcation of periodic orbits for non-smooth systems

14:20 Hany A. Hosham (Köln)
Nonstandard bifurcation phenomena in nonsmooth system

14:40 Daniel Weiss (Tübingen)
Existence of Invariant Cones for Piecewise Linear Systems

15:00 Olga Voytolovska (Köln)
Discontinuity induced Boundary Equilibrium Bifurcations in Filippov systems

15:20 Albert Granados (Stuttgart)
Melnikov's method for subharmonic orbits in a piecewise-defined Hamiltonian system with impacts

15:40 Tassilo Küpper (Köln)
Bells as impacting system „Die Kaiserglocke im Kölner Dom“

Albert Granados, John Hogan, Tere Seara
Universität Stuttgart, University of Bristol, Universitat Politècnica de Catalunya
Melnikov's method for subharmonic orbits in a piecewise-defined Hamiltonian system with impacts

In this work we consider a two-dimensional piecewise smooth system, defined in two sets separated by the switching curve $x = 0$. We assume that there exists a piecewise-defined continuous Hamiltonian that is a first integral of the system. We also suppose that the system possesses an invisible fold-fold at the origin and two heteroclinic orbits connecting two critical saddle points located at each side of $x = 0$. Finally, we assume that the region closed by these heteroclinic connections is fully covered by periodic orbits surrounding the origin, whose periods monotonically increase as they approach the heteroclinic connection.
When considering a non-autonomous (T-periodic) Hamiltonian perturbation of amplitude ε, using an impact Poincaré map, we rigorously prove that, for every n and m relatively prime and $\varepsilon > 0$ small enough, there exists a nT-periodic orbit impacting $2m$ times with the switching curve at every period. In addition, we also prove that, if the orbits are forced to undergo a discontinuity when they cross $x = 0$, which simulates a loss of energy, then all these orbits persist if the relative size of $\varepsilon > 0$ with respect to the magnitude of this jump is large enough.

Hany A. Hosham
Universität zu Köln
Nonstandard bifurcation phenomena in nonsmooth system

Due to the presence of discontinuities on the manifold, nonsmooth system (PWS) present a wide variety of bifurcations. In particular, if the behavior of PWS relies on the dynamics of the separation boundaries, nonstandard bifurcations may occur. It was recently shown that the existence of invariant cones C plays an important role in describing the dynamical behavior for PWS relevant to the transition law between the subsystems. The sliding dynamics along the separation manifold for PWS are formulated by using differential inclusions. We show the existence of C containing a segment of sliding orbits and study stability on these cones. Our approach is developed to investigate the existence of C induced sliding bifurcation. Different sliding bifurcation scenarios such as: invariant cones exhibiting *crossing-sliding*, *grazing-sliding* and *switching-sliding* bifurcation are treated. Further, catastrophic bifurcation may occur.

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Tassilo Küpper
Universität zu Köln
Bells as impacting system "Die Kaiserglocke im Kölner Dom"

Ringing bells provide a beautiful example for a dynamical system where impacts occur in a natural way. Bells considered as a dynamical system give rise to several interesting mathematical problems. Starting with the fascinating story of the famous emperor's bell in the Cathedral of Cologne who could not be forced to ring appropriately and for that reason had been nicknamed "Die Stumme". We provide a dynamical system approach to investigate motions of a bells inducting impacts.

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Tassilo Küpper
Universität zu Köln
Bifurcation of periodic orbits for non-smooth systems

For smooth dynamical systems Hopf bifurcation provides a well established approach to generate periodic solutions. In recent studies this approach has been extended to non-smooth systems. In this lecture we will present an overview of recent results concerning the bifurcation of periodic solutions. In particular we will show how the dynamics of high-dimensional systems can be reduced to the investigation of low dimensional systems. For that purpose the concept of center manifolds is generalized to invariant "cone-like" objects which may involve grazing/sliding bifurcation.

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Olga Voytolovska
Universität zu Köln
Discontinuity induced Boundary Equilibrium Bifurcations in Filippov systems

A rich variety of applications in physics and mechanics can be modeled with non-smooth dynamical systems. Nowadays there is no complete theory for bifurcations of non-smooth systems such as for classical smooth systems. These difficulties arise due to the existence of a discontinuity manifold, separating disjoint regions of the state space. The interaction of invariant sets, e.g. limit cycles and equilibria, with the separating manifold may lead to bifurcations that are not possible in smooth systems. Here we study bifurcations of equilibria in autonomous piecewise smooth discontinuous dynamical systems, called Filippov systems. These are boundary equilibria bifurcations (BEB) that occur as a result of the collision of a pseudo- and a standard-equilibrium branch on the discontinuity manifold. The main focus is on analyzing of 3-dimensional Filippov systems. Based on examples we also illustrate a co-dimension 2 BEB with a non-hyperbolic equilibrium and a system where the existence and absence of a sliding area depend solely on parameter values. The work concludes with an outlook of open problems, especially concerning a possible construction of a center manifold for non-smooth Filippov systems.

Daniel Weiss
University of Tübingen
Existence of Invariant Cones for Piecewise Linear Systems

Recently the concept of center manifolds of smooth dynamical systems generated by a pair of complex conjugated eigenvalues with vanishing real part has been carried over to piecewise nonlinear systems. In this process so called invariant cones of corresponding piecewise linear systems play an important role, invariant cones consisting of periodic orbits or orbits spiraling in respectively out.
In this talk we derive conditions of existence of invariant cones and study their stability introducing the monodromy matrix of an invariant cone. We apply the results to general 3 dimensional piecewise linear systems and discuss a 6 dimensional brake system.

Minisymposium 12

Numerische Finanzmathematik

Pascal Heider (Köln), Ralf Korn (Kaiserslautern), Rüdiger Seydel (Köln)

Donnerstag, 22. September **Seminargebäude, S24**

14:00 Kees Oosterlee (Delft)
Efficient valuation methods for contracts in finance and insurance

14:40 Jan H. Maruhn (UniCredit, München)
Exploiting GPUs and Adjoints for Rapid Monte Carlo Calibrations

15:20 Pascal Heider (Köln)
Arbitrage-free Approximation of Call Price Surfaces

16:00h – 16:30h Pause

16:30 Ralf Korn (Kaiserslautern)
Recent Advances in Option Pricing with Binomial Trees

17:10 Christoph Winter (Zürich)
Wavelet Galerkin schemes for option pricing in multidimenstional Lévy models

17:50 Christian Jonen (Köln)
Valuing High-Dimensional American-Style Derivatives: A Robust Regression Monte Carlo Method

Pascal Heider
Universität Köln
Arbitrage-free Approximation of Call Price Surfaces

In this talk I present a construction of arbitrage-free call price surfaces from observed market data by locally constrained least squares approximations. Derivatives of the surface are computed accurately so that implied volatility, local volatility and transition probability density are obtained at no additional costs. Observed input data are afflicted by a price uncertainty and cause an input data risk on the computed call surface. I present a simple model for the input risk and perform an analysis to study and measure the effect of the input risk on the surfaces. With this analysis one can determine the trust-worthiness of the computed results and their implications on option pricing a posteriori.

Christian Jonen
Universität zu Köln
Valuing High-Dimensional American-Style Derivatives: A Robust Regression Monte Carlo Method

Pricing high-dimensional American-style derivatives is still a challenging task, as the complexity of numerical methods for solving the underlying mathematical problem rapidly grows with the number of uncertain factors. In this paper we extend the important class of regression-based Monte Carlo methods for valuing these complex financial products. The key idea of our proposed approach is to fit the continuation value at every exercise date by robust regression rather than by ordinary least squares. By using robust regression, we are able to get a more accurate approximation of the continuation value due to taking outliers in the cross-sectional data into account. In order to guarantee an efficient implementation of our Robust Regression Monte Carlo (RRM) method, we suggest a new Newton-Raphson-based solver for robust regression with very good numerical properties. We use techniques of the statistical learning theory to prove the convergence of our RRM estimator. In order to test the numerical efficiency of our proposed method, we price Bermudan options on up to thirty assets. It turns out that our RRM approach shows a remarkable convergence behavior; we get speed-up factors of up to over four compared with the state-of-the-art Least Squares Monte Carlo method proposed by Longstaff and Schwartz (2001).

Literatur

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Ralf Korn
University of Kaiserslautern
Recent Advances in Option Pricing with Binomial Trees

Binomial trees are used in option pricing for over 30 years. However, their irregular convergence and problems with multi-dimensional trees still call for research. In the talk, we will present the so-called optimal drift method to speed up the convergence of approximating binomial trees in the univariate setting by generalizing results by Chang and Palmer. Further, we introduce the orthogonal decomposition method to construct regular multivariate trees that can be applied universally for valueing options on multiple assets.

Jan H. Maruhn
UniCredit, München
Exploiting GPUs and Adjoints for Rapid Monte Carlo Calibrations

Due to performance constraints the class of Equity models used in the front office has often been limited to models with closed form solution for plain vanilla options, or models with on-the-fly calibration (like the Dupire local volatility model). In this talk we will show that recent developments on the hardware and algorithm side allow to break this paradigm. By combining the speedup of GPUs, adjoints and multi-layer techniques, the Monte Carlo calibration of financial market models has become feasible for large scale purposes - thus allowing to choose models based on their dynamics, and not their feasibility.

Kees Oosterlee
Techische Universität Delft
Efficient valuation methods for contracts in finance and insurance

In this presentation we will discuss the use of Fourier cosine expansions for pricing financial and insurance derivative contracts. We will discuss hybrid SDE models, like the Heston Hull-White model, modelling for example inflation options, and stochastic control problems.

Christoph Winter
Eidgenössische Technische Hochschule Zürich (ETHZ)
Wavelet Galerkin schemes for option pricing in multidimensional Lévy models

We consider a wavelet Galerkin scheme for solving partial integrodifferential equations arising from option pricing in multidimensional Lévy models. Sparse tensor product spaces are applied for the discretization to reduce the complexity in the number of degrees of freedom and wavelet compression methods are used to decrease the number of non-zero matrix entries. We give numerical examples. In particular, the regularization of the multidimensional Lévy measure is considered where small jumps are either neglected or approximated by an artificial Brownian motion.

Minisymposium 13

Operatortheorie

Bernhard Gramsch (Mainz), Birgit Jacob (Wuppertal), Marko Lindner (Chemnitz), Carsten Trunk (Ilmenau)

Montag, 19. September **Seminargebäude, S23**

14:00 Johannes Brasche (Clausthal-Zellerfeld)
On the absolutely continuous spectra of selfadjoint extensions

14:30 Christian Wyss (Wuppertal)
Bounded solutions of operator Riccati equations

15:00 Carsten Trunk (Ilmenau)
Variational Principles of Eigenvalues of a Class of Block Operator Matrices

15:30 Friedrich Philipp (Berlin)
Bounds on the non-real spectrum of indefinite Sturm-Liouville operators

16:00h – 16:30h Pause

16:30 Rainer Picard (Dresden)
A class of Time-Shift Invariant Evolutionary Equations with an Application to Acoustic Waves with Impedance Type Boundary Conditions

17:00 Sascha Trostorff (Dresden)
Well-posedness and causality of a class of evolutionary inclusions

17:30 Birgit Jacob (Wuppertal)
Weighted interpolation in Paley-Wiener spaces and finite-time controllability

18:00 Sebastian Häsler (Chemnitz)
Generalized solutions and spectrum for Dirichlet form on graphs

Dienstag, 20. September **Seminargebäude, S23**

14:00 Marko Lindner (Chemnitz/Freiberg)
Spectra and Finite Sections of Random Jacobi Operators

14:30 Swanhild Bernstein (Freiberg)
Inverse Scattering with Dirac Operators

15:00 Kenro Furutani (Tokyo)
Heat Kernel of Grushin Operator and Complex Hamilton-Jacobi Method

15:30 Jonathan Eckhardt (Wien)
Inverse spectral theory for Schrödinger operators with strongly singular potentials: a uniqueness theorem

16:00h – 16:30h Pause

16:30 Bernhard Gramsch (Mainz)
Fredholm Operatoren in topologischen Algebren der mikrolokalen Analysis

17:30 Joshua Isralowitz (Göttingen)
Schatten class Toeplitz and Hankel operators on the Segal-Bargmann and Bergman spaces

18:00 Wolfram Bauer (Göttingen)
Algebraic properties and the finite rank problem for Toeplitz operators

Wolfram Bauer
Georg-August-Universität, Göttingen
Algebraic properties and the finite rank problem for Toeplitz operators

We address three different problems in the area of Toeplitz operators on the Segal-Bargmann space over $\mathbb{C}^n$. First, we determine the commutant of a given Toeplitz operator with radial symbol which has a controlled growth behaviour at infinity. Then we provide explicit examples of zero-products of non-trivial Toeplitz operators. These examples show the essential difference between Toeplitz operators on the Segal-Bargmann space and on the Bergman space over the unit ball. Finally, we discuss the "finite rank problem" in the setting of an unbounded domain. In all these problems the growth at infinity of the operator symbol plays a crucial role. The results presented in this talk are joint work with Trieu Le, University of Toledo.

Literatur

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Swanhild Bernstein
TU Bergakademie Freiberg
Inverse Scattering with Dirac Operators

We develop a reconstruction scheme of the potential from the scattering matrix of the Dirac operator by using Faddeev's method for the multi-dimensional inverse scattering theory for Schrödinger operators. We also demonstrate how Dirac operators can be used to construct Lax pairs for linear and non-linear systems of partial differential equations. Further, we construct Lax pairs using the AKNS method for a higher dimensional version of the nonlinear KdV equation.

Literatur

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Johannes Brasche
TU Clausthal
On the absolutely continuous spectra of selfadjoint extensions

Let S be a symmetric operator in a Hilbert space $\mathscr{H}$. We give conditions which are sufficient in order that for every selfadjoint operator A_{aux} in $\mathscr{H}$ there exists a selfadjoint extension A of S such that the absolutely continuous parts of A and A_{aux} are unitarily equivalent and show how to construct such an extension A.

Jonathan Eckhardt
Universität Wien
Inverse spectral theory for Schrödinger operators with strongly singular potentials: a uniqueness theorem

Consider self-adjoint Schrödinger operators

$$H = -\frac{d^2}{dx^2} + q(x),$$

in the Hilbert space $L^2(a,b)$, where $q \in L^1_{loc}(a,b)$ is real-valued. Given some nontrivial real entire solution ϕ of

$$-\phi''(z,x) + q(x)\phi(z,x) = z\phi(z,x), \quad x \in (a,b),\ z \in \mathbb{C},$$

which is square integrable near a and satisfies the boundary condition there (if any), it is possible to construct an associated spectral measure. Utilizing de Branges' theory of Hilbert spaces of entire functions, we give conditions under which this spectral measure uniquely determines the operator H. As an example we apply our result to perturbed Bessel operators and show that in this case the associated spectral measure uniquely determines the operator.

Kenro Furutani
Tokyo University of Science
Heat Kernel of Grushin Operator and Complex Hamilton-Jacobi Method

First, I will overview two methods for constructing the heat kernel of Grushin operator. One is the eigenfunctions expansion and Mehler formula. The other is, so called, the complex Hamilton-Jacobi method invented by Beals-Gaveau-Greiner. Then by comparing these methods, I will discuss the possible formula of the heat kernel for the higher step Grushin operators with giving an explicit solution of the Hamilton-Jacobi equation associated to the higher step Grushin operators.

Literatur

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Bernhard Gramsch
Universität Mainz
Fredholm Operatoren in topologischen Algebren der mikrolokalen Analysis

Zunächst wird ein Überblick gegeben zur relativen Inversion von Pseudodifferentialoperatoren. Die spektrale Invarianz der Frechet-Operatoralgebren ist für die analytische homogene Struktur einiger Klassen von Fredholmoperatoren entscheidend, dies ist wichtig für das Okasche Prinzip in der komplex-analytischen Homotopietheorie. Es hat sich aber herausgestellt, dass für gewisse Schlußweisen mit Liftingmethoden und unendlichen Produkten die Frechetalgebren, die projektive Limiten von Banachalgebren sind, viele Anwendungen finden. Insbesondere ist die symmetrische Hörmander-Klasse (1,1) von diesem Typ, aber nicht spektralinvariant auf einem Hilbertraum. Eine Anwendung auf die Division von Operatordistributionen durch analytische Fredholmfunktionen wird in solchen Frechetalgebren abgeleitet. Auch im Zusammenhang mit den Resultaten von Gromov (1989) kam es etwa seit 2000 zu interessanten Entwicklungen in Bezug auf das Oka Prinzip (vgl. z.B. Forstneric, Lempert, in Complex Analysis, Birkhäuser 2010). In Verbindung damit ergibt sich eine Reihe interessanter Probleme auch in der Operatortheorie auf singulären Räumen.

Sebastian Häsler
Technische Universität Chemnitz
Generalized solutions and spectrum for Dirichlet forms on graphs

We study the connection of the existence of solutions with certain properties and the spectrum of operators in the framework of regular Dirichlet forms on infinite graphs. In particular we prove a version of the Allegretto-Piepenbrink theorem, which says that positive (super-)solutions to a generalized eigenvalue equation exist exactly for energies not exceeding the infimum of the spectrum. Moreover we show a version of Shnol's theorem, which says that existence of solutions satisfying a growth condition with respect to a given boundary measure implies that the corresponding energy is in the spectrum.

Joshua Isralowitz
Universität zu Göttingen
Schatten class Toeplitz and Hankel operators on the Segal-Bargmann and Bergman spaces

We discuss and compare Schatten p class membership for $0 < p < \infty$ of Toeplitz and Hankel operators on the Segal-Bargmann space and the Bergman space of the unit ball in C^n. In particular, we discuss the cut-off phenomenon that occurs when characterizing Schatten p class membership of Toeplitz and Hankel operators on the Bergman space of the unit ball, but which does not occur when characterizing Schatten class Toeplitz and Hankel operators on the Segal-Bargmann space. This is partly joint work with K. Zhu.

Birgit Jacob
Bergische Universität Wuppertal
Weighted interpolation in Paley-Wiener spaces and finite-time controllability

We consider the solution of weighted interpolation problems in model subspaces of the Hardy space H^2 that are canonically isometric to Paley–Wiener spaces of analytic functions. A new necessary and sufficient condition is given on the set of interpolation points which guarantees that a solution in H2 can be transferred to a solution in a model space. The techniques used rely on the reproducing kernel thesis for Hankel operators, which is given here with an explicit constant. One of the applications of this work is to the finite-time controllability of diagonal systems specified by a C_0 semigroup.

Literatur

B. Jacob, J.R. Partington and S. Pott. Weighted interpolation in Paley-Wiener spaces and finite-time controllability, Journal of Functional Analysis, 259 (2010), 2424-2436

Marko Lindner
TU Chemnitz, TU Freiberg
Spectra and Finite Sections of Random Jacobi Operators

For a random singly- or bi-infinite Jacobi matrix A, we give upper and lower bounds on the spectrum and present a version of the finite section method for the approximate solution of equations $Ax = b$ that is stable as soon as A is invertible.

Friedrich Philipp
Technische Universität Berlin
Bounds on the non-real spectrum of indefinite Sturm-Liouville operators

We consider indefinite Sturm-Liouville operators A of the form

$$(Af)(x) = \operatorname{sgn}(x)\,\big(-f''(x) + q(x)f(x)\big) \quad x \in \mathbb{R},\ f \in H^2(\mathbb{R})$$

with an essentially bounded and real-valued potential $q \in L^\infty(\mathbb{R})$. It is well-known that the non-real spectrum of the operator A is bounded, consists of normal eigenvalues and can only accumulate to the compact interval $[m_+, m_-]$ (which might be the empty set if $m_+ > m_-$), where

$$m_+ = \liminf_{x\to\infty} q(x) \quad \text{and} \quad m_- = -\liminf_{x\to-\infty} q(x).$$

So far, the non-real spectrum of A could not be localized in quantitative terms. We tackle this problem by proving an abstract result concerning bounded perturbations of non-negative operators in Krein spaces and find explicit bounds on the non-real spectrum of the operator A. It should be mentioned that the perturbation result is applicable to a large class of ordinary and partial differential operators with indefinite weights. This is a joint work with J. Behrndt (TU Graz) and C. Trunk (TU Ilmenau).

Rainer Picard
Technische Universität Dresden
A Class of Time-Shift Invariant Evolutionary Equations with an Application to Acoustic Waves with Impedance Type Boundary Conditions.

A well-posedness result for a time-shift invariant class of evolutionary operator equations is considered and exemplified by an application to an impedance type initial boundary value problem for the system of linear acoustics. The acoustic initial boundary value problem allows for dynamics (including memory effects) in the domain as well as on the domain boundary. The application presented here is an improvement on a previously presented model class.

Sascha Trostorff
Technische Universität Dresden
Well-posedness and causality of a class of evolutionary inclusions

In 2009 R. Picard has shown that most of the problems occurring in classical mathematical physics posses the form

$$\left(\partial_0 M(\partial_0^{-1}) + A\right) U = F,$$

where ∂_0 denotes the time derivative established as a normal operator in suitable weighted Hilbert space, $M(\partial_0^{-1})$ is an analytic, operator valued function of ∂_0^{-1}, describing the behaviour of the underlying material and A is a skew-selfadjoint operator. The well-posedness and causality of this problem class has been shown. We extend these results to differential inclusions, by replacing the operator A by a maximal monotone relation. Thus we arrive at a class of differential inclusions which are encountered in many applications, for example in hysteresis models or for switched dynamical systems. We apply our solution theory to a system describing the diffusion of a fluid through a saturated poro-plastic media, including hysteresis effects (see Showalter & Stefanelli 2004).

Literatur

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Showalter, R. E., Stefanelli, U. (2004). Diffusion in poro-plastic media. *Math. Methods Appl. Sci.*, **27 (18)**, 2131 - 2151.

Carsten Trunk
Technische Universität Ilmenau
Variational Principles for Eigenvalues of a Class of Block Operator Matrices

We consider eigenvalues of block operator matrices

$$\mathscr{A} = \begin{bmatrix} 0 & I \\ -A_0 & -D \end{bmatrix} \tag{4}$$

which can be written as a quadratic eigenvalue problem. Under certain assumptions (A_0 uniformly positive with a compact resolvent, $A_0^{-1/2} D A_0^{-1/2}$ bounded and nonnegative) the essential spectrum of $\mathscr{A}$ is located on the negative half-axis. We characterise eigenvalues above and below the essential spectrum, even in the presence of complex eigenvalues. As a consequence we can compare these eigenvalues if the entries A_0 and D are increased/decreased.
Operators of the form (4) arise, e.g., in the investigation of small transverse oscillations of a pipe carrying steady-state fluid of ideal incompressible fluid. This talk is based on a joint work with Birgit Jacob (Bergische Universität Wuppertal, Germany) and Matthias Langer (University of Strathclyde, Glasgow).

Christian Wyss
Bergische Universität Wuppertal
Bounded solutions of operator Riccati equations

We consider Riccati equations of the form

$$A^*X + XA - XQ_1X + Q_2 = 0$$

for linear operators on a Hilbert space, where Q_1 and Q_2 are selfadjoint and nonnegative. Riccati equations of this type are of interest e.g. in systems theory; in particular their bounded nonnegative solutions X. However, in the general case there will also be unbounded solutions. We will study different methods to characterise the boundedness of a solution X. Among the tools that we use are invariant subspaces of the block operator matrix

$$T = \begin{pmatrix} A & -Q_1 \\ -Q_2 & -A^* \end{pmatrix},$$

Riesz bases, and indefinite inner products.

Minisymposium 14

Qualitative Aspekte nichtlinearer partieller Differentialgleichungen

Joachim Escher (Hannover), Christoph Walker (Hannover)

Montag, 19. September **Seminargebäude, S13**

14:00 Mark Peletier (Eindhoven)
Passing to the limit in the Wasserstein Gradient-flow formulation

14:30 Mats Ehrnström (Hannover)
Steady waters waves with multiple critical layers

15:00 Jürgen Saal (Darmstadt)
Analysis of a General Model in Electrokinetics

15:30h – 16:30h Pause

16:30 Daniela Treutler (Hannover)
On the behaviour of solutions to a parabolic evolution equation on two scales

17:00 Bogdan Matioc (Hannover)
On two-phases flows modelling thin films in porous media

17:30 Helmut Abels (Regensburg)
On a New Diffuse Interface Model for Two-Phase Flows with Different Densitites

18:00 Thomas Marquardt (Potsdam-Golm)
A Neumann Problem for Inverse Mean Curvature Flow

Dienstag, 20. September **Seminargebäude, S13**

14:00 Wolfgang Reichel (Karlsruhe)
Symmetry of solutions for quasimonotone second-order elliptic systems in ordered Banach spaces

14:30 Friederich Lippoth (Hannover)
Classical solutions for a one phase osmosis model

15:00 Anca Matioc (Hannover)
Analysis of a two-phase model describing the growth of solid tumors

15:30 Robert Denk (Konstanz)
Maximal Lp-regularity of non-local boundary value problems

Helmut Abels
Universität Regensburg
On a New Diffuse Interface Model for Two-Phase Flows with Different Densities

We present a new diffuse interface for a two-phase flow of two partialy miscible viscous incompressible fluids with different densities. The model is based on a solenoidal velocity field for the fluid mixture and is thermodynamically consistent and frame indifferent. We briefly discuss its derivation and a recent result on existence of weak solutions for singular free energy densities.
This is a joint work with Harald Garcke and Günther Grün (modeling) as well as Daniel Depner and Harald Garcke (analysis).

Robert Denk
Universtität Konstanz
Maximal L_p-regularity of non-local boundary value problems

Maximal L_p-regularity of operators corresponding to boundary value problems is closely related to the $\mathscr{R}$-boundedness of the resolvent. In several applications nonlocal operators appear, and one has to consider classes of operators belonging to the Boutet de Monvel calculus. In the talk we present some results on the $\mathscr{R}$-boundedness of pseudodifferential operators and parameter-dependent Green operators. As an application, we consider the Stokes equation in cylindrical domains. The talk is based on joint results with Jörg Seiler.

Mats Ehrnström
Leibniz Universität Hannover
Steady water waves with multiple critical layers

We construct steady and periodic gravity water waves with multiple critical layers. Those are i) waves with arbitrarily many critical layers and a single crest in each period, and ii) multimodal waves with several crests and troughs in each period. The mathematical setting is that of the two-dimensional Euler equations with a free surface, a flat bed, and otherwise periodic boundary conditions. In the steady frame, this is an elliptic problem in an unknown domain, and the goal is to find small-amplitude solutions via bifurcation from a solution curve of rotational running streams with stagnation. Using the Lyapunov-Schmidt reduction we find solutions in the vicinity of a particular class of eigenvalues, some of which are not simple. The main novelty lies in the type of vorticity distributions considered, which in their turn influence the kernel of the linearized problem at the bifurcation points. In particular, the problem admits two-dimensional bifurcation. The talk is based on joint work with J. Escher, G. Villari and E. Wahlén.

Friedrich Lippoth
Leibniz Universität Hannover
Classical solutions for a one phase osmosis model

For a moving boundary problem modelling the motion of a semipermeable membrane by osmotic pressure and surface tension we prove the existence and uniqueness of classical solutions on small time intervals. Moreover, we construct solutions existing on arbitrary long time intervals, provided the initial geometry is close to an equilibrium. In both cases, our method relies on maximal regularity results for parabolic systems with inhomogeneous boundary data.

Thomas Marquardt
MPI Golm
A Neumann Problem for Inverse Mean Curvature Flow

In this talk we consider hypersurfaces with boundary in Euclidean space which evolve in the direction of the unit normal with speed equal to the reciprocal of the mean curvature. We choose Neumann boundary conditions, i.e. the hypersurface moves along but stays perpendicular to a fixed supporting hypersurface. After short time existence for that nonlinear parabolic Neumann problem is established we will concentrate on the case where the supporting hypersurface is a convex cone. In this case we obtain long time existence and convergence to a piece of a round sphere.
If time permits we will present an approach to define weak solutions using a level set formalism which leads to a mixed Dirichlet-Neumann problem.

Anca Matioc
Leibniz Universität Hannover
Analysis of a two-phase model describing the growth of solid tumors

We consider a two-phase model describing the growth of avascular solid tumors which takes into account the effects of cell-to-cell adhesion and taxis due to nutrient.
We prove that the mathematical model is well-posed and determine all radially symmetric steady-state solutions of the problem. Furthermore, we also study the stability properties of the radially symmetric equilibria in dependence of the biophysical parameters involved in the problem.
This is a joint work with J. Escher.

Bogdan Matioc
Leibniz Universität Hannover
On two-phase flows modelling thin films in porous media

Starting from a moving boundary problem which describes the motion of two fluids in a porous medium, known as the Muskat problem, we pass to the limit of small layer thickness and obtain a second order degenerate parabolic system of equations. This strongly coupled system is the generalisation of the Porous Medium equation to the case of two fluids.
We show that if the initial data are nonnegative, then the degenerate system possesses a global solution which remains nonnegative and which converges exponentially fast towards some flat equilibrium.
This is a joint work with J. Escher and Ph. Laurencot.

Mark Peletier
Eindhoven University of Technology
Passing to the limit in the Wasserstein Gradient-flow formulation

The Wasserstein gradient-flow structure describes a large number of parabolic, diffusive systems. This structure has been used to derive many properties of such systems, such as well-posedness, stability, and large-time behaviour. Here we focus on the use of the gradient-flow structure to prove convergence.
Extending ideas of Stefanelli and Serfaty, we use the Wasserstein gradient-flow structure to prove convergence in a singularly perturbed diffusion problem. Our test problem arises from the interpretation of chemical reactions as diffusion in a potential landscape, initiated by Wigner and Kramers in the 1930's. In this interpretation a reaction event corresponds to the escape of the diffusing particle from one potential well into another. In earlier work (with Savare and Veneroni) we proved the convergence of this system in the limit of high activation energy to the corresponding reaction-diffusion system — but without making use of the Wasserstein gradient-flow structure.
In this talk I revisit the result, and reprove it using the Wasserstein gradient-flow structure. The method has some interesting aspects, such as relatively weak compactness requirements, a somewhat surprising limit, and a tight connection to stochastic particle systems. In addition it has the potential for wide applicability among the broad class of Wasserstein gradient flows.
This is work with Steffen Arnrich, Alexander Mielke, Giuseppe Savare, and Marco Veneroni.

Wolfgang Reichel
KIT - Karlsruhe Institute of Technology
Symmetry of solutions for quasimonotone second-order elliptic systems in ordered Banach spaces

We consider symmetry properties of solutions to nonlinear elliptic boundary value problems defined on bounded symmetric domains of $\mathbb{R}^n$. The solutions take values in ordered Banach spaces E, e.g. $E = \mathbb{R}^N$ ordered by a suitable cone. The nonlinearity is supposed to be quasimonotone increasing. By considering cones which are different from the standard cone of componentwise nonnegative elements we can prove symmetry of solutions to nonlinear elliptic systems which are not covered by previous results. We use methods based on maximum principles (the method of moving planes) suitably adapted to cover the case of solutions of nonlinear elliptic problems with values in ordered Banach spaces.(With Gerd Herzog, Karlsruhe.)

Jürgen Saal
Universität Konstanz
Analysis of a General Model in Electrokinetics

We present a thorough analysis of the Navier-Stokes-Nernst-Planck-Poisson equations. This system describes the dynamics of charged particles dispersed in an incompressible fluid. In contrast to existing literatur and in view of its physical relevance, we also allow for different diffusion coefficients of the charged species. Our aim is to present results on local and global well-posedness as well as (in-) stability of equilibria. The results are obtained jointly with Andre Fischer.

Daniela Treutler
Leibniz Universität Hannover
On the behaviour of solutions to a parabolic evolution equation on two scales

We consider solutions to a distributed microstructure model in the sense of Showalter and Walkington that describes solute transport in fissured porous media. It reflects the geometry of the porous blocks inside the material. The coupling of the equations is represented by a source term on the macroscopic scale and a matching boundary condition on the microscopic one. For Dirichlet boundary conditions on the large domain we show that the concentration decays exponentially fast in time. On the other hand a no-flux condition on the macroscopic domain assures conservation of the amount of solute in the whole system.

Minisymposium 15

Übergang Schule - Hochschule

Tassilo Küpper (Köln), Roman Wienands (Köln)

Im Jahr der Mathematik ist anhand zahlreicher Präsentationen die Bedeutung dieser Disziplin und ihrer vielfältigen Anwendungen erfolgreich einer breiten Öffentlichkeit nahegebracht worden: Diese Wertschätzung von Mathematik als Schlüsselwissenschaft muss nachhaltig gepflegt werden: Das Memorandum der 27. Sylter Runde zum Thema „Jahr der Mathematik – und was kommt danach?“ (www.sylter-runde.de) fasst konkrete Empfehlungen zusammen:

Eine besondere Aufgabe bei der Stärkung des Verständnisses für die zentrale Stellung der Mathematik kommt der Schule zu, in der zuerst das Verhältnis dazu geprägt wird, und damit stellt sich auch für die Hochschulen die Frage, inwieweit sie sich dabei einbringen können:

Neben der zentralen Aufgabe bei der Ausbildung qualifizierter Lehrer bieten sich viele Möglichkeiten, frühzeitig Interesse für Mathematik zu wecken und mathematisch Interessierte zu fördern: Dazu zählt die gezielte Förderung besonders talentierter Schüler z:B: durch ergänzende Kurse, die Unterstützung bei Wettbewerben oder die Teilnahme von ausgewählten Schülern an Vorlesungen wie im Rahmen der Aktion „Schüler an die Uni“, aber auch das Angebot an „Kinderuni-Veranstaltungen“ oder die Junioruniversität:

Nach unseren Erfahrungen hat sich auch die Berücksichtigung lebensnaher mathematischer Anwendungen in den Schulunterricht als sehr motivierend erwiesen: Eine Umsetzung solcher Ziele erfordert eine entsprechende praxisnahe Ausbildung der Studierenden mit schulgeeigneten Methoden und Beispielen aus der Angewandten Mathematik – eine wichtige Aufgabe für die Hochschulen!

In diesem Minisymposium werden einige Initiativen zum Übergang „Schule-Hochschule“ vorgestellt: Ausgehend von diesen Präsentationen möchten wir zu einer Diskussion über dieses wichtige Thema einladen.

Donnerstag, 22. September **Seminargebäude, S21**

14:00 Tassilo Küpper (Köln)
Kölner Initiativen: „Schüler an die Uni“ – „Kinderuni“ – „Junioruni“

14:20 Ulrich Halbritter, Lennart Jansen, Rolf Theil (Köln)
Das Projekt „Schüler an die Uni“ – ein Erfolgsmodell

14:45 Ernestina Dittrich (Karlsruhe)
Karlsruher Modell – Neue Wege an der Schnittstelle Schule – Universität

15:10 Anton Schüller (Köln)
Angewandte Mathematik für den Schulunterricht

15:35 Thomas Gawlick (Hannover)
Förderung mathematisch interessierter Fünftklässler in MALU – ausgewählte Methoden und Ergebnisse

16:30 Anschließende Diskussion

Ernestina Dittrich
Karlsruher Institut für Technologie (KIT), Abteilung für Didaktik der Mathematik
Karlsruher Modell - Neue Wege an der Schnittstelle Schule - Universität

Hinter den Aktivitäten für Schulen der Abteilung für Didaktik der Mathematik am Karlsruher Institut für Technologie (KIT) steht das Bestreben, das Interesse der Schülerinnen und Schüler für das Fach Mathematik zu wecken. Je nach Neigungen und Vorkenntnissen sind unterschiedliche Strategien nötig. Neben der Förderung hochbegabter Schülerinnen und Schüler im Schülerstudium, sollte nun gerade auch bei denjenigen das Interesse für Mathematik geweckt werden, die dem Fach vielleicht sogar ablehnend gegenüberstehen. Dieses Ziel kann nur erreicht werden, wenn ein neuer Zugang gefunden wird. Das Schülerlabor Mathematik mit seinen über 70 Exponaten unterstützt das entdeckende Lernen, ohne die Mathematik auf eine nur spielerische Ebene einzuschränken. In Workshops, die teilweise von den Teilnehmern selbst entwickelt werden, wird das Verständnis für mathematische Themen vertieft. Im Vortrag wird die Verzahnung zwischen der Weiterentwicklung der theoretischen Grundlagen und der Umsetzung in die Praxis bei der fachdidaktischen Ausbildung vorgestellt und reflektiert. An Beispielen wird das Gesamtkonzept erklärt.

Thomas Gawlick
Leibniz Universität Hannover, Institut für Didaktik der Mathematik & Physik
Förderung mathematisch interessierter Fünftklässler in MALU - ausgewählte Methoden und Ergebnisse

MALU (Mathe-AG an der Leibniz Universität) fördert seit 2008 Fünftklässler, die einmal wöchentlich in Paaren selbständig Problemaufgaben bearbeiten. Im Vortrag werden zunächst Inhalte und Ablauf der Förderung erläutert. Dann wird aus der begleitenden mathematikdidaktischen Forschung berichtet. Ausgehend von der Frage, worin ein Erfolg der Förderung bestehen und worauf er beruhen könnte, werden die Problemlöseprozesse und -produkte der Kinder eingehend untersucht. Folgende Aspekte stehen im Vordergrund zweier laufender Disserationen: 1. Wie lassen sich erfolgreiche Bearbeitungen aufgabenübergreifend charakterisieren? 2. Wie hängt der Bearbeitungserfolg zusammen mit a) heuristischen Arbeitsweisen, b) dem Kooperationsverhalten? Dazu wurde anknüpfend an Schoenfeld das von Polya in “How to solve it” beschriebene Vorgehen zur Lösung von Aufgaben operationalisiert, um den Verlauf der Problemlöseprozesse vergleichend beschreiben zu können. Damit kann man erfolgreiche und erfolglose Prozesse recht gut differenzieren. Abschließend soll diskutiert werden, wie solche Forschungsergebnisse zu einer Vergrößerung des Fördererfolgs beitragen können, z.B. hinsichtlich der Frage: welche heuristischen Strategien sind für Fünftklässer zugänglich und wie können sie trainiert werden?

Ulrich Halbritter, Lennart Jansen, Rolf Theil
Mathematisches Institut der Universität zu Köln, Rhein-Gymnasium Köln
Das Projekt “Schüler an der Universität” - ein Erfolgsmodell

Seit dem Wintersemester 2000/2001 erlaubt die Universität zu Köln im Rahmen des Projektes “Schüler an der Universität” geeigneten Schülerinnen und Schülern, an Vorlesungen, Übungen und Seminaren in den Fächern teilzunehmen, die nicht mit einem NC belegt sind oder in denen - trotz NC - noch Kapazitäten in ausgewählten Veranstaltungen frei sind. Das allein ist selbstverständlich nichts Besonderes - buchstäblich jeder kann nach Zahlung der Gasthörergebühr an der akademischen Ausbildung teilhaben. Aber: Schülerinnen und Schüler zahlen keine Gebühren; sie dürfen (im Gegensatz zu Gasthörerinnen und Gasthörern) Leistungen erbringen, insbesondere auch Prüfungen ablegen, die ihnen später, im regulären Studium, anerkannt werden; sie werden von ihren Schulen zur Förderung ihrer Begabungen an die Hochschulen abgeordnet und müssen versäumten Schulunterricht selbstständig nachholen. Mehr als die Hälfte der deutschen Universitäten hat das Projekt inzwischen eingeführt, die Kultusministerkonferenz hat es empfohlen, in einer großen Zahl von Bundesländern ist es mittlerweile im jeweiligen Hochschulgesetz (oder anderen Rechtsvorschriften) verankert. - Der Vortrag befasst sich mit Chancen und Problemen des Projekts aus Sicht der Dozenten, der Lehrer und der Teilnehmer.

Tassilo Küpper
Mathematisches Institut der Universität zu Köln
Kölner Initiativen: “Schüler an die Uni” - “Kinderuni” - “Junioruni”

Ausgehend von Ferienkursen der Hochbegabten-Stiftung der Kreissparkasse Köln wurde im Jahr 2000 in Köln das Projekt “Schüler an die Uni” gestartet, das zunächst für die Fächer Mathematik, Informatik, Physik und Chemie konzipiert war und seitdem weiterentwickelt und mittlerweile von vielen Hochschulen aufgegriffen worden ist. Seit 2003 besteht an der Universität zu Köln ein Kinderuni-Programm, das inzwischen auf mehrere Kölner Hochschulen ausgedehnt worden ist und eine große Anzahl von Kindern in der Region anspricht. Neben Vorlesungen speziell für Kinder werden auch Workshops angeboten. Seit 2010 ist dieses Format erweitert worden um Vorlesungen zu mathematischen Themen, die von Kindern selbst unter Anleitung vorbereitet und vorgetragen werden. Bei der Betreuung sind auch Lehramtsstudenten im Zuge einer praxisnahen Ausbildung einbezogen. Die Verbindung von mathematischen Fragen mit konkreten Anwendungen ist nach unserer Erfahrung gut geeignet, um generell Interesse an der Mathematik zu wecken. Im Hinblick auf eine thematische Vorbereitung der Lehramtsstudenten auf einen praxisnahen und motivierenden Unterricht haben wir speziell für Lehramtskandidaten Seminare angeboten mit dem Schwerpunkt bei anwendungsnahen Themen, die auch im Unterricht behandelt werden können.

Anton Schüller, Ulrich Trottenberg, Roman Wienands, Günter Seebach
Fraunhofer-Institut für Algorithmen und Wissenschaftliches Rechnen (SCAI),
Mathematisches Institut der Universität zu Köln

Angewandte Mathematik für den Schulunterricht

Die Angewandte Mathematik durchdringt heute alle naturwissenschaftlichen und technischen Disziplinen und ist Grundlage nahezu jeder technischen Entwicklung. Dies steht in engem Zusammenhang mit der rasanten Entwicklung der Computer. Die Rechnerentwicklung hat die Angewandte Mathematik revolutioniert: Hierbei spielen Algorithmen eine zentrale Rolle. Mit Hilfe moderner Computer und effizienter Algorithmen kann man heute viele Problemstellungen mehrere Millionen Mal so schnell lösen wie noch vor 20 Jahren. So können heute Probleme in Sekundenschnelle gelöst werden, die vor 20 Jahren noch Tage und Wochen an Rechenzeit erforderten. Diese Entwicklung spiegelt sich jedoch in der Schulmathematik und im öffentlichen Bild der Mathematik kaum wieder. Einen Beitrag zur Behebung dieses Missverhältnisses versucht das Seminar “Algorithmen für den Schulunterricht” an der Universität zu Köln zu leisten, das sich an Mathematik-Lehramtsstudenten richtet. In ihm werden Themen wie mp3, Verkehrssimulation, Kryptographie, Lösung großer Gleichungssysteme oder Optimierung von Wegen so aufbereitet, dass sie im Schulunterricht einsetzbar sind und Schülerinnen und Schülern ein modernes und spannendes Bild der Mathematik geben. Dieser Vortrag gibt einen Überblick über Erfahrungen und Praxisbeispiele, die aus diesem Seminar erwachsen sind.

Minisymposium 16

Versicherungsmathematik

Hanspeter Schmidli (Köln), DGVFM

Mittwoch, 21. September **Seminargebäude, S23**

14:00 Nicole Bäuerle (Karlsruhe)
Optimal Dividend-Payout in Random Discrete Time

15:00 Natalie Scheer (Köln)
Optimale stochastische Kontrolle von Dividenden und Kapitalzuschüssen

16:00h – 16:30h Pause

16:30 Hansjörg Albrecher (Lausanne)
Insurance Risk Theory with Tax and Dividend Payments

Donnerstag, 22. September **Seminargebäude, S23**

14:00 Dietmar Pfeifer (Oldenburg)
Neue Ideen zur Spätschadenreservierung bei Rechtsschutzversicherungen

15:00 Julia Eisenberg (Wien)
Optimal Control of Capital Injections by Reinsurance With and Without Regime Switching

16:00h – 16:30h Pause

16:30 Hanspeter Schmidli (Köln)
Dividend barrier strategies in a renewal risk model with generalized Erlang interarrival times

Hansjörg Albrecher
Université de Lausanne
Insurance Risk Theory with Tax and Dividend Payments

In this talk it is shown how a mixture of analytical and probabilistic techniques can be used to assess the effect of dividend and tax payments on the solvency of an insurance portfolio. This will be illustrated both for the classical risk model and some of its extensions. It will also be discussed how symbolic techniques and links between risk theory and queueing theory can enrich the set of tools for these investigations.

Nicole Bäuerle
Karlsruhe Institute of Technology (KIT), Karlsruhe
Optimal Dividend-Payout in Random Discrete Time

We assume that the surplus process of an insurance company is described by a general Lévy process and that possible dividend pay-outs to shareholders are restricted to random discrete times which are determined by an independent renewal process. Under this setting we show that the optimal dividend pay-out policy is a so-called band-policy. If the renewal process is a Poisson process, it is further shown that for Cramér-Lundberg risk processes with exponential claim sizes and its diffusion limit, the optimal policy collapses to a barrier-policy. Some numerical examples are presented for which the optimal bands can be calculated explicitly. This is joint work with H. Albrecher and S. Thonhauser.

Julia Eisenberg
Technische Universität Wien
Optimal Control of Capital Injections by Reinsurance With and Without Regime Switching

We consider an insurance company, where the claims are reinsured by some reinsurance. Concerning the surplus of the insurance company two different cases are studied. In the first case the surplus process is supposed to follow a diffusion; in the second case we let the drift and the volatility of the diffusion-surplus depend on an observable continuous-time Markov chain. This Markov chain represents regime switching - the macroeconomic changes impacting the parameters of our model.
Our objective is to minimize the value of expected discounted capital injections, which are necessary to keep the risk process above zero. Thus, we goal to find the value function defined as the infimum of expected discounted capital injections over all reinsurance strategies; and to derive the optimal strategy leading to the value function.
Whereas in the case of a “simple” diffusion the value function is an exponential function, things are different in the case of regime switching. A general form explicit solution could not be given. However, we illustrate how the value function can be calculated by a simple example with a two states Markov chain.

Dietmar Pfeifer
Karl von Ossietzky Universität Oldenburg
Neue Ideen zur Spätschadenreservierung bei Rechtsschutzversicherungen

Verfahren zur Reservierung von Spätschäden gehören seit langem zum Standardrepertoire von Aktuaren in der Sachversicherung. Sie orientieren sich dabei im Wesenlichen am Chain Ladder Verfahren und dessen diversen Varianten. In dieser Präsentation wird ein anderes Verfahren zur Bestimmung von Spät- und IBNR-Schäden für Rechtsschutzversicherungen vorgeschlagen, das sich spezifischer am Geschäftsmodell dieser Sparte orientiert und an die Kalkulationsprinzipien der Lebensversicherung angelehnt ist.

Natalie Scheer
Universität Köln
Optimale stochastische Kontrolle von Dividenden und Kapitalzuschüssen

Wir betrachten Optimierungsprobleme eines Versicherungsunternehmens, dessen Überschuss-prozess mit einem klassischen Risikomodell beschrieben wird. Der Versicherer hat die Möglichkeit, Dividenden an die Anteilseigner zu zahlen, die ihrerseits Kapitalzuschüsse tätigen können, damit der Überschuss nicht-negativ bleibt. Das Ziel ist es, den Wert der erwarteten diskontierten Dividenden abzüglich der erwarteten diskontierten Kapitalzuschüsse inkl. der dabei anfallenden Kosten zu maximieren und eine optimale Strategie zu finden, die zu diesem maximalen Wert führt. Wir zeigen, dass es unter Berücksichtigung von proportionalen Kosten optimal ist, Dividenden entsprechend einer Barrierenstrategie zu zahlen, d.h., der ganze Überschuss, der eine bestimmte Barriere überschreitet, wird als Dividende ausgezahlt. Wenn zusätzlich Fixkosten eingerechnet werden, dann ist die optimale Strategie vom sogenannten Bandtyp, d.h., es werden entweder Dividenden zur Prämienrate, eine Pauschalsumme oder keine Dividenden gezahlt.

Hanspeter Schmidli
Universität Köln
Dividend barrier strategies in a renewal risk model with generalized Erlang interarrival times

We consider a renewal risk model with generalised Erlang distributed interarrival times. In order to solve de Finetti's dividend problem, we first consider barrier strategies and look for the optimal barriers when the initial capital is zero. For exponentially distributed claim sizes, we show that the barrier strategy is optimal among all admissible strategies. For the special case of Erlang(2) interarrival times, we calculate the value function and the optimal barriers.
The talk is based on joint work with Yuliya Mishura (Kiev).

Minisymposium 17

Wechselwirkende Teilchensysteme und zugehörige nichtlineare (stochastische) Bewegungsgleichungen

Martin Grothaus (Kaiserslautern), Yuri Kondratiev (Bielefeld), Michael Röckner (Bielefeld)

Montag, 19. September **Seminargebäude, S24**

14:00 Maria João Oliveira (Lissabon)
Glauber dynamics in the continuum via generating functionals evolution

15:00 Oleksandr Kutovyi (Bielefeld)
Markov Jump Dynamics in Continuum: State Evolution and Vlasov Scaling

16:00h – 16:30h Pause

16:30 Dimitri Finkelshtein (Kiew)
Semigroup approach to birth-and-death stochastic dynamics in continuum

17:30 Yuri Kozitsky (Lublin)
Evolution of states in spatial Glauber dynamics

Dienstag, 20. September **Seminargebäude, S24**

14:00 Tanja Pasurek (Bielefeld)
Gibbs states of disordered anharmonic crystals

15:00 Florian Conrad (Bielefeld)
On a tagged particle process in continuum with singular interaction potential

16:00h – 16:30h Pause

16:30 Benedict Baur (Kaiserslautern)
Strong Feller Property up to the Boundary for Elliptic Diffusions

17:30 Torben Fattler (Kaiserslautern)
The dynamical wetting model in (1+1)-dimension

Mittwoch, 21. September **Seminargebäude, S24**

14:00 Eugene Lytvynov (Swansea)
Determinantal point processes with J-Hermitian correlation kernels

15:00 Tobias Kuna (Reading)
Truncated moment problem and Realizability of point processes

16:00h – 16:30h Pause

16:30 Dennis Hagedorn (Bielefeld)
Gibbs distributions related to a Gamma measures over the cone of positive discrete Radon measures

17:00 Christoph Berns (Bielefeld)
Kawasaki Dynamics of continuous Interacting Particle Systems

17:30 Anatoly Vershik (t.b.a.)
t.b.a.

Benedict Baur
University of Kaiserslautern
Strong Feller Property up to the Boundary for Elliptic Diffusions

For a gradient Dirichlet form with Hölder continuous matrix and density and a piecewise C^1-domain we prove L^p-strong Feller property of the associated resolvent and semigroup. Under additional smoothness assumptions on the coefficients and the boundary we construct a diffusion process with generalized reflection at the boundary starting in all points where the density is not zero and which are either interior points or have local C^2-smooth boundary. Finally we apply these concepts to the construction of stochastic dynamics for interacting particle systems.

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T. Fattler and M. Grothaus. Strong Feller property for distorted Brownian motion with reflecting bounday condition. Journal of Functional Analysis, 246(2): 217-241. 2007

Christoph Berns
Universität Bielefeld
Kawasaki Dynamics of Continuous Interacting Particle Systems

In this talk we discuss a stochastic (conservative) jump dynamics of interacting particles in continuum. This dynamics is an analog of the Kawasaki dynamics of lattice spin systems. The Kawasaki dynamics is now process where interacting particles randomly hop over R^d. We give a microscopic and a mesoscopic description of such dynamics.

Florian Conrad
Universität Bielefeld
On a tagged particle process in continuum with singular interaction potential

We consider the dynamics of a tagged particle in a (moving) environment consisting of infinitely many particles interacting by a physically realistic pair potential like e.g. the Lennard-Jones potential. The dynamics of the environment as well as the coupled dynamics of the tagged particle and the environment have recently been constructed using Dirichlet form methods by T. Fattler and M. Grothaus in the sense of martingale solutions for the corresponding generators. We derive several results to strengthen the relation between the path $(\xi_t)_{t\geq 0}$ of the tagged particle and the environment $(\gamma_t)_{t\geq 0}$ seen from the tagged particle (with γ_t being a locally finite subset the d-dimensional Euclidean space). As a consequence, this better understanding of the tagged particle process shows that a general method by de Masi, Ferrari, Goldstein and Wick (1989) can be directly applied for proving that under diffusive scaling the displacement of the tagged particle converges to a Brownian motion scaled by some diffusion matrix.
(Joint work with Torben Fattler, Martin Grothaus and Yuri Kondratiev.)

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Torben Fattler
Technische Universität Kaiserslautern
The dynamical wetting model in (1+1)-dimension

We consider a dynamical $\nabla\phi$ interface model (also known as Ginzburg–Landau dynamics) on a one-dimensional lattice with reflection and an additional pinning effect on a hard wall for a large class of interaction potentials. The pinning effect on the hard wall is modeled by an additional self-potential. In particular, we make use of a δ-pinning potential, but also the relation to a square well pinning potential is discussed. The dynamics under consideration realizes the so-called dynamical wetting model. It describes the motion of an interface resulting from wetting of a solid surface by a fluid. For the construction of the underlying stochastic process we apply Dirichlet form techniques in combination with Wentzell boundary conditions. Finally, we use the obtained results as ingredients for the study of fluctuations of the interface near the hard wall.

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Dmitri Finkelshtein
Institute of Mathematics, Kiev
Semigroup approach to birth-and-death stochastic dynamics in continuum

We consider general approach using perturbation semigroup technic for construction birth-and-death spatial dynamics for interacting particle systems

Dennis Hagedorn
Universität Bielefeld
Gibbs distributions related to a Gamma measures over the cone of positive discrete Radon measures

A Gamma measure $\mathscr{G}_\theta$, $\theta > 0$ being a shape parameter, can be regarded as the 'free' case of a Gibbs measure because the involved potential is zero. Vershik, Gel'fand and Graev introduced the Gamma measure $\mathscr{G}_\theta$ in the context of the representation theory in 1975. It can be seen as a "marked" Poisson measure with an (infinite) Levy measure λ_θ on the marks.

We construct a Gibbs measure that corresponds to a (possibly negative,) non-symmetric potential with infinite interaction range and the to $\mathscr{G}_\theta$ associated "marked" Poisson measure.

A biological **motivation** to consider a Gamma measure is that it discribes the allocation of animals of different sizes. Namely, we can model that there are few big animals and many small ones like plancton, which seem to be almost continuously distributed. For this a Gamma measures yields an appropriate distribution.

But, a ('free') Gamma measure does not take into account interaction. The interaction yields a distribution of the size and position of animals depending on the surrounding animals. An interesting interacting potential has an infinite interaction range and is not translation invariant. Using the (not necessarily positive) potential we can define via a relative energy and the DLR equation the notion of a Gibbs measure on the cone, whose existence we prove.

Yuri Kozitsky
Uniwersytet Marii Curie-SkAlodowskiej, Lublin
Evolution of states in spatial Glauber dynamics

Tobias Kuna
University of Reading
Truncated moment problem and Realizability of point processes

To reconstruct in a systematical way from observable quantities, the underlying effective description of a complex system on relevant scales is a task of enormous practical relevance. Realizability considers the partial question if the system can be described by point-like objects on the relevant scale, cf. Percus(1964) and Crawford et al. (2003). In this talk, based on Kuna et al. (2009), the realizability problem is introduced. It is identified as an infinite dimensional version of the classical truncated power moment problem. One can associate a linear functional on the space of polynomials to any kind of moment problem. A classical theorem for complete moment sequences, see e.g. Haviland(1935/6) states that solvability of the moment problem is equivalent to positivity of this functional. However, this is wrong in general for truncated moment problems. A new general approach for truncated moment problems will be presented which overcomes this difficulty. To our knowledge this approach is also new for finite dimensional problem, however it may be more adapted for infinite dimensional problems. An extension to random closed set is considered in Lachieze-Rey et al. (2011), where the technique is also presented in general terms. Finally, it is shown that all known restrictions for realizability can be easily derived using this criteria.

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Oleksandr Kutovyi
Bielefeld Universität
Markov Jump Dynamics in Continuum: State Evolution and Vlasov Scaling

We investigate a stochastic (conservative) jump dynamics of interacting particles in continuum. We consider objects dual to correlation functions (respectively correlation measures), which are called quasi-observables. By solving the evolution equation for quasi-observables, we obtain the non-equilibrium evolution of these objects. The corresponding dual equation describes the time evolution of correlation functions and generalizes the BBGKY-hierarchy from Hamiltonian to jump dynamics. By means of the duality between quasi-observables and correlation functions we can transfer the evolution of quasi-observables to correlation functions. Afterwards we perform a Vlasov-type scaling of the dynamics, which leads to a rescaled and limiting evolution of correlation functions. We show convergence of the solution of the rescaled hierarchy to the solution of the limiting one. The chaos preservation property of the limiting hierarchy leads to the derivation of a kinetic equation for the particle density which is a Vlasov-type equation for the considered model.

Eugene Lytvynov
Swansea University
Determinantal point processes with J-Hermitian correlation kernels

Let X be a locally compact Polish space. The configuration space over X, denoted by Γ, is defined as the set of all locally finite subsets of X. A probability measure on Γ is called a point process. A point process μ can be described with the help of correlation functions: the n-th correlation function is a non-negative symmetric function $k^{(n)}(x_1,\dots,x_n)$ on X^n which may be heuristically interpreted as the μ-probability to find points $x_1,\dots,x_n$ in a configuration. A point process is called determinantal if there exists a function $K(x,y)$ on X^2, called the correlation kernel, such that the n-th correlation function of this point process is given by $\det[K(x_i,x_j)]_{i,j=1}^n$. If the correlation kernel is Hermitian, the Macchi–Soshnikov theorem gives a necessary and sufficient condition for the existence of a determinantal point process with correlation kernel $K(x,y)$. We will derive a counterpart of this theorem in the case where the correlation kernel is J-Hermitian, i.e., Hermitian in an indefinite scalar product. Such point processes occurred in Borodin and Olshanski's studies on harmonic analysis of the infinite symmetric group.

Maria João Oliveira
Universidade Aberta/CMAF
Glauber dynamics in the continuum via generating functionals evolution

We construct the time evolution of Glauber dynamics for a continuous infinite particle system in terms of generating functionals. This is carried out by Peano-type approximations in a scale of Banach spaces, leading to a local (in time) solution which may be extended to a global one. An application of this approach to Vlasov-type scaling in generating functionals is considered as well.

Tanja Pasurek
Universität Bielefeld
Gibbs states of disordered anharmonic crystals

We consider a multi-component continuum model of classical particles described by their positions $x \in \mathbb{R}^n$ and vector spins $s_x \in \mathbb{R}^m$. The interaction between the particles is given by the pair potential

$$W(x,y;s_x,s_y) := \phi\left(|x-y|_{\mathbb{R}^n}\right) + J\left(|x-y|_{\mathbb{R}^n}\right) \cdot |s_x - s_y|^2_{\mathbb{R}^m}, \quad x,y \in \mathbb{R}^n.$$

The purely position term $\phi\left(|x-y|_{\mathbb{R}^n}\right)$ is assumed to be superstable (e.g., of the Lennard-Jones type). The intensity $J\left(|x-y|_{\mathbb{R}^n}\right)$ of the harmonic spin-spin interactions $|s_x - s_y|^2_{\mathbb{R}^m}$ is bounded and of finite range, but not necessary ferromagnetic. The reference (i.e., free) measure is the Poisson point process π_σ on the marked configuration space $\Gamma(\mathbb{R}^n, \mathbb{R}^m)$ with the intensity measure $\sigma(dx,ds) = \exp\{-V(s)\}dxds$, where $V(s)$ is an anharmonic single-spin potential. We construct corresponding Gibbs distributions both in the annealed and quenched approaches and discuss their properties.

Anatoly Vershik
t.b.a.
t.b.a.

Autorenverzeichnis