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Cantor-Vortrag **Montag, 09:45-10:45, Tulla-Hörsaal (11.40)**

The Hard Lefschetz Theorem, history and recent progress

Hélène Esnault[1,*]

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The Hard Lefschetz Theorem is a corner stone of complex analytic geometry and arithmetic geometry. Lefschetz' own original proof was not complete. Hodge gave the first proof using harmonic theory. Deligne developed the theory of weights to give a proof which then holds in positive characteristic. On the complex side, harmonic theory enabled Simpson to generalize Hard Lefschetz to semi-simple complex local systems. We'll report on recent progress on the arithmetic side. (The new material is joint work with Moritz Kerz).

Emmy-Noether-Vorlesung **Montag, 11:15-12:15, Tulla-Hörsaal (11.40)**

The classical coagulation equation: gelation, self-similarity and oscillations

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In 1916 Smoluchowski derived a mean-field model for mass aggregation in order to develop a mathematical theory for coagulation processes. Since Smoluchowski's groundbreaking work this model and various extensions have been used in a diverse range of applications such as aerosol physics, polymerization, population dynamics, or astrophysics.

Fundamental questions are whether the model exhibits gelation, that is loss of mass in finite time, or whether solutions develop a universal self-similar form for large times. These issues are understood only for some exactly solvable models, while in the general case these problems are basically still open. I will give an overview of the basic properties of these models, explain some of the main challenges in the analysis and report on recent progress. We will see that in contrast to common belief solutions to this model can evolve towards a time-periodic peak solutions.

Plenarvortrag **Montag, 14:00-16:00, Tulla-Hörsaal (11.40)**

Nonclassical minimizing oriented surfaces

Camillo De Lellis[1,*]

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Consider a smooth closed simple curve Γ in a given Riemannian manifold. Following the classical work of Douglas and Rado it can be shown that, given any natural number g, there is an oriented surface which bounds Γ and has least area among all surfaces with genus at most g. Obviously as we increase g the area of the corresponding minimizer can only decrease. If the ambient manifold has dimension 3 and the curve is sufficiently regular (C^2 suffices), works of De Giorgi and Hardt and Simon guarantee that such number stabilizes, in other words the absolute (oriented) minimizer has finite topology. In a joint work with Guido De Philippis and Jonas Hirsch we show that the latter property might fail in higher codimension even if the curve is C^∞. Some results point instead to its validity for analytic curves (and analytic ambient metrics), confirming a conjecture of Brian White.

Plenarvortrag **Dienstag, 08:45-09:45, Tulla-Hörsaal (11.40)**

Gradient systems and evolutionary Γ-convergence

Alexander Mielke[1,*]

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Many ordinary and partial differential equations can be written as a gradient flow, which means that there is an energy functional that drives the evolution of the the solutions by flowing down in the energy landscape. The gradient is given in terms of a dissipation structure, which in the simplest case is a Riemannian metric. We will highlight classical and nontrivial new examples in reaction-diffusion systems or dissipative quantum mechanics. We will emphasize that providing a gradient structure for a given differential equation means that we add additional physical information.

Considering a family of gradient systems depending on a small parameter, it is natural to ask for the limiting or effective gradient system describing the evolution in the limit of the parameter tending to 0. This can be achieved on the basis of De Giorgi's Energy-Dissipation Principle. We discuss the new notion of "EDP convergence" and show by examples that this theory is flexible enough to allow for situations where starting from a linear Riemannian structure (or quadratic dissipation potentials) we arrive at physically relevant, nonlinear effective kinetic relations, namely exponential laws for transmission at membranes or slip-stick motion on rough surfaces.

Plenarvortrag **Dienstag, 14:30-15:30, Tulla-Hörsaal (11.40)**

Linking in torus bundles and Hecke L-functions

Nicolas Bergeron[1,*]

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Torus bundles over the circle are among the simplest and cutest examples of 3-dimensional manifolds. After presenting some of these examples, using in particular animations realized by Jos Leys, I will consider periodic orbits in these fiber bundles over the circle. We will see that their linking numbers — that are rational numbers by definition — can be computed as certain special values of Hecke L-functions. Properly generalised, this viewpoint leads to topological proofs of old and new algebraicity (or even integrality) theorems on special values of Hecke L-functions. It also leads to interesting new "arithmetic lifts" that I will briefly explain. All this is extracted from joint works with Pierre Charollois, Luis Garcia and Akshay Venkatesh.

Öffentlicher Vortrag **Dienstag, 19:00-20:00, Tulla-Hörsaal (11.40)**

Grenzen der Wettervorhersage - eine mathematische Perspektive

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Wie funktioniert Wettervorhersage heutzutage, und was kann sie leisten? Der Vortrag gibt einen Einblick in die Bedeutung der Mathematik und das faszinierende Zusammenspiel von Supercomputern, physikalisch-numerischer und statistischer Modellierung in der Praxis der Wettervorhersage. Dabei werden insbesondere auch die Rollen von "Chaos" und "Zufall" beleuchtet und Forschungsarbeiten im Rahmen aktueller Kooperationen zwischen Mathematik und Meteorologie am Karlsruher Institut für Technologie vorgestellt.

Plenarvortrag **Mittwoch, 08:45-09:45, Tulla-Hörsaal (11.40)**

Energy based network modeling, numerical simulation, and control of multi-physics systems

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Most real world dynamical systems consist of subsystems from different physical domains, modelled by partial-differential equations, ordinary differential equations, algebraic equations, combined with input and output connections. To deal with such complex system, in recent years the class of dissipative port-Hamiltonian (pH) systems has emerged as a very efficient modeling methodology. The main reasons are that the network based interconnection of pH systems is again pH, Galerkin projection in PDE discretization and model reduction preserve the pH structure and the physical properties are encoded in the geometric properties of the flow as well as the algebraic properties of the equations. Furthermore, dissipative pH system form a very robust representation under structured perturbations and directly indicate Lyapunov functions for stability analysis.

We discuss dissipative pH systems and describe how many classical models can be formulated in this class. We illustrate some of the nice algebraic properties, including local canonical forms, the formulation of an associated Dirac structure, and the local invariance under space-time dependent diffeomorphisms.

We illustrate the results with some real world examples.

Plenarvortrag **Mittwoch, 14:00-15:00, Tulla-Hörsaal (11.40)**

Learning without a Dictionary

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Consider the classical problem of learning a signal when observed with noise. One way to do this is to expand the signal in terms of basis functions and then try to learn the coefficients. The collection of basis functions is called a dictionary and the approach is sometimes called "synthesis" because the signal is synthesised from the coefficients. Another learning approach, called "analysis", is based on a linear operator that describes the signal's structure. As an example one may think of a signal that lives on a graph, and the linear operator describes the change when going from one node to the next in the graph. The sum of the absolute values of the changes is called the total variation of the signal over the graph. The analysis problem can be reformulated as a synthesis problem, for which the theory is well-developed. But instead of this, we take an easier direct route to derive the statistical properties of analysis. This will be done in the context of ℓ_1-norm regularisation. For the total variation example it leads to creative cutting and pasting.

Plenarvortrag **Donnerstag, 08:45-09:45, Tulla-Hörsaal (11.40)**

Large scale geometry: what it is and what it is good for

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The philosophy of "large scale geometry", also called "coarse geometry" is: look at the space from really far away, so that all local features are blurred out, and concentrate on the features which remain. As an example: from this point of view Euclidean space and the integer lattice become equivalent.

Powerful tools from operator algebras have been developped to study these features. Combined with differential geometry and global analysis via the index theory of geometric differential operators this has applications to small scale geometric question. For example, it can help to understand which compact smooth manifolds admit a Riemannian metric of positive scalar curvature, a question which has relevance even in Einstein's general relativity.

The talk aims to give a gentle introduction to the subject, getting to some of the most interesting differential geometric examples.

Plenarvortrag **Donnerstag, 14:00-15:00, Tulla-Hörsaal (11.40)**

Intersection theory and combinatorics

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I will review some interesting combinatorial problems and results, and discuss their relation to intersection theory of algebraic varieties. I will then discuss instances where these problems have led us to generalize concepts far beyond algebraic geometry. In particular, we will discuss the problem of embedding d-complexes in R^{2d}, the hard Lefschetz property for non-projective varieties and generic intersection theory.

Minisymposien

Analysis of wave propagation
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Organisation: Müller-Hill, Paravicini, Skill 26

Nonlinear Evolution Equations and Applications
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Analysis of wave propagation

The aim of this minisymposium is to present recent results in analysis with eventual applications in the study of elliptic or hyperbolic PDEs related to wave propagation. This includes resolvent estimates (Limiting Absoprtion Principles), Strichartz estimates, Fourier restriction theory and applications to PDEs.

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 2.059**

Maximizers for Spherical Restriction

Diogo Oliveira e Silva[1,*], **René Quilodrán**[2]

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This talk is based on recent results obtained in [1]. We prove that constant functions are the unique real-valued maximizers for a large number of $L^2 - L^{2n}$ adjoint Fourier restriction inequalities on the unit sphere $\mathbb{S}^{d-1}$, $d \in \{3, 4, 5, 6, 7\}$, which in particular contains the sharp instances of the corresponding $L^2 - L^6$ and $L^2 - L^8$ inequalities. The proof brings together tools from probability theory, functional analysis, and Lie theory. It also relies on general solutions of the underlying Euler–Lagrange equation being smooth, a fact of independent interest which we discuss. We further show that complex-valued maximizers coincide with nonnegative maximizers multiplied by the character $e^{i\xi\cdot\omega}$, for some ξ, thereby extending the main results of [2] to higher dimensions and general even exponents.

References

[1] D. Oliveira e Silva and R. Quilodrán, Global maximizers for adjoint Fourier restriction inequalities on low dimensional spheres, preprint, 2019.

[2] M. Christ and S. Shao, On the extremizers of an adjoint Fourier restriction inequality, *Adv. Math.* **230** (2012), no. 3, 957–977.

Dienstag, Beginn: 10:30 Uhr **Seminarraum: 2.059**

Global existence of Dirac-wave maps with curvature term on expanding spacetimes

Volker Branding[1,*], **Klaus Kröncke**[2]

[1]*Department of Mathematics, University of Vienna, Austria*
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The action functional of the supersymmetric nonlinear sigma model is an important model in modern quantum field theory. From a mathematical point of view it consists of a map between two manifolds and a vector spinor defined along that map.

If one chooses a Riemannian domain manifold its critical points couple the elliptic harmonic map equation with the vector spinor, this system became known as Dirac-harmonic maps and variants thereof. Since the action functional of the supersymmetric nonlinear sigma model is unbounded from below it is very difficult to obtain existence results for this system.

However, in the case of a globally hyperbolic domain manifold the critical points lead to the Dirac-wave map system which is a hyperbolic system of partial differential equations. In this setup unbounded action functionals are much better to deal with.

We will present an existence result for wave maps and Dirac-wave maps with curvature term with small initial data on globally hyperbolic manifolds of arbitrary dimension which satisfy a suitable growth condition.

References

[1] V. Branding, K. Kröncke, Global existence of Dirac-wave maps with curvature term on expanding spacetimes *Calculus of Variations and Partial Differential Equations* **57** (2018).

Dienstag, Beginn: 11:00 Uhr **Seminarraum: 2.059**

Breather solutions on necklace graphs

Daniela Maier[1,*]

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We will present the main steps of the construction of real-valued, time-periodic and spatially localized solutions (breathers) of small amplitude of nonlinear Klein-Gordon equations on a periodic necklace graph. Our results builds upon a spatial dynamics ansatz combined with center manifold reduction and bifurcation theory. Spectral gaps in the Floquet-Bloch spectrum of the linearized operator occur in a natural way for periodic necklace graphs and are essential for the construction. The major challenge arises from the irregularity of the solutions due to the Kirchhoff boundary conditions.

References

[1] D. Maier, Construction of breather solutions for nonlinear Klein-Gordon equations on periodic metric graphs, *Journal of Differential Equations*, to appear.

Dienstag, Beginn: 11:30 Uhr **Seminarraum: 2.059**

Unique Continuation for the Zakharov Kuznetsov equation

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In this talk we analyze uniqueness properties of solutions to the Zakharov-Kuznetsov (ZK) equation

$$\partial_t u + \partial_x^3 u + \partial_x \partial_y^2 u + u\partial_x u = 0, \qquad (x, y) \in \mathbb{R}^2, \quad t \in [0, 1].$$

Mainly motivated by the very well known PDE's counterpart of the Hardy uncertainty principle, we provide a two times unique continuation result. More precisely, we prove that given u_1, u_2 two solutions to ZK, as soon as the difference $u_1 - u_2$ decays (spatially) fast enough at two different instants of time, then $u_1 = u_2$. As expected, it turns out that the decay rate needed to get uniqueness reflects the asymptotic behavior of the fundamental solution of the associated linear problem. Encouraged by this fact we also prove optimality of the result.

Some recent results concerning the $(3+1)$-dimensional ZK equation will be also presented.

The seminar is based on a recent paper [1] in collaboration with L. Fanelli and F. Linares.

References

[1] L. Cossetti, L. Fanelli and F. Linares, Uniqueness results for Zakharov-Kuznetsov equation, *Comm. Partial Differential Equations*, DOI:10.1080/03605302.2019.1581803

Dienstag, Beginn: 16:00 Uhr **Seminarraum: 2.059**

The non-linear Brascamp-Lieb inequality

Jon Bennett[1], **Neal Bez**[2], **Stefan Buschenhenke**[3,*], **Michael G. Cowling**[4], **Taryn C. Flock**[5]

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We prove a nonlinear variant of the general Brascamp-Lieb inequality. Instances of this inequality are quite prevalent in analysis, and we illustrate this with substantial applications in the theory of oscillatory integrals, abstract harmonic analysis and partial differential equations. Our proof consists of running an efficient, or "tight", induction on scales argument, which uses the existence of Gaussian near-extremisers to the underlying linear Brascamp-Lieb inequality (Lieb's theorem) in a fundamental way. A key ingredient is an effective version of Lieb's theorem, which we establish via a careful analysis of near-minimisers of weighted sums of exponential functions. This is joint work with Jon Bennett, Neal Bez, Michael Cowling and Taryn Flock.

Dienstag, Beginn: 16:30 Uhr **Seminarraum: 2.059**

Local wellposedness of quasilinear Maxwell equations on domains

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In this talk we study the macroscopic Maxwell equations on domains with perfectly conducting and absorbing boundary conditions as well as the Maxwell interface problem. Equipped with instantaneous material laws the Maxwell equations lead to a first order quasilinear system. We develop a local wellposedness theory in H^m for all $m \geq 3$. First we construct a unique solution of the nonlinear system assuming that the initial value, the inhomogeneity, and the boundary value satisfy certain compatibility conditions. We then characterize the case of a finite maximal existence time by a blow-up condition in the Lipschitz norm and show the continuous dependence on the data. Our construction relies on the wellposedness theory for linear nonautonomous Maxwell equations, which we derive using energy-type H^m-estimates and several regularization techniques. Since the Maxwell system has characteristic boundary, we also have to exploit the structure of the Maxwell equations to avoid a loss of regularity.

Dienstag, Beginn: 17:00 Uhr **Seminarraum: 2.059**

The Hilbert transform along curves, anisotropically homogeneous multipliers and the polynomial Carleson theorem

João P. G. Ramos[1,*]

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In 1966, Fabes and Riviere investigated L^p bounds for Calderón-Zygmund operators with suitable anisotropic homogeinity, in relation to regularity questions for parabolic equations. Inspired by that, E. Stein asked when the Hilbert transform along a smooth curve is L^p-bounded, in terms of fundamental curvature properties of the curve.

Many subsequent works address this question, but we shall mainly focus on a celebrated result with many different proofs: the (two-dimensional) parabolic Hilbert transform given by

$$Tf(x,y) = p.v. \int_{\mathbb{R}} f(x-t, y-t^2)\frac{dt}{t}$$

is bounded in every L^p space for $1 < p < +\infty$.

Passing to the multiplier side, its symbol satisfies a quadratic anisotropic 0-homogeneity relationship. In connection to the classical Carleson theorem, one may ask whether Carleson-like operators associated to this transformation share similar bounds, as the usual Carleson symbol belongs to a linear 0-homogeneous class.

This has been an open problem in time-frequency analysis for the past decade, with particularly intense activity in the past 3 years. In this talk, we shall discuss recent developments on the topic, as well as draw connections between this problem and the celebrated polynomial Carleson theorem of Lie and Zorin-Kranich in order to obtain concrete consequences. As a by-product, we obtain a new proof of a special case of the polynomial Carleson theorem.

Dienstag, Beginn: 17:30 Uhr **Seminarraum: 2.059**

Knocking out teeth in one-dimensional periodic NLS: Local and global wellposedness results

Leonid Chaichenets,[1] **Dirk Hundertmark,**[1] **Peer Kunstmann,**[1] **Nikolaos Pattakos**[1,*]

[1] *Karlsruhe Institute of Technology, Karlsruhe, Germany*
[*] Email: nikolaos.pattakos@kit.edu

In this talk local and global wellposedness results of the 1-dimensional nonlinear Schrodinger equation

$$iu_t - u_{xx} \pm |u|^{\alpha-1}u = 0$$

will be discussed with initial data $u_0 \in H^s(\mathbb{R}) + H^s(\mathbb{T})$ where $s \geq 0$, $\alpha \in [1, 5]$ and $\mathbb{T}$ is the one dimensional torus.

In the case of the cubic nonlinearity, $\alpha = 3$, local existence of weak solutions in the extended sense is shown through a differentiation by parts argument and in the case of the quadratic nonlinearity, $\alpha = 2$, global existence is established with the use of Strichartz type estimates and a conserved quantity argument.

References

[1] L. Chaichenets, Dirk Hundertmark, P. Kunstmann and N. Pattakos, *Knocking out teeth in one-dimensional periodic NLS*. arXiv:1808.03055 (2018), submitted to SIAM Journal of Mathematical Analysis.

[2] L. Chaichenets, Dirk Hundertmark, P. Kunstmann and N. Pattakos, *On the global wellposedness of the quadratic NLS on* $L^2(\mathbb{R}) + H^1(\mathbb{T})$. arXiv:1904.04030 (2019), submitted to the Journal of Mathematical Analysis and Applications.

Computeralgebra

Das Minisymposium befasst sich mit Computeralgebra in ihrer ganzen Breite und hat das Ziel, Forscher aus verschiedenen Bereichen zusammenzubringen. Dabei sollen aktuelle Richtungen wie beispielhaft tropische Geometrie, kombinatorische Algebra sowie arithmetische und algebraische Geometrie zur Sprache kommen. Die Initiative für das Minisymposium geht aus von der Fachgruppe Computeralgebra, die es als ihre Aufgabe ansieht, Lehre, Forschung, Entwicklung, Anwendungen, Informationsaustausch und Zusammenarbeit auf dem Gebiet der Computeralgebra in Deutschland zu fördern.

Montag, Beginn: 15:30 Uhr **Seminarraum: 2.058**

Tropical bases and faithful tropicalizations

Yue Ren[1,*]

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In this talk, we will give a simple introduction to tropical algebraic geometry and highlight its differences to classical algebraic geometry. To be precise, we will discuss about the concepts of tropical bases and faithful tropicalizations and show how computer algebra can be used to understand the first and resolve the latter. This talk includes joint work with Paul Goerlach, Marvin Hahn, Hannah Markwig, Jeff Sommars, Ilya Tyomkin.

Montag, Beginn: 16:00 Uhr **Seminarraum: 2.058**

Curves and their Jacobians in computer algebra

Jeroen Sijsling[1,*]

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Algebraic curves over number fields play an important role in arithmetic geometry, for example in the proof by Andrew Wiles of the modularity Theorem, which uses elliptic curves. A very useful object for the study of more general algebraic curves is its Jacobian, which has a more linear structure than the curve itself.

This talk describes how one can calculate with Jacobians in computer algebra systems. Many of these techniques use analytic approximations, in which case it is important to certify the correctness of such results. We discuss current algorithms by many authors [1, 2, 3] for:

1. Calculating endomorphism rings of Jacobians;
2. Decomposing Jacobians into simple factors; and
3. Reconstructing curves from period matrices.

References

[1] E. Costa, N. Mascot, J. Sijsling and John Voight, Rigorous computation of the endomorphism ring of a Jacobian, *Math. Comp.* **88** (2019), no. 317, 1303–1339.

[2] R. Lercier, C. Ritzenthaler and J. Sijsling, Reconstructing plane quartics from their invariants, accepted by *Disc. Comp. Geo.*

[3] P. Molin and C. Neurohr, Computing period matrices and the Abel-Jacobi map of superelliptic curves, *Math. Comp.* **88** (2019), no. 316, pp. 847–888.

Montag, Beginn: 17:00 Uhr **Seminarraum: 2.058**

Minimal models of symplectic quotient singularities

Ulrich Thiel[1,*]

[1] *University of Sydney, School of Mathematics and Statistics, Sydney, Australia*
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Namikawa associated to any conic symplectic singularity a hyperplane arrangement which is deeply intertwined with its geometry. For example, Bellamy proved that for a symplectic quotient singularity the cohomology of the complement of this arrangement encodes the number of minimal models of the singularity. For the symplectic singularity associated to a complex reflection group we were able to prove that the Namikawa arrangement coincides with the degenericity locus of the number of torus fixed points of the corresponding Calogero-Moser deformation. This has a series of nice consequences, especially it proves a conjecture by Bonnafé and Rouquier. Using representation theory and elaborate computer algebraic methods, we could compute this arrangement explicitly for several exceptional complex reflection groups. The arrangements seem to be of a new kind, and many more are out there. This is joint work with Gwyn Bellamy (Glasgow) and Travis Schedler (London), and with Cédric Bonnafé (Montpellier).

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 2.058**

General Equations for the Classical Groups in Differential Galois Theory

Matthias Seiß[1,*]

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In classical Galois theory there is the well-known construction of the general equation with Galois group the symmetric group S_n. One starts with n indeterminates $T = (T_1, \dots, T_n)$ and considers the rational function field $\mathbb{Q}(T)$. The group S_n acts on $\mathbb{Q}(T)$ by permuting the indeterminates $T_1, \dots, T_n$. One can show that $\mathbb{Q}(T)$ is a Galois extension of the fixed field $\mathbb{Q}(T)^{S_n}$ for a polynomial equation of degree n whose coefficients are the elementary symmetric polynomials and are algebraically independent over $\mathbb{Q}$. A generalisation of this idea leads to the so-called Noether problem.

In this talk we perform a similar construction in differential Galois theory for the classical groups of Lie type. Let G be one of them and denote by ℓ its Lie rank. Using the geometrical structure of G we build a *general* differential extension field E of differential transcendence degree ℓ and define a group action of G on E. We show that the field of invariants E^G is a purely differential transcendental extension of the field of constants of degree ℓ and that E over E^G is a Picard-Vessiot extension with group G for a *nice* linear differential equation. Finally we discuss for which Picard-Vessiot extensions our construction is generic.

Dienstag, Beginn: 10:30 Uhr **Seminarraum: 2.058**

Generalising Statistics on Young Tableaux

Jacinta Torres[1,*], **Maciej Dołęga**[2], **Thomas Gerber**[3]

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In this talk I will give an overview on the general problem of generalising various statistics defined on Young tableux, usually related to positive formulas for polynomials of broad interest in algebraic combinatorics and representation theory. I will present various examples and discuss a generalisation of the charge statistic of Lascoux and Schützenberger, used to give a closed formula for Kostka-Foulkes polynomials.

References

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Dienstag, Beginn: 11:00 Uhr **Seminarraum: 2.058**

Representation categories of quantum groups and computational approaches

Moritz Weber[1,*]

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Symmetries are usually modelled by groups. However, in many modern contexts new kinds of symmetries arise and one is obliged to consider quantum groups. I will briefly survey some aspects of noncommutative mathematics and give a short introduction to compact quantum groups as defined by Woronowicz in the 1980s. In this context, interesting representation categories arise resembling Brauer algebras in terms of their combinatorics. I will present some recent work in this direction highlighting computational aspects using GAP and SINGULAR amongst others.

This work has been supported by the SFB-TRR 195, Symbolic tools in mathematics and their application.

Dienstag, Beginn: 11:30 Uhr **Seminarraum: 2.058**

Parallel Enumeration of Triangulations

Michael Joswig[1,*], **Charles Jordan**[2], **Lars Kastner**[1]

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We report on the implementation of an algorithm for computing the set of all regular triangulations of finitely many points in Euclidean space. This algorithm, which we call down-flip reverse search, can be restricted, e.g., to computing full triangulations only; this case is particularly relevant for tropical geometry. Most importantly, down-flip reverse search allows for massive parallelization, i.e., it scales well even for many cores. Our implementation allows to compute the triangulations of much larger point sets than before.

FAIRmath: Opening mathematical research data for the next generation

Findability, accessibility, interoperability, and reusability (FAIR) are the key principals for modern research data. While data-driven science started to implement these principals for measurement and simulation data, it is not completely immanent how these principles translate to (pure) mathematics research. Although mathematics research results are time independent, a new generation of mathematicians demands a timely research infrastructure. In this symposium, we discuss the question of FAIR data for mathematics from two perspectives: 1) What are the needs of future mathematicians and 2) what is technically possible today?

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 2.066**

Mathematical Data wants to be Deep FAIR

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Over the last years the publication and management of research data have gained increasing attention and support. There are large research data initiatives at the national (e.g. NFDI; Germany) and European level (e.g. EOSC and EUDATA). Even though there are large data mathematical collections like the OEIS, LMFDB, GAP small groups library, or the House of Graphs, by and large Mathematicians are unaware and unaffected by the whole trend. This talk discusses notions of mathematical data, their role in mathematical practice, and their inter-dependence with mathematical knowledge and proof. Based on this we discuss what it would take to make mathematical (research) data FAIR. We will present a paradigm for establishing a unified data infrastructure, and building mathematical services on this.

Dienstag, Beginn: 10:24 Uhr **Seminarraum: 2.066**

Openess and FAIRness for mathematical research data: the legal framework

Fabian Rack[1,*], **Thomas Hartmann**[1], **Klaus Hulek**[2], **Olaf Teschke**[1]

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For a long time, the mathematical community has been a driving force toward an accessible, efficient, fair and transparent system of scientific information. Legal requirements are also relevant for data-sets and publications in mathematics.

Relevant associations – such as the DMV, EMS, GAMM, or GOR – and scientific institutions – such as universities – have already started with open access policies, directives and goals. To reach common standards the implementation requires certain licensing information and further considerations in the fields of IP, privacy or contracting (i.e. liability). The variety of relevant interests within the mathematical community must also be taken into account developing terms of use.

The international mathematical research community is highly connected. In order to maintain and extend the international impact and compatibility of German mathematics, it is essential for research data infrastructures and services to develop and establish widely recognised legal standards. So the legal analysis should be accompanied by an analysis from the perspective of scientific ethics.

Dienstag, Beginn: 10:48 Uhr **Seminarraum: 2.066**

Collecting Datasets by Analyzing References in the zbMATH Database

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References to non-traditional forms of publications like software packages, datasets, and the like, are often constructed in a non-normalized ad-hoc fashion, hurting both the findability of the result as well as the attribution of research output to a researcher. In this talk, we present a preliminary analysis of the references used in the publications indexed by zbMATH. In particular, we inspect references that do not point to classical research papers. Therefore, we apply a twofold approach. For one, we use random sampling, for explorative analysis of the dataset. In a second step, we apply heuristics and clustering to quantify the findings of the explorative analysis.

Dienstag, Beginn: 11:12 Uhr **Seminarraum: 2.066**

alsoMATH - A Database for Mathematical Algorithms and Software

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Mathematical publications are an important resource for the development of machine-based methods for mathematical knowledge management. This article describes the publication-based approach to improve the information and the access to two important classes of mathematical research, mathematical software and mathematical algorithms. The publication-based approach is based on analyzing links and the structure of mathematical publications. It has been used to build the swMATH service which provides comprehensive information about mathematical software and algorithms.

References

[1] swMATH *The database swMATH* (2014 -), http://swmath.org

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Dienstag, Beginn: 11:36 Uhr **Seminarraum: 2.066**

Cultivating Cooperation in a Competitive Community

Christian Himpe[1,*], **Peter Benner**[1], **Jan Heiland**[1], **Jens Saak**[1]

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A common theme in numerical mathematics is the race for the most efficient, universal and elegant algorithm for a class of problems. Yet, this principally healthy competition is only beneficial to mathematics, science, industry and society if the research output is actually comparable. The comparison of numerical algorithms can be a complex endeavor as the implementation, configuration, compute environment and test problems need to be well defined. For a single mathematician this is addressed by best practices for mathematical software, see for example [1] and references therein. Communities, around specific (numerical) problems, need, in addition to inclusive broader guidelines, infrastructure for the exchange, comparison and progress in the field. As a case study we present the groundwork and coming challenges for the *model reduction* community. Model reduction (also known as model order reduction) is a young discipline in applied mathematics concerned with the algorithmic simplification of numerical differential equation models, which has engendered numerous methods, each with many application-specific and algorithmic variants. In this regard, we point out problems, alongside possible measures with the aim to ensure scientificity and comparability of model reduction research and with the ultimate goal of becoming FAIR.

References

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Dienstag, Beginn: 16:00 Uhr **Seminarraum: 2.066**

Confirmable workflows in `polymake`

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The three-dimensional simplex dilated by a factor of three has 910 974 879 regular triangulations. These play an important role in tropical geometry, when classifying tropical cubics and the discriminant of a cubic quaternary form. They were recently enumerated by `mptopcom` together with `polymake`. To produce and manage such and bigger amounts of mathematical data requires a suitable workflow. Publishing this result then raises the question, how can one make this data accessible to other researchers?

We will discuss confirmable workflows within `polymake` alongside the example above. The computation producing these triangulations involves heavy usage of computing clusters, putting all features of `polymake` on trial. Processing the result benefits from several important features of `polymake`, such as storing, porting, and publishing data. The latter involves the polymake database `polyDB`.

References

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Dienstag, Beginn: 16:24 Uhr **Seminarraum: 2.066**

Storage of Number Fields and Related Objects

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Long term storage of number fields suffers from a hard problem: number fields do not have a canonical, unique representation, they are typically represented by an integral polynomial - which is non-canonical. Even worse, for databases, the size taken by such a presentation can differ by orders of magnitude.

Representation of invariants of the field, e.g. elements, thus in their presentation depend on the chosen polynomial of the field. This lack of unique-ness makes efficient databases difficult: retrieving data via keys and de-duplication have to depend on mathematically hard problems that do not have a fast (constant time) solution. This for example occurs trying to store representations of finite groups in characteristic 0 or Puiseux expansions of roots of bi-variate polynomials.

A similar problem is already visible in finite fields: while the field is uniquely specified by the size, the defining polynomial (the presentation) is not. There are several normalisations available in the literature (Conway polynomials for example), but typically they are extremely hard to get. Data depending on this, such as matrices defining codes or group representations, then have to be specified relative to the presentation.

In this context, any serialisation scheme need to support the notion of a parent of an object, providing the neccessary context in which the presentation of the elements can be understood.

In this talk, I will explain the problems and discuss some of the attemps we tried so far. In particular, in view of the OSCAR project and the data to be generated there, this is an important problem.

Dienstag, Beginn: 16:48 Uhr **Seminarraum: 2.066**

Modal Pathway Diagrams for the Representation of Mathematical Models

Thomas Koprucki[1,*], **Karsten Tabelow**[1]

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We present a concept for a machine-actionable representation of mathematical models. The approach is based on Model Pathway Diagrams (MPD), which specify the physical quantities that are described in the model as well as the relations between them (laws, constitutive equations), see [1,2]. MPDs provide a visual tool for understanding the structural properties of models as well as algorithms for numerical simulations. We illustrate our approach by application to the van Roosbroeck system describing the carrier transport in semiconductors by drift and diffusion. We discuss the block-based composition of models from simpler components. We indicate how MPDs can be used to assist a formalized representation of mathematical models based on OMDoc/MMT, a special machine-readable description language for mathematical documents, in order to obtain a machine-actionable as well as human-understandable representation of the mathematical knowledge and the domain-specific semantics they contain.

References

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Dienstag, Beginn: 17:12 Uhr **Seminarraum: 2.066**

From the A&S handbook to a digital mathematics platform: reusing the DLMF for the DRMF

Howard S. Cohl[1,*], **Moritz Schubotz**[2]

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The Digital Library of Mathematical Functions (DLMF) is the digital successor of one of the most cited books, "The Handbook of Mathematical Functions with Formulas, Graphs, and Mathematical Tables," edited by Milton Abramowitz and Irene A. Stegun. In contrast to the book, the DLMF provides machine-readable semantics that allows for formulae search and interactive display of additional metadata. This includes links to definitions for the symbols and identifiers used in the formula, references to proofs and sketches of proofs when proofs are not available on the literature, as well as hyperlinks to related concepts. The NIST Digital Repository of Mathematical Formulae previously used a MediaWiki based framework to reimplement these features but focusses on individual mathematical formulae rather than continuous chapters regarding mathematical topics.

In this talk, we show the current status of a new experiment: the utilization of the full software used by the DLMF to display DRMF formulae.

Mathematical Perspectives on General Relativity

General Relativity is a beautiful physical theory which has successfully predicted many natural phenomena such as black holes and gravitational waves. Since Yvonne Choquet-Bruhat's seminal work in the 1960's, it has attracted the attention of mathematicians whose attention is caught by the fascinating interactions between the differential geometric setting of the theory, the partial differential Einstein equations describing the behavior of gravitational systems, and the intimate connections with mathematical and theoretical physics. The aim of the minisymposium is to discuss recent progress in this very active subfield of geometric analysis in a way that is also inviting for young and experienced researchers from neighboring disciplines.

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 2.067**

The problem of existence of static and electrostatic solutions of the Einstein equations in arbitrary topology

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Vacuum static black hole solutions of the Einstein equations are central in General Relativity and important in geometry. A recent classification showed that S^1-symmetric black holes can be only of three kinds: Schwarzschild, Boost, or Myers/Korotkin-Nicolai, each family having its distinct topology type. We will explain that, while Schwarzschild's topology admits charged static S^1-symmetric black holes, those of the Boosts and Myers/Korotkin-Nicolai do not. Black holes in such topologies cannot hold a charge. The proof of this peculiar fact is done by first transforming the static solution into a vacuum stationary solution by means of a Kramer-Neugebauer transform, then proving decay estimates using techniques a la Bakry-Émery, and finally showing that too much electrostatic energy would concentrate at infinity, thus reaching an impossibility. The type of result, as well as the techniques, appear to be new.

Dienstag, Beginn: 10:30 Uhr **Seminarraum: 2.067**

A uniqueness result for higher-dimensional Reissner–Nordström manifolds

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We consider $n+1$-dimensional static solutions of the electrovacuum equations which are asymptotic to a member of the Reissner–Nordström family, with a lapse and an electric potential fulfilling some asymptotic conditions. Assuming that we are given such a spacetime whose inner boundary (a priori possibly with multiple connected components) consists of static horizons or photon spheres (which are characterized by a quasilocal subextremality condition), we show that it is isometric to a subextremal Reissner–Nordström spacetime of positive mass [3]. The proof relies on ideas going back to the well-known black hole uniquess thereom by Bunting and Masood-ul Alam [1] and generalizes classical black hole uniqueness results, as well as recent photon sphere uniqueness theorems (e.g. [2]).

References

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[2] Carla Cederbaum and Gregory J. Galloway. Uniqueness of photon spheres via positive mass rigidity. *Commun. Anal. Geom.*, 25(2):303–320, 2017.

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Dienstag, Beginn: 11:00 Uhr **Seminarraum: 2.067**

The Hawking energy on the large and small scale

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The Hawking energy is a quasi local energy in General Relativity. The idea is to obtain a measure for the energy contained within a given volume by measuring the bending of light rays across its boundary. We simply regard it as a functional on spherical surfaces.

On the one hand we analyze the behavior of critical surfaces with small area and identify points in the ambient manifold around which they concentrate. Additionally, we present an expansion of the Hawking energy on small spheres. On the other hand we investigate the Hawking energy on asymptotically Schwarzschild manifolds. In particular, we construct a foliation of the outer region of the asymptotically flat end by large critical surfaces. Not only does this allow us to calculate the total energy of the ambient manifold, but it also yields a notion of center of mass.

This work is part of my dissertation and is strongly inspired by the corresponding analysis of the Willmore functional in [1,2,3],

References

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Dienstag, Beginn: 11:30 Uhr **Seminarraum: 2.067**

Geometric Inequalities for Axially Symmetric Initial Data

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The current model of gravitational collapse asserts that a series of inequalities may hold, between physical quantities such as mass, angular momentum, and charge of the initial data set for the Einstein-Maxwell equations. A major breakthrough in the study of these geometric inequalities was made by Dain et al. [1], proving the mass-angular momentum inequality for a large class of 3 dimensional, axially symmetric, maximal initial data for the Einstein equations. Recently, Alaee, Khuri, Kunduri showed that the analogous inequalities hold for 4 dimensional, bi-axisymmetric, maximal initial data [2]. In this talk, I will present the recent progress to extend these results for near maximal initial data [3-4], and discuss the remaining open problems in this topic.

References

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[4] Y.-S. Cha, On Geometric Inequalities for Near Maximal Axially Symmetric Initial Data (Work in Progress)

Dienstag, Beginn: 16:00 Uhr **Seminarraum: 2.067**

Stability of the Milne model with matter

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The celebrated future stability of the Milne model under the vacuum Einstein flow by Andersson and Moncrief has been generalised in recent years to different Einstein-matter systems in 3+1-dimensions. The problem has been considered for the Einstein-Vlasov system by Anderson-F., for the Einstein-Klein-Gordon system by F.-Wyatt and for the Einstein-Maxwell system as part of a more general class of systems, arising from higher-dimensional spacetimes with symmetries by a Kaluza-Klein reduction, by Branding-F.-Kröncke. Each result requires individual technical ideas to control the respective matter model in the perturbed Milne geometry. We will give an overview on the main mechanism of stability of the Milne geometry for these Einstein-matter systems.

Dienstag, Beginn: 16:30 Uhr **Seminarraum: 2.067**

The Conformal Method and Matter Models

Jim Isenberg[1], **David Maxwell**[2,*]

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We discuss the application of the conformal method to generating non-vacuum initial data sets. There are a number of different schemes for including matter in the conformal method including so-called scaling and non-scaling sources. These techniques have been presented in the literature as ad-hoc methods. We show that there is a principled idea that leads to a variation of scaled sources and that leads to decoupling of the momentum and Hamiltonian constraints in the CMC case.

Dienstag, Beginn: 17:00 Uhr **Seminarraum: 2.067**

Lorentzian warped products with one dimensional base and length space fibers

Stephanie B. Alexander[1], **Melanie Graf**[2,*], **Michael Kunzinger**[3], **Clemens Sämann**[3]

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Smooth Lorentzian warped products of the form $I \times_f (M, g)$, where (M, g) is a Riemannian manifold and f is a positive smooth function on an intervall I, are important examples of spacetimes: They contain well-known physical models (such as the FLRW spacetimes) and admit a very simple description of causal curves and geodesics.

We will examine what happens if one replaces the Riemannian manifold (M, g) with a locally compact length space (X, d). As long as f is continuous and positive there still exists a natural notion of causal curves and their length and hence also of the causality relations on the product $I \times_f X$. This turns $I \times_f X$ into a Lorentzian length space (as defined in [1]). Analogous to the smooth case the causal structure of such warped products is very simple and one has an explicit description of $\partial J^+(p)$. Inspired by the well-developed Riemannian theory of warped products of length spaces, we also obtain some results concerning timelike curvature bounds for Lorentzian warped products of this type.

References

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Dienstag, Beginn: 17:30 Uhr **Seminarraum: 2.067**

Topology and singularities in cosmological spacetimes obeying the null energy condition

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The relationship between the topology of spacetime and the occurrence of singularities (causal geodesic incompleteness) is a topic of long-standing interest. In this talk we focus on the cosmological setting: We consider globally hyperbolic spacetimes with compact Cauchy surfaces under assumptions compatible with the presence of a positive cosmological constant. More specifically, for $3+1$ dimensional spacetimes which satisfy the null energy condition and contain a future expanding compact Cauchy surface, we establish a precise connection between the topology of the Cauchy surfaces and the occurrence of past singularities. The proof makes use of certain fundamental existence results for minimal surfaces and of some recent advances in the topology of 3-manifolds.

Mathematiklehre im ersten Studienjahr: Was, wie und wozu?

Wenn DozentInnen ein grundständiges, stark heterogen belegtes Mathematikmodul verantworten – man denke alleine an Fachbachelor, Lehramt und Service Nawi/Ing/WiWi/SoWi – geraten sie regelmäßig in einen Zielkonflikt:

- Erstens sind hohe Abbrecherquoten zu vermeiden – dies wird durch die Bildungspolitik verstärkt gefordert.
- Zweitens sind für die unterschiedlichen Adressatengruppen Sinn- und Anwendungsbezüge herzustellen.
- Drittens sind die für das weitere Studium notwendigen Fertigkeiten, Methoden und Konzepte zu vermitteln und
- viertens valide Prüfungsformate zu festlegen, welche häufig darüber bestimmen, ob jemand fortstudiert oder nicht.

Vor dem Hintergrund dieses Zielkonflikts sind von den DozentInnen Entscheidungen zu treffen: Inhaltliche Entscheidungen (stoffdidaktische Reduktion; Anschauung vs. Kalkül), methodische Entscheidungen (Vorlesung, Übungsform, e-Aufgaben, Aktivierungen in Veranstaltungen wie Peer Instruction etc.), aber auch Prüfungsformen (Auswahl von Zulassungsvoraussetzungen, Klausur, Portfolioprüfungen, etc.) und Zielformulierung zu den Fertigkeiten (dies bestimmt stark, wie die Studierenden lernen). Im Symposium werden Beiträge zu klassischen grundständigen Mathematikmodulen präsentiert: dabei reicht das Spektrum von ganzen Veranstaltungskonzepten bis zu Ansätzen, die sich bspw. auf bestimmte Schlüsselbegriffe der jeweiligen Thematik fokussieren.

Montag, Beginn: 15:30 Uhr **Seminarraum: 1.067**

Analysis I – Didaktisch durchdacht

Reinhard Oldenburg[1,*]

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Die Analysis I Vorlesung im Studiengang Bachelor Mathematik und in verwandten Studiengängen stellt für Lernende eine große Hürde dar wie die üblichen Durchfallquoten eindrücklich belegen. Die didaktische Forschung hat bisher viel Zeit investiert, die Schwierigkeiten an der Diskontinuitätsstelle zwischen Schule und Universität zu beschreiben und methodische Fragen zu untersuchen. Vergleichsweise weniger beforscht sind konkret-inhaltliche Fragen. Bei dem Versuch der Weiterentwicklung der Analysis I in Augsburg mussten daher einige Dinge explorativ erprobt werden. Zentral ist die Idee eines genetischen Aufbaus, der den Studierenden frühzeitig die Möglichkeit gibt, selbst forschend zu lernen. Außerdem wurde Computereinsatz in moderatem Umfang erprobt und evaluiert. Der Vortrag gibt einen Überblick über Konzeption und Durchführung der Veranstaltung und berichtet erste Ergebnisse.

Montag, Beginn: 16:00 Uhr **Seminarraum: 1.067**

Stochastik im Grundstudium: Konzept und Erfahrungen

Norbert Henze[1,*]

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Stochastik gilt gemeinhin als schwierig, weil sie im Spannungsfeld zwischen Mathematik, Modellbildung und persönlichen Erfahrungen mit stochastischen Vorgängen steht. Eine grundständige Stochastik-Vorlesung, die auf den Kenntnissen des ersten Studienjahres eines Mathematikstudiums aufbaut, muss diesem Spannungsfeld Rechnung tragen. Im Vortrag stelle ich mein diesbezügliches, vom Studiengang (Bachelor bzw. gymnasiales Lehramt) abhängendes Konzept vor und berichte von den damit gemachten Erfahrungen.

Montag, Beginn: 16:30 Uhr **Seminarraum: 1.067**

Eine spezielle Lineare Algebra für Lehramtsstudierende

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Ausgangspunkt dieses Projekts im Rahmen von „Mathematik Neu Denken“[1] war die Beobachtung, dass sich Lehramtsstudierende, wenn sie die gleiche Veranstaltung wie Bachelor-Studierende besuchen, sich zurückgesetzt fühlen und ein Leben als „Studierende zweiter Klasse“ führen. Für die fachliche Ausbildung der Studierenden für das gymnasiale Lehramt im Fach Mathematik hat „Mathematik Neu Denken“ u.a. folgende Ziele formuliert: Die Studierenden sollen eine aktive Beziehung zur Mathematik als Wissenschaft erhalten und der Stoff soll an schulmathematische Erfahrungen anknüpfen und diese reflektieren.

Für die Veranstaltung „Lineare Algebra“, bedeutet u.a. das Folgende:

- Eine eigene Veranstaltung für Lehramtsstudierende.
- Vom Konkreten zum Abstrakten: Darin wurden wesentliche Begriffe, Sätze und Beweise schon in einem vertrauten Spezialfall präsentiert, so dass sie sich später abstrakt als „völlig selbstverständlich“ ergeben.
- Entschlackung des Stoffs: möglichst schnell zu den Vektorräumen (über $\mathbb{Q}$ bzw. $\mathbb{R}$) kommen.
- Immer zuerst ein Beispiel, und dann die Definition, der Satz oder der Beweis.
- Konstruktives Lernen wurde durch einfache Aufgaben innerhalb der Vorlesung verwirklicht.

References

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Montag, Beginn: 17:00 Uhr **Seminarraum: 1.067**

Höhere Algebra für Lehramtsstudierende – genetisch verstehen und aktiv mathematisieren

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In der Schule wird klassische Algebra (Variablen und Gleichungen) betrieben, an der Hochschule wird moderne Algebra (mit ihren „Operationsstrukturen“) gelehrt. Studierende des Lehramtes sollten, die vielfältige Bezüge zwischen Schul- und Universitätsmathematik erleben und dabei erkennen, welche Abstraktionsleistung in der modernen Algebra steckt, aber auch, wie diese Abstraktion aus konkreten Situationen und Problemen hervorgegangen ist. Es wird ein Lehrkonzept vorgestellt, das didaktisch auf sinnstiftende, genetische Zugänge zu algebraischen Strukturen setzt und methodisch eine hohe Studierendenaktivierung durch interaktive Explorationsumgebungen, Forschungshefte und flipped classroom realisiert.

Nonlinear Evolution Equations and Applications

The aim of the minisymposium is to bring together specialists in nonlinear partial equations and their applications in natural sciences. It particularly addresses young scientists in this field. The range of applications includes any branch of science and technology such as solid and fluid mechanics, material science, mathematical biology, and chemistry.

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 0.019**

Well-Posedness for a Moving Boundary Model of an Evaporation Front in a Porous Medium

Georg Prokert[1,*], **Friedrich Lippoth**[2]

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We consider a two-phase elliptic-parabolic moving boundary problem modelling an evaporation front in a porous medium [2]. Our main result is a proof of short-time existence and uniqueness of strong solutions to the corresponding nonlinear evolution problem in an L^p-setting. It relies critically on nonstandard optimal regularity results for a linear elliptic-parabolic system with dynamic boundary condition. We identify a nontrivial well-posedness condition that can be interpreted as a "linear combination" of the corresponding conditions for the Stefan and Hele-Shaw type problems to which the problem formally reduces in the single phases.

References

[1] F. Lippoth and G. Prokert, Well-Posedness for a Moving Boundary Model of an Evaporation Front in a Porous Medium, to appear in *Journ. Math. Fluid Mech.*, Preprint arXiv:1702.04530, (2017)

[2] A.T. Il'ichev, and G.G. Tsypkin, Catastrophic transition to instability of evaporation front in a porous medium, *Eur. Journ. Mech. B/ Fluids* **27** (2008), pp. 665–677

Mittwoch, Beginn: 10:30 Uhr **Seminarraum: 0.019**

Threshold for blowup for the supercritical cubic wave equation

Birgit Schörkhuber[1,*], **Irfan Glogić**[2], **Maciej Maliborski**[3]

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In this talk, we discuss recent results concerning singularity formation for the focusing cubic wave equation in the energy supercritical regime. In [1] we found an explicit non-trivial self-similar blowup solution, which is defined on the whole space and exists in all supercritical dimensions $d \geq 5$. Furthermore, for $d = 7$ we proved its stability along a co-dimension one Lipschitz manifold of initial data. Based on numerical experiments performed in [2] we conjecture that this manifold is in fact a threshold between finite-time blowup and dispersion.

References

[1] I. Glogić and B. Schörkhuber, Co-dimension one stable blowup for the supercritical cubic wave equation, *arXiv:1810.07681v2*, Preprint 2018

[2] I. Glogić, M. Maliborski and B. Schörkhuber, Threshold for blowup for the supercritical cubic wave equation, *arXiv:1905.13739*, Preprint 2019

Mittwoch, Beginn: 11:00 Uhr **Seminarraum: 0.019**

Renormalized solutions for a stochastic p-Laplace equation with L^1-initial data

Aleksandra Zimmermann[1,*]

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We consider a p-Laplace evolution problem with stochastic forcing on a bounded domain $D \subset \mathbb{R}^d$ with homogeneous Dirichlet boundary conditions for $1 < p < \infty$. The additive noise term is given by a stochastic integral in the sense of Itô. The technical difficulties arise from the merely integrable random initial data under consideration. Due to the poor regularity of the initial data, estimates in $W_0^{1,p}(D)$ are available with respect to truncations of the solution only and therefore well-posedness results have to be formulated in the sense of generalized solutions. We extend the notion of renormalized solution for this type of SPDEs, show well-posedness in this setting and study the Markov properties of solutions.

Mittwoch, Beginn: 11:30 Uhr **Seminarraum: 0.019**

Long-time behaviour of non-local in time Fokker-Planck equations via the entropy method

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[2]*Applied and Computational Mathematics, University of Oulu, Finland*
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We consider a rather general class of non-local in time Fokker-Planck equations and show by means of the entropy method that as $t \to \infty$ the solution converges in L_1 to the unique steady state. Important special cases are the time-fractional and ultraslow diffusion case. We also provide estimates for the rate of decay. In contrast to the classical (local) case, where the usual time derivative appears in the Fokker-Planck equation, the obtained decay rate depends on the entropy, which is related to the integrability of the initial datum. It seems that higher integrability of the initial datum leads to better decay rates and that the *optimal decay rate* is reached, as we show, when the initial datum belongs to a certain weighted L_2 space. Our estimates can be adapted to the discrete-time case thereby improving known decay rates from the literature.

References

[1] J. Kemppainen, R. Zacher, Long-time behavior of non-local in time Fokker-Planck equations via the entropy method. *Math. Models Methods Appl. Sci.* **29** (2019), pp. 209–235.

Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 0.019**

The Mullins-Sekerka problem with contact angle

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The Mullins-Sekerka problem for closed interfaces is widely studied since it appears naturally as a gradient flow of the area functional, as a sharp interface limit of the Cahn-Hilliard equation, and in physical models of phase changes. In this talk I will address the Mullins-Sekerka problem for interfaces with a ninety degree contact angle. In particular, I will show existence and uniqueness of strong solutions and discuss stability properties.

Mittwoch, Beginn: 16:00 Uhr **Seminarraum: 0.019**

Spectral instability of the peaked periodic wave in the reduced Ostrovsky equations

Anna Geyer[1,*], **Dmitry Pelinovsky**[2]

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The reduced Ostrovksy equation is a model for small-amplitude long waves in a rotating fluid. Peaked periodic waves of this equation are known to exist since the late 1970's. In this talk I will present recent results in which we answer the long standing open question whether these solutions are stable. We first prove linear instability of the peaked periodic waves using semi-group theory and energy estimates. Moreover, we show that the peaked wave is unique and that the equation does not admit Hölder continuous solutions, which implies that the reduced Ostrovsky equation does not admit cusps. Finally, we show that the peaked wave is also spectrally unstable and by so doing we discover a new instability phenomenon.

Mittwoch, Beginn: 16:30 Uhr **Seminarraum: 0.019**

On three-dimensional water flows with constant vorticity

Calin Martin[1,*]

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We present some new results on three-dimensional water flows which exhibit constant vorticity vector. We also consider geophysical effects.

References

[1] C. I. Martin, Constant vorticity water flows with full Coriolis term, *Nonlinearity* **32** (2019), pp. 2327–2336.

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[3] C. I. Martin, Non-existence of time-dependent three-dimensional gravity water flows with constant non-zero vorticity, *Physics of Fluids* **30** (2018) no. 10, 107102 .

Mittwoch, Beginn: 17:00 Uhr **Seminarraum: 0.019**

The spectral problem associated with the time-periodic NLS

Ronald Quirchmayr[1,*], **Jonatan Lenells**[1]

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According to its Lax pair formulation, the nonlinear Schrödinger equation (NLS) can be expressed as the compatibility condition of two linear ordinary differential equations with an analytic dependence on a complex parameter. The first of these equations—often referred to as the *x-part* of the Lax pair—can be rewritten as an eigenvalue problem for a Zakharov-Shabat operator. The spectral analysis of this operator is crucial for the solution of the initial value problem for NLS via inverse scattering techniques. For space-periodic solutions, this leads to the existence of a Birkhoff normal form, which beautifully exhibits the structure of NLS as an infinite-dimensional completely integrable system. In this talk we present several aspects of the recent work [1], in which we take the crucial steps towards developing an analogous picture for time-periodic solutions by performing a spectral analysis for the *t-part* of the Lax pair with periodic potentials. In particular, we discuss the asymptotics of the fundamental matrix solution of the underlying generalized eigenvalue problem for arbitrary potentials, which implies estimates for large periodic eigenvalues. Furthermore we present qualitative aspects of the periodic spectrum for small periodic potentials of so-called real or imaginary type being particularly relevant for NLS. Finally we illustrate these results with the help of a single exponential potential whose corresponding fundamental solution exhibits an explicit formula.

References

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Donnerstag, Beginn: 10:00 Uhr **Seminarraum: 0.019**

Recent progress in the analysis of the temporal evolution of magnetoviscoelastic materials

Anja Schlömerkemper[1,*], **Martin Kalousek**[1], **Joshua Kortum**[1]

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In magnetoviscoelastic systems elasticity is coupled with magnetism. While the former is usually phrased in Lagrangian coordinates, the latter is written up in Eulerian coordinates. Here, we follow an approach in which the coupled system is expressed in Eulerian coordinates [1,2]. The system of partial differential equations consists of the incompressible Navier-Stokes equations, an evolution equation for the deformation gradient as well as the Landau-Lifshitz-Gilbert equation, which describes the dynamics of the magnetization vector. We present the latest state of the art on the analysis of this system including existence of weak and strong solutions as well as corresponding uniqueness results [2].

References

[1] B. Benešová, J. Forster, C. Liu and A. Schlömerkemper, Existence of weak solutions to an evolutionary model for magnetoelasticity, *SIAM J. Math. Anal.* **50** (2018), pp. 1200–1236.

[2] M. Kalousek, J. Kortum and A. Schlömerkemper, Mathematical analysis of weak and strong solutions to an evolutionary model for magnetoviscoelasticity, arXiv:1904.07179.

Donnerstag, Beginn: 10:30 Uhr **Seminarraum: 0.019**

Analysis of a free boundary problem modeling 3D MEMS

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An idealized electrostatic microelectromechanical system (MEMS) consists of a rigid ground plate above which a thin elastic plate is suspended. The elastic plate is assumed to be hinged on its boundary. Applying a voltage difference between the two plates induces a Coulomb force that deforms the elastic plate. The corresponding mathematical model couples a fourth-order parabolic equation for the vertical deformation of the elastic plate to the harmonic electrostatic potential in the free domain between the two plates.

In this talk, I will present some recent results on local and global well-posedness of the model as well as on existence and non-existence of stationary solutions.

Donnerstag, Beginn: 11:00 Uhr **Seminarraum: 0.019**

Analysis of a structured population model

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In this talk I present a nonlinear model which allows to describe the time evolution of a spatial- and age-structured population. After a discussion of the mathematical features, a solution concept will be introduced. Subsequently I will outline a stability result for equilibria.

Sektionen

Algebra und Zahlentheorie
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Differentialgeometrie, globale Analysis und Anwendungen
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Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 3.069**

Diffusion on the moduli space of p-adic Mumford curves

Patrick Erik Bradley[1,*]

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In this talk a construction of pseudo-differential operators of Taibleson-Vladimirov type on the moduli space of Mumford curves of genus g over non-archimedean local fields is given by using the Gerritzen-Herrlich Teichmüller space of discrete representations of finitely generated free groups in g generators as projective linear transformations. Corresponding Cauchy problems are stated and solved.

Mittwoch, Beginn: 16:00 Uhr **Seminarraum: 3.069**

On the factors of CNS polynomials

Horst Brunotte[1,*]

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Extending several known number systems A. Pethő and J. Thuswaldner [1] recently introduced and studied the notion of a generalized number system (GNS) over an order $\mathcal{O}$ in an algebraic number field. A GNS is a pair $(p, \mathcal{D})$ where p is a monic univariate polynomial with coefficients in $\mathcal{O}$ and $p(0) \neq 0$ and $\mathcal{D} \subset \mathcal{O}$ is a complete residue system modulo $p(0)$. The GNS $(p, \mathcal{D})$ enjoys the finiteness property if every polynomial in $\mathcal{O}[X]$ is congruent modulo p to some polynomial in $\mathcal{D}[X]$. An example of a GNS is the canonical number system (CNS) which has been introduced by A. Pethő. Recall that an integer polynomial $p \in \mathbb{Z}[X]$ is a CNS polynomial if $(p, \{0, \ldots, |p(0)| - 1\})$ is a GNS with finiteness property.

Many years ago, A. Pethő asked whether each monic integer polynomial all of whose roots lie outside the closed unit disk and are non-positive is a factor of a CNS polynomial. We give an affirmative answer to this question by a constructive proof based on a classical result by S. Akiyama – H. Rao and K. Scheicher – J. M. Thuswaldner.

References

[1] A. Pethő and J. Thuswaldner, Number systems over orders, *Monatsh. Math.* **187** (2018), pp. 681–704.

Mittwoch, Beginn: 16:30 Uhr **Seminarraum: 3.069**

Primzahlen mit einer ausgeschlossenen Ziffer

Fabian Karwatowski[1,*]

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Für eine gegebene Basis $b \geq 10$ und eine ausgeschlossene Ziffer $a_0 \in \{0, ..., b-1\}$ definieren wir $\mathcal{A}$ als Menge aller nicht-negativen ganzen Zahlen, welche die Ziffer a_0 nicht in ihrer b-adischen Zifferndarstellung besitzen. Wir untersuchen, ob es unendlich viele Primzahlen in der Menge $\mathcal{A}$ gibt und zählen die Primzahlen in $\mathcal{A}$, die kleiner als $X = b^k$ sind. Dazu verallgemeinern wir Maynard's Beweis für den Fall $b = 10$ und geben einen kurzen Einblick in die benutzte Methode. Schließlich sehen wir, dass wir vor allem dann Maynard's Beweis auf beliebige Basen $b \geq 10$ und ausgeschlossene Ziffern $a_0 \in \{0, ..., b-1\}$ übertragen können, wenn zwei betragsmäßig größte Eigenwerte von Matrizen, die durch b und a_0 parametrisiert werden, bestimmten Abschätzungen genügen. Zudem ist es durch leichte Modifikationen möglich, die entsprechende Aussage auch auf die Paare $(b, a_0) = (9, 0)$ und $(b, a_0) = (9, 8)$ einer gegebenen Basis b und einer ausgeschlossenen Ziffer a_0 zu übertragen.

Referenzen

[1] James Maynard, Primes with restricted digits, *Inventiones mathematicae* **217** (2019), pp. 127–218.

Mittwoch, Beginn: 17:00 Uhr **Seminarraum: 3.069**

The p-adic zeta function and a p-adic Euler constant

Heiko Knospe[1,*]

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We study the p-adic analogue γ_p of the Euler-Mascheroni constant γ, also known as Euler constant. The p-adic Euler constant can be defined using the p-adic analogue of the gamma function. The constant γ_p can also be expressed in terms of the Kubota-Leopoldt p-adic L-function: γ_p is the constant term in the Laurent series expansion of the $\chi = 1$ branch of the p-adic zeta function about $s = 1$ (see [1]).

The p-adic zeta function can be constructed using p-adic distributions or measures and there are different series expansions (see [2], [3]). We derive several formulas for γ_p (compare [3], [4]) and present computations with SageMath.

References

[1] N. Koblitz, Interpretation of the p-adic log gamma function and Euler constants using the Bernoulli measure, *Transactions of the American Mathematical Society* **242** (1978), pp. 261–269.

[2] L. C. Washington, *Introduction to Cyclotomic Fields*, 2nd edition, Springer, New York, 1997.

[3] D. Delbourgo, The convergence of Euler products over p-adic number fields, *Proceedings of the Edinburgh Mathematical Society* **52** (2009), pp. 583–606.

[4] H. Knospe, Nonstandard measure spaces with values in non-Archimedean fields, *arXiv preprint* arXiv:1612.09108 (2016).

Donnerstag, Beginn: 10:00 Uhr **Seminarraum: 0.014**

On formal Fourier–Jacobi expansions, revisited

Jürg Kramer[1,*]
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In our talk, we will revisit the main result of [1], stating that formal Fourier–Jacobi expansions satisfying a natural symmetry condition give rise to Siegel modular forms in case of genus $g > 1$. While the proof given in [1] is carried out in the analytic category, our approach is based on the theory of arithmetic compactifications [2] of the moduli space of abelian schemes of dimension g. In particular, this allows to generalize the results of [1] to the arithmetic setting.

References

[1] J. H. Bruinier and M. Westerholt-Raum, Kudla's modularity conjecture and formal Fourier–Jacobi series, *Forum of Mathematics, Pi* **3** (2015), 30 pages.

[2] G. Faltings and C.-L. Chai, Degeneration of abelian varieties, *Ergebnisse der Mathematik und ihrer Grenzgebiete (3), vol. 22,* Springer-Verlag, Berlin, 1990.

Donnerstag, Beginn: 11:00 Uhr **Seminarraum: 0.014**

Saito-Kurokawa Lift for Orthogonal Modular Forms

Roland Matthes[1,*]
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The aim of this paper is to give a short proof of the Saito-Kurokawa lift for orthogonal modular forms along the lines we gave in two earlier papers [3], [4]. The proof uses a converse theorem as was stated by Imai [2] for Siegel modular forms as was already done by Duke and Imamoglu [1], yet avoiding the framework of spectral analysis.

Instead we are able to write the partial Mellin transform of the Saito-Kurokawa lift as a Rankin-Selberg integral of the theta lift of f twisted by an Eisenstein series. The functional equation of the Eisenstein series then implies the desired functional equation for the partial Mellin transform which in turn proves the lift to be an orthogonal modular form.

References

[1] W. Duke, Ö. Imamoḡlu, A converse theorem and the Saito-Kurokawa lift, *Internat. Math. Res. Notices 1996* no. 7, pp. 347–355

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[3] R.Matthes, The Saito-Kurokawa lift and Siegel's theta series; *Int. J. Number Theory* **13**, No. 7 (2017), pp. 1679–1693, DOI: 10.1142/S1793042117500968

[4] R.Matthes, A note on the Saito-Kurokawa lift for Hermitian forms; preprint (2018)

Donnerstag, Beginn: 11:30 Uhr **Seminarraum: 0.014**

Moments of spinor L-functions and symplectic Kloosterman sums

Fabian Waibel[1,*]

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Spectral summation formulas - such as the Selberg, Petersson or Kuznetsov trace formulas for GL(2) - constitute a powerful class of tools in analytic number theory. In the higher rank case, however, there are only few results. For Siegel modular forms of degree two an analogue of the Petersson formula was derived by Kitaoka [1].

By performing a detailed analysis of this Kitaoka-Petersson formula Blomer [2] obtains information on spectral averages of spinor L-functions for large weights. In this talk, I focus on the level aspect and show how to get similar results to [2] for large prime level. Taking into account the recent proof of Böcherer's conjecture, I hereby evaluate a fourth moment of the spinor L-function in the level aspect. The core of this computation is based on the manipulation of symplectic Kloosterman sums and the application of the adelic framework.

References

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[2] V. Blomer, Spectral summation formula for $GSp(4)$ and moments of spinor L-functions, *J. Eur. Math. Soc.* **21** (2019), pp. 1751–1774.

Donnerstag, Beginn: 15:30 Uhr **Seminarraum: 0.014**

The construction of Green currents and singular theta lifts for unitary groups

Jens Funke[1,*]

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In this talk we describe how singular theta lifts for the reductive dual pair $\mathrm{U}(p,q) \times \mathrm{U}(1,1)$ can be employed to construct two different kinds of Green forms for codimension q-cycles in Shimura varieties associated to unitary groups. In particular, we establish an adjointness result between the singular theta lift and the Kudla-Millson theta lift and discuss further applications in the context of the Kudla Program.

This is joint work with Eric Hofmann.

Donnerstag, Beginn: 16:30 Uhr **Seminarraum: 0.014**

Siegel modular forms associated to indefinite quadratic forms

Christina Röhrig[1,*]

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Vignéras [1] showed that there exists a simple criterion for generating (almost holomorphic) modular forms associated to an indefinite quadratic form on $\mathbb{R}^n$, i. e. by solving a second-order differential equation examples in the form of theta series may be obtained. Considering Siegel modular forms, one can construct theta series with modular transformation behavior, which is described by Freitag [2] for positive definite quadratic forms. In a similar way this can be done for indefinite quadratic forms by choosing suitable coefficients in the theta series. Those fulfill a system of second-order partial differential equations which turns out to be a straightforward generalization of the one-dimensional case. However, showing that this is also a sufficient criterion to determine whether a theta series transforms like a modular form seems to be more difficult.

References

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Donnerstag, Beginn: 17:00 Uhr **Seminarraum: 0.014**

Periodicities for Taylor coefficients of half-integral weight modular forms

Michael H. Mertens[1,*], **Pavel Guerzhoy**[2], **Larry Rolen**[3]

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Congruences of Fourier coefficients of modular forms have long been an object of central study. By comparison, the arithmetic of other expansions of modular forms, in particular Taylor expansions around points in the upper-half plane, has been much less studied. Recently, Romik made a conjecture about the periodicity of coefficients around $\tau_0 = i$ of the classical Jacobi theta function θ_3. Here, we generalize the phenomenon observed by Romik to a broader class of modular forms of half-integral weight and, in particular, prove the conjecture.

Differentialgeometrie, globale Analysis und Anwendungen

Organisation: Agricola, Marinescu

Montag, Beginn: 15:30 Uhr **Seminarraum: 2.059**

Regularity of Lie Groups

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In a survey article from 1984, Milnor formulated the regularity concept for infinite-dimensional Lie groups (a la Bastiani) to enable proofs of fundamental Lie theoretical facts in infinite dimensions. Roughly speaking, regularity is concerned with definedness and smoothness/continuity of the product integral – a concept that naturally generalizes the notion of the Riemann integral for curves in locally convex vector spaces to (infinite-)dimensional Lie groups (Lie algebra valued curves are thus integrated to Lie group elements). For instance, the exponential map of a Lie group is the restriction of the product integral to constant curves; and, given a principal fibre bundle, holonomies are product integrals of Lie algebra valued curves that are pairings of smooth connections with derivatives of curves in the base manifold of the bundle.

Although individual arguments show that all known example classes of infinite dimensional Lie groups admit regularity, only recently general regularity criteria had been found. We present these results, including a complete solution to the differentiability (smoothness) issue that forms a substantial part of the regularity problem. We furthermore discuss integrability conditions for Lie algebra valued curves (domain of the product integral), and show that C^0-continuity of the product integral is equivalent to a generalized triangle inequality involving the Lie group multiplication. As a real-life application, we will discuss the strong Trotter property in the given context.

Montag, Beginn: 15:50 Uhr **Seminarraum: 2.059**

Higher order energy functionals

Volker Branding[1,*], **Stefano Montaldo**[2], **Cezar Oniciuc**[3], **Andrea Ratto**[4]

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The study of higher order energy functionals was first proposed by Eells and Sampson in 1965 and, later, by Eells and Lemaire in 1983. These functionals provide a natural generalization of the classical energy functional. More precisely, Eells and Sampson suggested the investigation of the so-called $ES-r$-energy functionals

$$E_r^{ES}(\varphi) = (1/2)\int_M |(d^* + d)^r(\varphi)|^2\, dV,$$

where $\varphi : M \to N$ is a map between two Riemannian manifolds.

After giving a short overview on similar higher order variational problems we clarify some relevant issues about the definition of an $ES-r$-harmonic map, i.e, a critical point of $E_r^{ES}(\varphi)$.

Then, we will present several examples of proper critical points of $E_r^{ES}(\varphi)$.

Finally, we shall also show that the functionals $E_r^{ES}(\varphi)$ may not satisfy the classical Palais-Smale Condition (C).

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Montag, Beginn: 16:10 Uhr **Seminarraum: 2.059**

On CMC-foliations of asymptotically flat manifolds

Carla Cederbaum[1,*], **Anna Sakovich**[2]

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In 1996, Huisken and Yau [3] constructed foliations by constant mean curvature (or *CMC*-) surfaces in the asymptotic ends of asymptotically flat Riemannian manifolds. Their result has been generalized in many ways — to weaker decay assumptions, by including strong uniqueness statements, and to higher dimensions — by Eichmair, Huang, Metzger, Nerz, Ye, etc.

Their work inspired the study of other foliations in asymptotically Euclidean ends, most notably by constrained Willmore surfaces by Lamm–Metzger–Schulze and by constant null mean curvature surfaces in initial data sets in General Relativity by Metzger. With Sakovich [2], we suggest a new foliation by constant spacetime mean curvature (or *STCMC*-) surfaces, also in initial data sets. The STCMC-foliation allows to define the center of mass of an isolated relativistic system, and remedies a deficiency of previous definitions uncovered with Nerz [1].

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Montag, Beginn: 16:50 Uhr **Seminarraum: 2.059**

Stability of the positive mass theorem for asymptotically hyperbolic graphs

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The rigidity of the Riemannian positive mass theorem asserts that the ADM mass of an asymptotically flat manifold with non-negative scalar curvature equals zero if and only if the manifold is the Euclidean space. It is natural to ask if the ADM mass of a given manifold is close to zero, is the manifold close to the Euclidean space in some sense? Huang and Lee proved the stability (in the sense of currents) of the positive mass theorem for asymptotically flat graphs. We will describe how to use results of Dahl, Gicquaud and Sakovich to adapt Huang and Lee's ideas to obtain a stability result for positive mass theorem for asymptotically hyperbolic graphs.

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Montag, Beginn: 17:10 Uhr **Seminarraum: 2.059**

Stability of the positive mass theorem for axisymmetric manifolds

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We investigate the stability of the Positive Mass Theorem for three-dimensional axisymmetric manifolds. It is widely known that asymptotically flat manifolds with nonnegative scalar curvature have nonnegative ADM mass, and that the only asymptotically flat manifold with nonnegative scalar curvature and zero ADM mass is Euclidean space. We will show that axisymmetric manifolds with nonnegative scalar curvature and small ADM mass, and which satisfy an additional technical assumption, are close to Euclidean space in a Sobolev sense.

Differentialgleichungen und Anwendungen

Organisation: Dohnal, Rademacher, Uecker

Montag, Beginn: 15:30 Uhr **Seminarraum: 0.014**

Steering pattern formation of viscous flows

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Viscous liquid layers on hydrophobic surfaces are susceptible to hydrodynamic instabilities. These instabilities trigger a complex dynamics that evolves an initially flat layer into a characteristic pattern of stationary droplets. By representing the boundary with functions $u(t)$, one can recast the hydrodynamic free boundary problem as a gradient flow $\partial_t u = -\mathbb{K}(u)\mathrm{D}\mathcal{E}(u)$, where the operator $\mathbb{K}$ describes the friction/dissipation of the flow and $\mathcal{E}$ measures the interfacial area of the boundary. In practice, modifications of surface properties change the dissipation $\mathbb{K}$, which in turn switches between various observed droplet patterns. This mechanism is demonstrated using a finite dimensional example and then extended to a free boundary problem for a viscous fluid. Numerical simulations are used to show the impact of the metric induced by the dissipation. The presentation covers mathematical and numerical aspects of free boundary problems for viscous flows and highlights the underlying gradient flow structure. The focus is the intruiging interplay of bulk-interface properties encoded in $\mathbb{K}$ and $\mathcal{E}$.

References

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Montag, Beginn: 16:15 Uhr **Seminarraum: 0.014**

An obstacle problem for cell polarization

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We investigate a model for cell polarization where a diffusion equation in the inner cell is coupled to reaction diffusion equations on the cell membrane. In a certain scaling limit we rigorously derive a variational problem which allows to characterize the parameter regime for the onset of polarization.

Montag, Beginn: 16:40 Uhr **Seminarraum: 0.014**

Towards more general constitutive relations for metamaterials: a checklist to rule out inconsistent formulations

F. Z. Goffi[1,*], **K. Mnasri**[2], **M. Plum**[1], **C. Rockstuhl**[2]

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When the period of unit-cells constituting metamaterials is no longer much smaller than the wavelength, local homogenization material laws fail to properly describe the propagation of light within [1]. By introducing nonlocal material parameters, this insufficiency could be lifted [2]. We introduce a list of several formulations. Therefore, a check process was established, that allowed us to conclude which formulations are correct or not. We discuss the additional interface conditions and the reflection and transmission coefficients from a slab for the different formulations and compared those to the response of an actual structure by using the Fourier Modal Method (FMM) [3].

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Montag, Beginn: 17:05 Uhr **Seminarraum: 0.014**

Local and global well-posedness for dispersion generalized Benjamin-Ono equations on the circle

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The Cauchy problem for dispersion generalized Benjamin-Ono equations

$$\begin{cases} \partial_t u + \partial_x D_x^a u &= u\partial_x u \quad (t,x) \in \mathbb{R}\times\mathbb{T} \\ u(0) &= u_0 \in H^s_{\mathbb{R}}(\mathbb{T}) \end{cases}$$

is considered on the circle $\mathbb{T} = \mathbb{R}/(2\pi\mathbb{Z})$ for $1 < a < 2$, where $D_x = (-\Delta)^{1/2}$.
The family of equations relates the Benjamin-Ono and the Korteweg-de Vries equation. Previous works on the Cauchy problem include [1,2]. We prove new local well-posedness results for $1 < a < 2$ admitting globalization in $L^2(\mathbb{T})$ provided that $3/2 < a < 2$. The analysis is available at arXiv:1906.01956.

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Dienstag, Beginn: 10:00 Uhr **Seminarraum: 1.067**

A dynamical systems approach to outlier robust machine learning

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We consider a typical problem of machine learning – the reconstruction of probability distributions of observed spatially distributed data. We introduce the so-called gradient conjugate prior update and study the induced dynamical system. We will explain the dynamics of the parameters and show how one can use insights from the dynamical behavior to recover the ground truth distribution in a way that is robust against outliers. The developed approach carries over to artificial neural networks.

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Dienstag, Beginn: 10:45 Uhr **Seminarraum: 1.067**

Long-time asymptotics of solutions to the Keller–Rubinow model for Liesegang rings in the fast reaction limit

Marcel Oliver[1,*], **Zymantas Darbenas**[1], **Rein van der Hout**[2]

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We consider the Keller-Rubinow model for Liesegang precipitation patterns in one spatial dimension in the fast reaction limit as introduced by Hilhorst, van der Hout, Mimura, and Ohnishi (J. Stat. Phys., 2009). We conjecture that solutions to this model converge, independent of the initial concentration, to a universal profile for large times in parabolic similarity coordinates. The candidate limit profile is necessarily thes the solution of a certain one-dimensional boundary value problem which can be solved explicitly. Depending on the strength of the source, there are two nontrivial regimes. In the first, the *transitional regime*, precipitation is restricted to a bounded region in space and the concentration converges to a single unique profile. In the second, the *supercritical regime*, the concentration converges to one of a one-parameter family of asymptotic profiles, selected by a solvability condition for the one-dimensional boundary value problem. Here, our convergence result is only conditional: we prove that if convergence happens, either pointwise for the concentration or in an averaged sense for the precipitation function, then the other field converges likewise; convergence in concentration is uniform, and the asymptotic profile is indeed the profile selected by the solvability condition. We demonstrate numerically that the solution behaves indeed as suggested by the theorem.

Dienstag, Beginn: 11:10 Uhr **Seminarraum: 1.067**

Non-selfsimilar collapse of surface quasi-geostrophic point-vortices

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Point vortex models are presented for the surface quasi-geostrophic (SQG) equations, which are characterized by a fractional Laplacian relation between the active scalar and the streamfunction and for which the existence of finite-time singularities is still a matter of debate. Point vortex trajectories are expressed using Nambu dynamics. The formulation is based on a noncanonical bracket and allows for a geometrical interpretation of trajectories as intersections of level sets of the Hamiltonian and Casimir. Within this setting, we focus on the collapse of solutions for the three point vortex model. In particular, we show that for SQG the collapse can be either self-similar or nonself-similar. Self-similarity occurs only when the Hamiltonian is zero, while non-selfsimilarity appears for non-zero values of the same. For both cases, collapse is allowed for any choice of circulations within a permitted interval. These results differ strikingly from the classical point vortex model. Results may also shed a light on the formation of singularities in the SQG partial differential equations, where the singularity is thought to be reached only in a self-similar way.

References

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Dienstag, Beginn: 11:35 Uhr **Seminarraum: 1.067**

Stochastic Homogenization of PDE on non-uniformly Lipschitz and percolating structures

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One of the major challenges in stochastic homogenization is the interplay of partial differential equations and geometry. This particularly applies to the setting when the geometry locally exhibits arbitrary large Lipschitz constants or separates into several (i.e. more than one) percolation clusters. The best result so far is [1] and applies to uniformly Lipschitz and non-percolating geometries.

We provide a new approach to handle homogenization on a class of non-uniformly Lipschitz and percolating structures and apply it to convex functionals on perforated domains with percolating holes. Particular geometric examples we will consider are ball processes, such as the poisson ball process, and some stochastically disturbed periodic geometries.

References

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Dienstag, Beginn: 16:00 Uhr **Seminarraum: 0.014**

Homogenized models for the mechanical behavior of fibre-reinforced hydrogels

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Fibre-reinforced hydrogels (FIHs), composites of micro-fibre scaffolds and hydrogel, are a promising concept in tissue engineering that tries to mimic the natural composite structure of soft tissue. The filament spacing of the scaffold is usually in the range of μm while the overall size of an FIH is in the range of mm to cm. Due to this scale heterogeneity, the mechanical properties of FIHs are not yet fully understood and, as a consequence, there is an interest in investigating their effective properties.

In this talk, we consider highly heterogeneous two-component media composed of a connected fibre-scaffold with periodically distributed inclusions of hydrogel. While the fibres are assumed to be elastic, the hydromechanical response of hydrogel is modeled via *Biot's poroelasticity*. This leads to a coupled system of elliptic and parabolic equations.

We show that the resulting mathematical problem admits a unique weak solution and investigate the limit behavior of the solutions with respect to a scale parameter characterizing the heterogeneity of the medium. This is done in the context of the two-scale convergence method. In doing so, we arrive at an homogenized model.

Dienstag, Beginn: 16:25 Uhr **Seminarraum: 0.014**

Minimising the Helfrich Energy

Sascha Eichmann[1,*]

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The Helfrich Energy is defined as $\int_\Sigma |H - H_0|^2 \, dA$ for some 2-dimensional smooth oriented manifold $\Sigma \subset \mathbb{R}^3$ and $H_0 \in \mathbb{R}$ some parameter. Here H is the mean curvature of Σ, i.e. the sum of the principal curvatures (see [3] for the original definition and some applications in biology). We will minimise the Helfrich energy under some constraints, for example prescribing Dirichlet boundary data. Compactness is easily achieved in the class of oriented varifolds.
Unfortunately by a counterexample of Große-Brauckmann (see [2]) the Helfrich Energy is in general not lower-semicontinuous with respect to varifold convergence. We are able to circumvent this problem by showing a lower-semicontinuity estimate for the minimising sequence itself (see [1]). This allows us to show some existence results of minimisers in the above mentioned classes.

References

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Dienstag, Beginn: 16:50 Uhr **Seminarraum: 0.014**

Differential equations on infinite-dimensional Lie groups

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Differential equations on non-normable locally convex spaces (or manifolds modelled on such) can be quite pathological: Examples of initial value problems without solutions are well-known, as well as examples of initial value problems with multiple solutions. The situation improves when only time-dependent, *left-invariant* vector fields are considered on a Lie group G modelled on a locally convex topological vector space E. Then solutions to initial value problems are always unique. Moreover, solutions exist for all classes of examples considered so far (when E is sufficiently complete), and depend smoothly on parameters. In technical terms, such Lie groups are *regular* in the sense of John Milnor. In the talk, I shall report on recent results concerning regularity properties of infinite-dimensional Lie groups, and their applications. Differential equations on G-manifolds given by time-dependent fundamental vector fields will also be discussed.

Dienstag, Beginn: 17:15 Uhr **Seminarraum: 0.014**

An existence result for a class of electrothermal drift-diffusion models with Gauss–Fermi statistics for organic semiconductors

Annegret Glitzky[1], **Matthias Liero**[1], **Grigor Nika**[1,*]

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This work is concerned with the analysis of a drift-diffusion model for the electrothermal behavior of organic semiconductor devices. A "generalized Van Roosbroeck" system coupled to the heat equation is employed, where the former consists of continuity equations for electrons and holes and a Poisson equation for the electrostatic potential, and the latter features source terms containing Joule heat contributions and recombination heat. Special features of organic semiconductors like Gauss–Fermi statistics and mobilities functions depending on the electric field strength are taken into account. We prove the existence of solutions for the stationary problem by an iteration scheme and Schauder's fixed point theorem. The underlying solution concept is related to weak solutions of the Van Roosbroeck system and entropy solutions of the heat equation. Additionally, for data compatible with thermodynamic equilibrium, the uniqueness of the solution is verified. It was recently shown that self-heating significantly influences the electronic properties of organic semiconductor devices. Therefore, modeling the coupled electric and thermal responses of organic semiconductors is essential for predicting the effects of temperature on the overall behavior of the device. This work puts the electrothermal drift-diffusion model for organic semiconductors on a sound analytical basis.

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 1.067**

Standing and moving breather solutions for a quasilinear wave equation

Wolfgang Reichel[1,*], **Gabriele Bruell**[1], **Simon Kohler**[1]

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For the quasilinear wave equation

$$g(x)\partial_t^2 u - \Delta u + \Gamma(x)\partial_t((\partial_t u)^3) = 0$$

with $(x,t) \in \mathbb{R}^{n+1}$ we are proving the existence of standing ($n = 1$) and moving ($n = 2$) breather solutions, i.e., solutions which are localized in space and periodic in time.

Under appropriate conditions on g and Γ we examine standing breathers via variational methods and moving breathers via bifurcation theory. Some of our analytical results are complemented by numerical simulations.

Mittwoch, Beginn: 10:45 Uhr **Seminarraum: 1.067**

Scattering in periodic waveguide: integral representation and spectrum decomposition

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We consider scattering problems in a periodic waveguide $\Omega = \mathbb{R} \times [0,1]$. The problem is formulated by the following equations:

$$\Delta u + k^2 q u = f \quad \text{in } \Omega; \quad \frac{\partial u}{\partial x_2} = 0 \quad \text{on } \partial\Omega; \tag{1}$$

where q is periodic and f is compactly supported. Due to the existence of eigenvalues, the problem is not always uniquely solvable in $H^1(\Omega)$. To this end, the *Limiting Absorption Principle (LAP)* is adopted. Based on the Floquet-Bloch transform, we obtain a contour integral representation for the solution from LAP, and also decompose the solution with generalized eigenfunctions. An efficient numerical method is also developed based on that.

References

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Mittwoch, Beginn: 11:10 Uhr **Seminarraum: 1.067**

Unexpected behaviour of fundamental solutions of general higher-order elliptic operators

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The positivity preserving property for second-order elliptic equations ($Lu = f \geq 0 \Rightarrow u \geq 0\,?$) is a well-known consequence of the maximum principle. In the higher-order setting such expected behaviour is often spoiled by the influence of the boundary conditions, and in general the answer is negative. However, one still expects that when applying an extremely concentrated right-hand side − a δ-distribution − then close to this point the solution should respond in the same direction. Such *local question* can be rewritten in terms of positivity of a suitable singular fundamental solution near to its pole, and it is known for the polyharmonic operator $(-\Delta)^m$, or - more in general - for powers of second-order operators, see [1]. In the work [2], we show that such results cannot be in general extended for any elliptic higher-order operator. Indeed, by means of explicit formulae for the singular fundamental solutions, we prove that positivity near the unbounded singularity persists only in special dimensions, while in general the behaviour is sign-changing.

References

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Mittwoch, Beginn: 11:35 Uhr **Seminarraum: 1.067**

A computer-assisted existence and multiplicity proof for travelling waves in a nonlinearly supported beam

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For a nonlinear beam equation with exponential nonlinearity, we prove existence of at least 36 travelling wave solutions for the specific wave speed $c = 1.3$. This complements known existence results of *one* solution for *varying* c [1,2,3]. Our proof makes heavy use of computer assistance: Starting from numerical approximations, we use a fixed point argument to prove existence of solutions "close to" the computed approximations.

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Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 0.014**

Nonlocal Solitary Traveling Waves in Diatomic FPUT Lattices under the Equal Mass Limit

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The diatomic Fermi-Pasta-Ulam-Tsingou (FPUT) lattice is an infinite chain of alternating particles connected by identical nonlinear springs. We prove the existence of nonlocal (or generalized) solitary traveling waves in the diatomic FPUT lattice in the limit as the ratio of the two alternating masses approaches 1, at which point the diatomic lattice reduces to the well-understood monatomic FPUT lattice. These are traveling waves whose profiles asymptote to a small periodic oscillation at infinity, instead of vanishing like the classical solitary wave. Unlike the related long wave and small mass limits for diatomic FPUT traveling waves, this equal mass problem is not singularly perturbed, and so the amplitude of the oscillation is not small beyond all orders. The central challenge of this problem hinges on a hidden solvability condition in the traveling wave equations, which manifests itself in the existence and fine properties of asymptotically sinusoidal solutions to an auxiliary advance-delay differential equation.

Mittwoch, Beginn: 15:55 Uhr **Seminarraum: 0.014**

Curved traveling fronts on a lattice

Mia Jukić[1,*], **Hermen Jan Hupkes**[2]

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We study dynamical systems posed on planar lattices. Throughout the talk we will explore the impact that the spatial topology of the lattice has on the dynamical behaviour of solutions. More specifically, we are interested in the behavior of deformed planar waves which arise as solutions to the Nagumo LDE. In contrast to previous work, the initial perturbation from the flat planar wave need only be bounded. We will make a connection between the evolution of the interface region and the solution of a discrete mean curvature flow with a drift term.

References

[1] H. Matano and M. Nara, Large time behavior of disturbed planar fronts in the Allen–Cahn equation, *Journal of Differential Equations* 251 (2011), pp. 3522-3557

[2] J. Mallet-Paret, The Global Structure of Traveling Waves in Spatially Discrete Dynamical Systems, *Journal of Dynamics and Differential Equations* 11 (1999)

Mittwoch, Beginn: 16:20 Uhr **Seminarraum: 0.014**

Floer theory for Hamiltonian PDE and the small divisor problem

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Hamiltonian Floer theory is the most important tool to prove the existence of periodic solutions of finite-dimensional Hamiltonian systems. In my talk I show how Hamiltonian Floer theory can be generalized to infinite dimensions in order to prove the existence of time-periodic solutions of important nonlinear PDEs like the nonlinear wave equation or the nonlinear Schrödinger equation. Apart from generalizing the tools from minimal surface theory to the infinite-dimensional setting, the main challenge is to deal with the newly arising small divisor problem. As main result we prove the existence of forced time- and space-periodic solutions for almost all time and space periods in the case when the nonlinearity is sufficiently regularizing.

References

[1] O. Fabert, Hamiltonian Floer theory for nonlinear Schrödinger equations and the small divisor problem, ArXiv preprint 1904.08830, 2019.

Mittwoch, Beginn: 16:45 Uhr **Seminarraum: 0.014**

Orbital stability investigation for travelling waves in a nonlinearly supported beam

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We consider the fourth-order wave equation $\varphi_{tt} + \varphi_{xxxx} + f(\varphi) = 0,\ (x,t) \in \mathbb{R} \times \mathbb{R}$ with a nonlinearity f vanishing at 0. Traveling waves $\varphi(x,t) = u(x-ct)$ satisfy the ODE $u'''' + c^2 u'' + f(u) = 0$ on $\mathbb{R}$, and for the case $f(u) = e^u - 1$, the existence of at least 36 solitary travelling waves was proved in [1] by computer assisted means.

We investigate the orbital stability of these solutions via computation of their Morse indices and using results from [2] and [3]. In order to achieve our results we make use of both analytical and computer-assisted techniques.

References

[1] B. Breuer, J. Horák, P. J. McKenna, M. Plum, A computer-assisted existence and multiplicity proof for travelling waves in a nonlinearly supported beam, *Journal of Differential Equations* **224** (2006), pp. 60–97.

[2] M. Grillakis, J. Shatah and W. Strauss, Stability Theory of Solitary Waves in the Presence of Symmetry, I *Journal of Functional Analysis* **74** (1987), pp. 160-197.

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Donnerstag, Beginn: 10:00 Uhr **Seminarraum: 1.067**

Birth of discrete Lorenz attractors in global bifurcations

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Discrete Lorenz attractors are chaotic attractors, which are the discrete-time analogues of the well-known continuous-time Lorenz attractors. They are genuine strange attractors, i.e. they do not contain simpler regular attractors such as stable equilibria, periodic orbits etc. In addition, this property is preserved under small perturbations. Thus, Lorenz attractors, discrete and continuous, represent the so-called robust chaos.

In the talk a list of global (homoclinic and heteroclinic) bifurcations (see [1, 2] and others) is presented, in which it was possible to prove the appearance of discrete Lorenz attractors. The proof is based on the study of first return (Poincare) maps [3, 4], which have a form of a three-dimensional Henon-like map.

References

[1] S. Gonchenko, I. Ovsyannikov, On global bifurcations of three-dimensional diffeomorphisms leading to Lorenz-like attractors, *Math. Model. Nat. Phenom.* **8** (2013), pp. 71–83.

[2] S. Gonchenko, I. Ovsyannikov, J. Tatjer, Birth of discrete Lorenz attractors at the bifurcations of 3D maps with homoclinic tangencies to saddle points, *Regul. Chaotic Dyn.* **19** (2014), pp. 495–505.

[3] S. Gonchenko, A. Gonchenko, I. Ovsyannikov, D. Turaev, Examples of Lorenz-like attractors in Hénon-like maps, *Math. Model. Nat. Phenom.* **8** (2013), pp. 32–54.

[4] I. Ovsyannikov, D. Turaev, Analytic proof of the existence of the Lorenz attractor in the extended Lorenz model, *Nonlinearity* **30** (2017), pp. 115–137.

Donnerstag, Beginn: 10:25 Uhr **Seminarraum: 1.067**

A proof of multistability in a phosphorylation cycle

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Phosphorylation networks are chemical reaction networks which are used to propagate signals in living cells. An important example is the multiple futile cycle, which can be modelled using a system of $3n + 3$ ordinary differential equations in the case that there are n phosphorylation sites. Central mathematical questions about this system, which are also of biological importance, are the following. How many steady states exist and how many of them are stable? A lower bound for the number of steady states which can occur was proved by Wang and Sontag but no rigorous results were available about their stability. We have proved a lower bound for the number of stable steady states which grows linearly with n. The proofs involve slow-fast systems and intricate centre manifold calculations.

References

[1] L. Wang and E. D. Sontag, On the number of steady states in a multiple futile cycle, *Journal of Mathematical Biology* **57** (2008), pp. 29—52.

[2] E. Feliu, A. D. Rendall and C. Wiuf, A proof of unlimited multistability for phosphorylation cycles, *Preprint* arXiv:190403983.

Donnerstag, Beginn: 10:50 Uhr **Seminarraum: 1.067**

Dynamics of the Selkov oscillator

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The Selkov oscillator is a simple mathematical model, a system of two ordinary differential equations, describing the metabolic pathway of glycolysis. Glycolysis is a central part of the energy metabolism that almost all living organisms have in common. Selkov's model was one of the first to mathematically describe the autonomous oscillations observed in experiments under constant substrate supply. To complete the analysis of the system and be able to identify all possible phase portraits, we studied the long term behavior of the solutions via a Poincaré compactification. The model obeys the expectations on a biological oscillator insofar as if there exists a periodic solution it is stable. In addition if the unique steady state is stable all bounded solutions eventually converge to it. At the same time it is the case that irrespective of the choice of parameters there are always solutions tending to a point at infinity. Furthermore it turns out that if the phase portrait does not correspond to one of those above then all solutions except the steady state either tend to a point at infinity or oscillate in a way that every variable takes on arbitrarily large and small values.

Donnerstag, Beginn: 11:15 Uhr **Seminarraum: 1.067**

The minimal model of Hahn for the Calvin cycle

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There are many models of the Calvin cycle in the literature. Due to their big sizes, models were mostly numerically investigated or using reduction techniques. We investigate a simple two dimensional model of the Calvin cycle in favor of getting the most detailed insights. In a variant of the model not including photorespiration, it is shown that there exists exactly one positive solution which is unstable. For generic initial data, concentrations tend to infinity and were later tracked using Poincaré compactification. When photorespiration is included and for a suitable choice of parameters, bistability is proved. For generic initial data either the solution tends to the stable steady state at late times or all concentrations tend to zero at late times. Rigorous mathematical proofs emphasize the idea that photorespiration stabilizes the operation of the Calvin cycle, although at the price of reducing the efficiency of the carboxylation reaction. This would suggest another considering of photorespiration not as a wasteful competitive process to carboxylation, but as stabilizer which prevents overproduction in the cycle.

Donnerstag, Beginn: 15:30 Uhr **Seminarraum: 1.067**

Calderón Projector and Dirichlet-Neumann Operator for Fibred Cusp Operators

Karsten Fritzsch[1,*], **Daniel Grieser**[2], **Elmar Schrohe**[1]

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In recent years, there has been great interest in the plasmonic eigenvalue problem on singular spaces. This is a two-sided boundary value problem that describes the coupling of electromagnetic fields to the electron gas of a conducting body, given by the geometry. The interest comes from the fact that the geometry can be used to specifically tailor properties of the resulting surface waves and hence electromagnetic properties of the body. As the plasmonic eigenvalue problem is directly linked to the interior and exterior Dirichlet-to-Neumann maps, which in turn can be described using the Calderón projectors, it is useful to construct and study Calderón projectors for interesting pairs of operators and geometries.

One such interesting geometry can be described by ϕ-manifolds with boundary. For instance, given two touching spheres, a quasi-homogeneous blow-up of the point of tangency will give rise to a further, singular boundary hypersurface of the exterior domain. This singular face comes equipped with a fibration onto a manifold with boundary, resembling the situation of Mazzeo & Melrose's ϕ-calculus, but with additional, regular boundary hypersurfaces.

Seeing the regular faces as carriers of boundary conditions, I will present the construction of the Calderón projector for the Laplacian of a ϕ-metric on a general ϕ-manifold with boundary and derive some of its key properties. In particular, I will show that the Calderón projector is a ϕ-pseudodifferential operator and identify its ϕ-principal symbol and normal family. If time permits, I will also talk about the resulting properties of the Dirichlet-to-Neumann map.

Donnerstag, Beginn: 15:55 Uhr **Seminarraum: 1.067**

Large-time behaviour of solutions of parabolic equations on the real line with convergent initial data

Antoine Pauthier[1,*], **Peter Poláčik**[1]

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We consider the following semilinear parabolic equation

$$\partial_t u = \partial_{xx} u + f(u) \tag{1}$$

where f is a Lipschitz function, with a bounded initial condition. If the solution $u(\cdot, t)$ is bounded, then it is a classical solution, defined for all $t \geq 0$, and it is well known that the set of all limit profiles $\omega(u) := \{\varphi \in L^\infty(\mathbb{R}),\ u(t_n, \cdot) \to \varphi \text{ in } L^\infty_{loc}(\mathbb{R}),\ \text{for some sequence } t_n \to \infty\}$ is non-empty and connected. One can wonder to what extend these limit profiles, and therefore the long-time behaviour of solutions, is determined by the stationary equation. If the solution is convergent, for instance, the $\omega-$limit set is reduced to a single element, stationary solution of the equation. Convergence is of course not the general behaviour for such an equation, but we can expect that all the limit profiles $\varphi \in \omega(u)$ are steady states for the initial equation. The solution is then said to be *quasiconvergent.*

In this talk, I will present some general quasiconvergence results when the initial condition admits finite limits at $x = \pm\infty$. In particular, in the generic situation $u_0(-\infty) \neq u_0(+\infty)$, any bounded solution is quasiconvergent, independently of the nonlinear term f. In a second part, we focus on the situation where the limits are equal, $u_0(-\infty) = u_0(+\infty)$. A similar result is impossible, due to known counter-examples. Assuming further non-degeneracy assumtions, we prove that these counter-examples are the only situations where quasiconvergence may fail to happen.

Donnerstag, Beginn: 16:20 Uhr **Seminarraum: 1.067**

The Limiting Absorption Principle for periodic Schrödinger operators

Rainer Mandel[1,*]

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We present a new Limiting Absorption Principle for Schrödinger operators $-\Delta+V(x)$ with periodic potentials $V \in L^\infty(\mathbb{R}^n)$. We will sketch its proof which is based on Floquet-Bloch theory and a careful analysis of oscillatory integrals over the associated Fermi surfaces (or isoenergetic surfaces). Applications to nonlinear Helmholtz equations will be provided.

References

[1] R. Mandel, The Limiting Absorption Principle for Periodic Differential Operators and Applications to Nonlinear Helmholtz Equations", *Commun. Math. Phys.* **368** (2019), no. 2, pp. 799–842.

Donnerstag, Beginn: 16:45 Uhr **Seminarraum: 1.067**

Bifurcations of a cubic Helmholtz system

Dominic Scheider[1,*], **Rainer Mandel**[1]

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In this talk I will present an existence result for localized vector solutions of the cubic Helmholtz system

$$\begin{aligned} -\Delta u - \mu u &= u^3 + buv^2 \qquad \text{in } \mathbb{R}^3, \\ -\Delta v - \nu u &= v^3 + bvu^2 \qquad \text{in } \mathbb{R}^3 \end{aligned}$$

for given $\mu, \nu > 0$ and a coupling parameter $b \in \mathbb{R}$. It is obtained using bifurcation from a simple eigenvalue and by analyzing the asymptotic behavior of the solutions in the far field, i.e. the leading order of the asymptotic expansion of $u(x), v(x)$ as $|x| \to \infty$.

I will then show how these methods can be applied to construct solutions of the cubic Klein-Gordon equation

$$\partial_t^2 U(t,x) - \Delta U(t,x) + m^2 U(t,x) = U(t,x)^3, \qquad (t,x) \in \mathbb{R} \times \mathbb{R}^3.$$

The talk is based on joint work with R. Mandel. For the first part, see [1]. It is supported by the German Research Foundation (DFG) through CRC 1173 "Wave phenomena: analysis and numerics".

References

[1] R. Mandel, D. Scheider: Bifurcations of nontrivial solutions of a cubic Helmholtz system, *Preprint*, https://arxiv.org/abs/1710.06332, accepted for publication in ANONA.

Diskrete Mathematik

Organisation: Joos

Donnerstag, Beginn: 10:00 Uhr **Seminarraum: 2.059**

Recent advances in graph and hypergraph decompositions

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In 1853, Steiner asked for which natural numbers $n > k > r$ exists a collection S of k-subsets of $\{1, \dots, n\}$ such that every r-subset of $\{1, \dots, n\}$ is contained in precisely one element of S. These 'Steiner systems' have applications in many areas of mathematics.

Despite extensive research, Steiner's question remained unanswered for more than 150 years. Recently, a blend of probabilistic, algebraic and combinatorial techniques led to the resolution of this problem (for large enough n) in the more general setting of hypergraph decompositions [4,2,3,5] (a Steiner system is equivalent to a clique decomposition of a complete uniform hypergraph). The developed techniques have also led to progress towards other decomposition problems, e.g. the resolution of the Oberwolfach problem from 1967 [1].

This talk will provide an overview over recent advances in this area, highlighting the use of probabilistic techniques and the central role of the absorbing method.

References

[1] S. Glock, F. Joos, J. Kim, D. Kühn, and D. Osthus, *Resolution of the Oberwolfach problem*, arXiv:1806.04644.

[2] S. Glock, D. Kühn, A. Lo, and D. Osthus, *The existence of designs via iterative absorption*, arXiv:1611.06827.

[3] S. Glock, D. Kühn, A. Lo, and D. Osthus, *Hypergraph F-designs for arbitrary F*, arXiv:1706.01800.

[4] P. Keevash, *The existence of designs*, arXiv:1401.3665.

[5] P. Keevash, *The existence of designs II*, arXiv:1802.05900.

Donnerstag, Beginn: 10:40 Uhr **Seminarraum: 2.059**

Berge hypergraphs - saturation and Ramsey properties

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For a graph G, a hypergraph H is called Berge-G if for some isomorphic copy G' of G and a bijection f from the edge set $E(G')$ to the hyperedge set $E(H)$, for each $e \in E(G')$, we have $e \subseteq f(e)$. A hypergraph F is Berge-G saturated if it does not contain a Berge-G subhypergraph but adding any new hyperedge of size at least two to F results in such a subhypergraph. Any Berge-G saturated hypergraph has at least $|E(G)| - 1$ hyperedges. We show that there are saturated Berge-G hypergraphs of size exactly $|E(G)| - 1$ for all but a few graphs G. Further, we show that Berge-G hypergraphs posess nice Ramsey properties - their monochromatic copies are unavoidable in edge-colored complete hypergraphs. In particular, we determine the multicolor Ramsey number for Berge triangle asymptotically.

Donnerstag, Beginn: 11:00 Uhr **Seminarraum: 2.059**

Characterising k-connected sets in infinite graphs

J. Pascal Gollin[1], **Karl Heuer**[2,*]

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While the connectivity of a graph is a global invariant, even graphs of low connectivity might contain objects that are highly connected in a certain way. One such type of highly connected objects are k-connected sets:

Given a graph G we define a *k-connected set*, where $k > 0$ is an integer, to be a vertex set $X \subseteq V(G)$ such that any two of its subsets of the same size $\ell \leq k$ can be connected by ℓ disjoint paths in G.

For finite graphs the existence of k-connected sets has already been characterised in terms of unavoidable minors and via certain tree-decompositions, but for infinite graphs similar characterisations were not completely known. In this talk I will discuss our results [1] and the involved proof ideas. This includes a characterisation for the existence of k-connected sets of arbitrary but fixed infinite cardinality via the existence of certain minors and topological minors. In particular, I will address the difficulties occurring when dealing with singular instead of regular infinite cardinals. Moreover, we proved a duality theorem for the existence of such k-connected sets: if a graph contains no such k-connected set, then it has a tree structure which, whenever it exists, precludes the existence of such a k-connected set.

References

[1] J.P. Gollin and K. Heuer, Characterising k-connected sets in infinite graphs, preprint (2018), https://arxiv.org/abs/1811.06411.

Donnerstag, Beginn: 11:20 Uhr **Seminarraum: 2.059**

Forcing Hamiltonicity for locally finite claw-free graphs via forbidden induced subgraphs

Karl Heuer[1], **Deniz Sarikaya**[2,*]

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Hamiltonicity is a central theme of finite graph theory, which has been transferred to infinite graphs. Following the topological approach of Diestel and Kühn [2,3] we define infinite cycles of a locally finite connected graph G via its Freudenthal compactification $|G|$: A homeomorphic image of the unit circle $S^1 \subseteq \mathbb{R}^2$ in $|G|$ is called an *infinite cycle of G*. Analogously to finite graphs, we call G *Hamiltonian* if there exists an infinite cycle of G containing all vertices of G.

We examine how to force Hamiltonicity via forbidden induced subgraphs and present recent extentions of results for Hamiltonicity in finite claw-free graphs [1,4,5] to locally finite ones.

References

[1] H. Broersma and H.J. Veldman, Restrictions on induced subgraphs ensuring Hamiltonicity or pancyclicity of $K_{1,3}$-free graphs. in *Contemporary methods in graph theory* (1990), pp. 181–194.

[2] R. Diestel and D. Kühn, On infinite cycles I, *Combinatorica* **24** (2004), pp. 69–89.

[3] R. Diestel and D. Kühn, On infinite cycles II, *Combinatorica* **24** (2004), pp. 91–116.

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Donnerstag, Beginn: 11:40 Uhr **Seminarraum: 2.059**

Planar Graphs have Bounded Queue Number

Vida Dujmović[1], **Gwenaël Joret**[2], **Piotr Micek**[3], **Pat Morin**[4], **Torsten Ueckerdt**[5,*], **David Wood**[6]

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We show that planar graphs have bounded queue number, thus proving a conjecture of Heath, Leighton and Rosenberg from 1992. The key to the proof is a new structural tool called layered partitions, and the result that every planar graph has a vertex-partition and a layering, such that each part has a bounded number of vertices in each layer, and the quotient graph has bounded treewidth. This result generalizes for graphs of bounded Euler genus. Building on this work and using the graph minor structure theorem, we prove that every proper minor-closed class of graphs has bounded queue number.

Donnerstag, Beginn: 15:30 Uhr **Seminarraum: 2.059**

d-layer Networks of Cubes

Walter Wenzel[1,*]

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We investigate universal approximation properties of multi-layered binary neural networks. This leads – in cooperation with Nihat Ay – to separate arbitrary vertex classes in n-cubes, thereby continuing a former paper by both of us, together with Frank Pasemann, where we devoted ourselves to the particular case of only one hidden layer.

Donnerstag, Beginn: 15:50 Uhr **Seminarraum: 2.059**

Edge-Unfolding Nearly Flat Prismatoids

Manuel Radons[1,*]

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A 3-Prismatoid P is the convex hull of two convex polygons A, B which lie in parallel planes $H, H' \subset \mathbb{R}^3$, respectively. Let A' be the orthogonal projection of A onto H'. Extending techniques introduced by Joseph O'Rourke [1], we show that P can be edge-unfolded if the boundaries of A' and B intersect in at most two points and P is sufficiently flat, that is, if the distance between H and H' is sufficiently small. Both conditions can be relaxed by imposing structural constraints on A and B.

References

[1] J. O'Rourke, Edge-Unfolding Nearly Flat Convex Caps, *34th International Symposium on Computational Geometry (SoCG 2018)*, pp. 64:1–64:14.

Donnerstag, Beginn: 16:10 Uhr **Seminarraum: 2.059**

The Schläfli Fan

Michael Joswig[1], **Marta Panizzut**[1,*], **Bernd Sturmfels**[2]

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In 1849, Arthur Cayley and George Salmon proved one of the most famous results in algebraic geometry: every smooth cubic surface contains exactly 27 lines. In tropical geometry algebraic surfaces are replaced with polyhedral complexes of dimension two. Since early development of this recent mathematical field, two natural problems were to understand whether the aforementioned statement holds for smooth tropical cubic surfaces and to classify combinatorial positions of their tropical lines. The answer to the first turned out to be false, as tropical surfaces might contain families of tropical lines. Moreover, classifying positions of tropical lines reveals computational challenges due to the massive number of combinatorial types of smooth tropical cubic surfaces. The latter are parametrized by 14 373 645 symmetry classes of maximal cones in the unimodular secondary fan of the triple tetrahedron.

In this talk, after introducing tropical surfaces and their lines, we will look at the Schläfli fan which gives a further refinement of these cones. It reveals all possible patterns of the 27 or more lines on tropical cubic surfaces, thus serving as a combinatorial base space for the universal Fano variety.

Donnerstag, Beginn: 16:30 Uhr **Seminarraum: 2.059**

On the structure of graphs without forbidden induced subgraphs

Lea Weber[1]

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The Erdős-Hajnal conjecture is one of the most challenging open conjectures in graph theory, which is a sub-branch of discrete mathematics. The conjecture asks if for every graph H there exists a constant ϵ, such that every graph on n vertices that does not contain H as an induced subgraph contains either a clique or an independent set of size n^{ϵ}. If such an ϵ exists for a graph H, one can also ask for the 'best' such exponent and define $\epsilon(H)$ as the supremum over all $\epsilon > 0$ for which the conjecture holds.

A bipartite version of the conjecture asks if for every bipartite graph H there exists a constant $\widetilde{\epsilon}(H)$, such that every bipartite graph G with n vertices in each part which does not contain H as an induced subgraph has a complete/empty bipartite subgraph, with parts of size $n^{\widetilde{\epsilon}(H)}$. This version of the conjecture is known to be true, but one can again ask about the 'best' $\widetilde{\epsilon}(H)$ for given bipartite H, which has not been addressed before. We determine values for $\widetilde{\epsilon}(H)$ for some small graphs H. We also answer the question for which forbidden graphs H $\widetilde{\epsilon}(H)$ is linear in n, except for 4 graphs.

References

[1] P. Erdős, A. Hajnal and J. Pach, A Ramsey-type theorem for bipartite graphs, *Geombinatorics* 10 (2000), pp. 64–68.

[2] P. Erdős and A. Hajnal, Ramsey-type theorems, *Discrete Applied Mathematics* **25:1-2** (1989), pp. 37–52.

Donnerstag, Beginn: 16:50 Uhr **Seminarraum: 2.059**

Highly linked tournaments with large minimum out-degree

Richard Snyder[1,*], **António Girão**[2], **Kamil Popielarz**

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Given a positive integer k, a directed graph is said to be *k-linked* if for any two disjoint sets of vertices $\{x_1, \dots, x_k\}$ and $\{y_1, \dots, y_k\}$ there are vertex disjoint directed paths $P_1, \dots, P_k$ such that P_i joins x_i to y_i for $i = 1, \dots, k$. Clearly, k-linkedness is a stronger notion than the usual notion of strong k-connectivity. But how much stronger is it? Thomassen constructed directed graphs with arbitrarily large connectivity that are not even 2-linked. It is natural, therefore, to address this question in the restricted setting of tournaments. Resolving a conjecture of Kühn, Lapinskas, Osthus, and Patel, Pokrovskiy showed that any $452k$-strongly-connected tournament is k-linked. He further conjectured, in analogy with the situation for undirected graphs, that there is a function $f : \mathbb{N} \to \mathbb{N}$ such that any $2k$-strongly-connected tournament with minimum in and out-degree at least $f(k)$ is k-linked. In this talk, I shall present some recent progress made on this conjecture.

Funktionalanalysis, Reelle, Komplexe Analysis

Organisation: Weidl, Wirth

Donnerstag, Beginn: 10:00 Uhr **Seminarraum: 2.066**

Biharmonic wave maps

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Biharmonic wave maps are functions $u : \mathbb{R}^n \times [0,T) \to M$ for a smooth and compact Riemannian manifold M such that the image of the plate operator $\partial_t^2 u + \Delta^2 u$ is normal to M at $u(x,t)$. We show the local wellposedness this system in Sobolev spaces of sufficiently high order and a blow-up criterion in the sup-norm of the gradient of the solutions. In contrast to the well studied (second-order) wave maps system, we use a vanishing viscosity argument and an appropriate parabolic regularization in order to obtain the existence result. Our arguments heavily employ the geometric nature of the problem.

If M is a sphere, we construct global weak solutions by means of a Ginzburg-Landau type approximation. The proof relies on a reformulation of the system as a conservation law.

The talk is based on two joint papers with Sebastian Herr (Bielefeld), Tobias Lamm (Karlsruhe) and Tobias Schmid (Karlsruhe).

Donnerstag, Beginn: 10:30 Uhr **Seminarraum: 2.066**

On the Łojasiewicz-Simon gradient inequality on submanifolds

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Since the pioneering work of L. Simon, the Łojasiewicz-Simon gradient inequality has been widely used as a powerful tool to analyze convergence properties of gradient flows.

The inequality was first proven for analytic functions in $\mathbb{R}^d$ in [2] and extended to analytic functions on a Banach space in [3]. Very general sufficient conditions for the inequality to hold are presented in [1].

We extend the results of [1] to energies on certain submanifolds of Banach spaces. Our results apply to study convergence properties of a class of parabolic evolution equations with (nonlinear) constraints.

References

[1] R. Chill, On the Łojasiewicz-Simon gradient inequality, *J. Funct. Anal.* **201** (2003), no. 2, pp. 572 – 601.

[2] S. Łojasiewicz, Une propriété topologique des sous-ensembles analytiques réels, *Les Équations aux Dérivées Partielles* (1963), pp. 87 – 89, CNRS, Paris.

[3] L. Simon, Asymptotics for a class of nonlinear evolution equations, with applications to geometric problems, *Ann. of Math. (2)* **118** (1983), no. 3, pp. 525 – 571.

Donnerstag, Beginn: 11:00 Uhr **Seminarraum: 2.066**

On the eigenvalues of the Robin Laplacian with a complex parameter

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We study the spectrum of the Robin Laplacian $-\Delta_\Omega^\alpha$ with a complex parameter α on a bounded Lipschitz domain $\Omega \subset \mathbb{R}^d$. We establish a number of properties, in particular regarding the analytic dependence of eigenvalues and eigenspaces on $\alpha \in \mathbb{C}$ as well as basis properties of the eigenfunctions. Using estimates on the numerical range of the associated operator we give bounds and asymptotics for the eigenvalues as functions of α, which lead to new eigenvalue bounds even in the self-adjoint case $\alpha \in \mathbb{R}$. For the asymptotics of the eigenvalues as $\alpha \to \infty$, in place of the variational min-max characterisation of the eigenvalues and Dirichlet-Neumann bracketing techniques commonly used in the self-adjoint case, we exploit the duality between the eigenvalues of the Robin Laplacian and the eigenvalues of the Dirichlet-to-Neumann map to show that every Robin eigenvalue either diverges to ∞ in $\mathbb{C}$ or converges to a point in the Dirichlet spectrum.

Donnerstag, Beginn: 11:30 Uhr **Seminarraum: 2.066**

Potential approximation of the one-dimensional Bose gas with contact interactions

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In this talk a Bose gas with δ-interactions in one space dimension is considered. We prove that the Hamiltonian of this system, which is defined by a closed semi-bounded quadratic form, naturally arises as a resolvent limit $\varepsilon \downarrow 0$ of Schrödinger operators H_ε, where the corresponding two-body potentials scale like a Dirac sequence in $\varepsilon > 0$. Moreover, we estimate the rate of norm convergence of the resolvents depending on the decay of the potential at infinity. Our results extend previous results (see [1]), concerning the three-body case, to the case of an arbitrary number of bosons $N \in \mathbb{N}$.

References

[1] G. Basti, C. Cacciapuoti, D. Finco, A. Teta. The three-body problem in dimension one: From short-range to contact interactions. *J. Math. Phys.* **59**, 072104 (2018).

Donnerstag, Beginn: 15:30 Uhr **Seminarraum: 0.019**

Variational methods for an elliptic singular SPDE describing the magnetization ripple

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The magnetization ripple is a microstructure formed by the magnetization in a thin-film ferromagnet due to the random orientation of the grains in the polycrystalline material.

In an approximation of the micromagnetic model the ripple can be described by a strongly anisotropic elliptic PDE driven by white noise in two dimensions. However, the noise is too rough to make sense of the nonlinearities appearing in the equation.

We develop a global well-posedness theory for this singular SPDE based on a renormalization of the corresponding energy functional, and prove optimal regularity results for minimizers of the renormalized energy. More precisely, we show that the renormalized energy functional can be obtained as a Γ–limit from regularizing the noise, independent of the regularization.

This complements the well-posedness theory for small data which was developed in [1], based on a renormalization of the ill-defined nonlinear terms à la Da Prato–Debussche.

References

[1] R. Ignat and F. Otto, The magnetization ripple: A nonlocal stochastic PDE perspective, *J. Math, Pures Appl. (2019)*, https://doi.org/10.1016/j.matpur.2019.01.010.

Donnerstag, Beginn: 16:00 Uhr **Seminarraum: 0.019**

On the virtual level of N-body Schrödinger operators

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In this talk we study the behaviour of the resonance functions of the Schrödinger operator

$$H = -\Delta + V$$

in the case of a virtual level at the threshold of the essential spectrum. Based on an Agmon-type argument a new approach is presented to derive rates of decay of the resonance functions for $|x| \to \infty$. This technique is applied to multi-particle systems to analyse virtual levels of N-body Schrödinger operators. As a consequence, one can show that the Efimov-effect is absent in the case of $N \geq 4$ particles in dimensions $d \geq 3$ or for $N \geq 4$ fermions in dimension $d = 1$ and $d = 2$.

Donnerstag, Beginn: 16:30 Uhr **Seminarraum: 0.019**

On the absence of the Efimov-effect for $N \geq 4$ particles

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According to the well-known Efimov-effect the resonance at the lower threshold of a two-body system turns into infinitely many bound states when adding a third particle. This comes from the behaviour of the resonance function for $|x| \to \infty$.
Based on the talk of A. Bitter we prove the absence of the Efimov-effect for $N \geq 4$ particles in dimension $d = 3$ and for $N \geq 4$ fermions in dimension $d = 2$. Precisely, we show that the discrete spectrum of the corresponding $N-$body Schrödinger operator H is finite, provided every subsystem with $n \leq N - 2$ particles has no negative spectrum and no virtual level.

Donnerstag, Beginn: 17:00 Uhr **Seminarraum: 0.019**

Continuous Wavelet Transform of (subrepresentations of) the left-regular representation

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Let $(\pi, \mathcal{H})$ be a unitary representation of a (second countable) locally compact group G. For a vector $\psi \in \mathcal{H}$, the (possibly unbounded) operator $V_\psi \colon \mathcal{H} \to L^2(G)$ given by $V_\psi f(x) = \langle \pi(x)\psi, f \rangle$ is called Continuous Wavelet Transform (CWT) if V_ψ is an isometry. [1]

The CWT has applications for instance in microlocal analysis (when studying singularities) as well as in applied mathematics (data analysis, data compression), where it is used as a starting point for the Discrete Wavelet Transform.

A necessary condition for admitting a CWT is that π is a subrepresentation of the left-regular representation of G. For non-unimodular groups this condition is already sufficient whereas unimodular groups do have subrepresentations admitting no CWT. In the talk I generalize the definition of a CWT to an isometry $\mathcal{H} \to L^2(G \times \mathbb{N})$ and show that using this definition every subrepresentation of the left-regular representation admits a generalized CWT. The idea for this result is based on [2].

References

[1] H. Führ, *Abstract Harmonic Analysis of Continuous Wavelet Transforms*, Lecture Notes in Mathematics **1863**, Springer, Berlin, 2005.

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Geometrie und Topologie

Organisation: Hanke, Lytchak

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 0.019**

K-theory and topological periodic homology

Thomas Nikolaus[1,*]

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We will review recent developments in the area of algebraic K-theory and trace methods. The idea is to compare K-theory to topological cyclic homology. In particular we shall explain how topological cyclic homology is related to arithmetic cohomology theories (like crystalline and prismatic cohomology) and how these relations lead to new insights.

Dienstag, Beginn: 11:00 Uhr **Seminarraum: 0.019**

Nonrealizable equivariant chain complexes

Marc Stephan[1,*], **Henrik Rüping**[2]

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Carlsson conjectured that if a finite CW complex admits a free action by an elementary abelian p-group G of rank n, then the sum of its mod-p Betti numbers is at least 2^n. In 2017, Iyengar and Walker constructed equivariant chain complexes that are counterexamples to an algebraic version of Carlsson's conjecture. This raised the question if these chain complexes can be realized topologically by free G-spaces to produce counterexamples to Carlsson's conjecture.

In this talk, I will explain that this is not possible, based on multiplicative properties of the spectral sequence obtained by filtration with powers of the augmentation ideal.

Dienstag, Beginn: 11:40 Uhr **Seminarraum: 0.019**

Decomposing the moduli space of decorated convex projective structures on non-compact surfaces

Robert Haraway[1], **Robert Löwe**[2,*], **Dominik Tate**[3], **Stephan Tillmann**[3]

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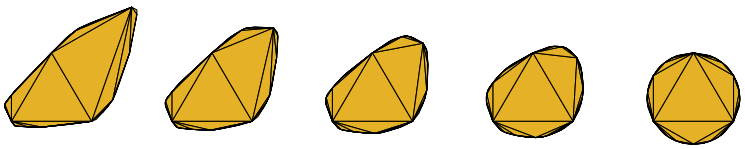
In 1988 Epstein and Penner devise a canonical cell decomposition of a decorated hyperbolic surface using the convex hull construction. Penner goes on and shows that the convex hull construction induces a cell decomposition of decorated Teichmüller space. Later, in 2015, Cooper and Long generalise the convex hull construction to surfaces with convex projective structure of finite area.

In this talk we generalise Penner's result by showing that Cooper and Long's cell decomposition induces a cell decomposition of the moduli space of decorated real convex projective structures on a given surface. Furthermore, we will discuss many open questions concerning this cell decomposition.



Dienstag, Beginn: 16:00 Uhr **Seminarraum: 2.058**

Geometry of subgroups of mapping class groups

Sebastian Hensel[1,*]

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Any finitely generated group G can be equipped with a *word metric* (unique up to bi-Lipschitz equivalence) turning it into a metric space. At the core of geometric group theory lies the idea of connecting geometric properties of this metric to algebraic properties of the group.

If $H < G$ is a finitely generated subgroup, then H has two natural metrics: its intrinsic word metric, and the restriction of the word metric of G. If G is a group whose geometry we understand, one might try to compare these metrics as a first step to understand the geometry of H. However, in general, these metrics can differ wildly, and Gromov defined the *distortion function* as a quantitative measure of how different they are.

In this talk we will give an overview about known results and open questions concerning distortion (and some intrinsic geometric results) in the case where G is the mapping class group of a surface, and H is a topologically motivated subgroup. Typical examples for H include stabilisers of curves, the Torelli subgroup (formed by those mapping classes acting trivially on the first homology of the surface), or the handlebody group (formed by those mapping classes extending from the surface to a three-dimensional handlebody).

Dienstag, Beginn: 17:00 Uhr **Seminarraum: 2.058**

Geometry of simple groups

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Simple groups form a very fundamental object of study in algebra. In particular, the finite simple groups have been classified in one of the biggest joint efforts in mathematics.

For the study of infinite (countable) groups, Gromov has proposed a geometric approach. He has shown that the geometry of a group does in fact reflect some of its algebraic properties. In this talk I will be interested in the interplay between geometry and simplicity. For instance:

1. What does the geometry of a group know about whether it is simple?
2. How does simplicity of a group constrain the geometry?

I will survey examples of phenomena that can occur.

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 2.058**

Counterintuitive approximations

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The Nash-Kuiper embedding theorem is a prototypical example of a counterintuitive approximation result: any short embedding of a Riemannian manifold into Euclidean space can be approximated by **isometric** ones. As a consequence, any surface can be isometrically C^1-embedded into an arbitrarily small ball in $\mathbb{R}^3$. For C^2-embeddings this is impossible due to curvature restrictions.

I will present a general result which allows for approximations by functions satisfying strongly overdetermined equations on open dense subsets. This will be illustrated by three examples: Lipschitz functions with surprising derivative, surfaces in 3-space with unexpected curvature properties, and a similar statement for abstract Riemannian metrics on manifolds.

Our method is based on "cut-off homotopy", a concept introduced by Gromov in 1986. This is joint work with Bernhard Hanke.

References

[1] C. Bär and B. Hanke, Local Flexibility for Open Partial Differential Relations, *arXiv* 1809.05703 (2018).

Mittwoch, Beginn: 11:00 Uhr **Seminarraum: 2.058**

On a rational analogue of a conjecture of Singer

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For a closed manifold M with contractible universal cover, the Singer conjecture predicts that the L^2-Betti numbers of M are concentrated in the middle dimension. In this talk I will discuss what is known and unknown about this conjecture, and describe a construction of closed manifolds with rationally acyclic universal covers whose L^2-Betti numbers are not concentrated in the middle dimension.

Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 2.058**

Area Estimates for High genus Lawson surfaces via DPW

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Starting at a saddle tower surface, we give a new existence proof of the Lawson surfaces $\xi_{m,k}$ of high genus by deforming the corresponding DPW potential. As a byproduct, we obtain for fixed m estimates on the area of $\xi_{m,k}$ in terms of their genus $g = mk \gg 1$.

References

[1] L. Heller, S. Heller, and Ch. B. Ndiaye, Area Estimates for High genus Lawson surfaces via DPW, preprint: arXiv:1907.07139.

Mittwoch, Beginn: 16:10 Uhr **Seminarraum: 2.058**

On the classification of vector bundles over 5-manifolds.

Panagiotis Konstantis[1,*]

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The classification of isomorphism classes of vector bundles over a fixed manifold in terms of computable invariants (e.g. by characteristic classes) is a classical and everlasting problem in topology. In particular in low dimensions such classifications are feasible. For example *Woodward* [1] succeeded to classify oriented n-dimensional vector bundles over n-manifolds for $n = 3, 4, 6, 7, 8$ in terms of characteristic classes and *Čadek* and *Vanžura* [2] for $n = 5$ in case the 5-manifold is not spin.

The case of a spin 5-manifold appears to be somewhat different as the example of the 5-sphere shows: the two isomorphism classes of oriented rank 5 vector bundles over S^5 cannot be distinguished by characteristic classes.

In this talk we will present a classification of rank 5 spin vector bundles over spin 5-manifolds M. For that, we will introduce a bordism theoretic invariant for spin vector bundles over spin manifolds, which is constructed by *framed divisors*. These are the zero loci of generic sections of vector bundles equipped with a natural framing of the normal bundle.

References

[1] L.M. Woodward, The classification of orientable vector bundles over CW-complexes, *Proc. Roy. Soc. Edinburgh Sect. A* vol. 92, no. 3-4 (1982), pp. 175–179.

[2] M. Čadek and J. Vanžura, On the classification of oriented vector over 5-complexes, *Czechoslovak Math. J.* vol. 43(118), no. 4 (1993), pp. 753–764.

Mittwoch, Beginn: 16:50 Uhr **Seminarraum: 2.058**

Sufficiently collapsed three-dimensional Alexandrov spaces.

Fernando Galaz-García[1,*]

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In Riemannian geometry, collapse imposes strong geometric and topological restrictions on the spaces on which it occurs. In the case of Alexandrov spaces, which are metric generalizations of complete Riemannian manifolds with a uniform lower sectional curvature bound, collapse is fairly well understood in dimension three. In this talk, I will discuss the geometry and topology of sufficiently collapsed three-dimensional Alexandrov spaces: when the space is irreducible, it is modeled on one of the eight three-dimensional dimensional Thurston geometries, excluding the hyperbolic one. This extends a result of Shioya and Yamaguchi, originally formulated for Riemannian manifolds, to the Alexandrov setting. (Joint work with Luis Guijarro and Jesús Núñez-Zimbrón).

Geschichte und Didaktik der Mathematik

Organisation: Roth, Sauer

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 2.059**

Die Theorie der analytischen Fakultäten, eine historische Fallstudie zur Übergeneraliserung

Peter Ullrich[1,*]

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Sowohl beim Lernen von Mathematik als auch in deren Entwicklung wird bei der Erweiterung von Zahlbereichen oder von Argumentbereichen von Funktionen häufig unreflektiert unterstellt, dass zuvor Gültiges wahr bleibt. Ein Beispiel hierfür ist die Ausdehung der Fakultät $n!$ von natürlichen Argumenten n auf beliebige reelle oder gar komplexe:

Obwohl schon L. Euler und C. F. Gauß die Γ-Funktion betrachtet hatten, entspann sich in der ersten Hälfte des 19. Jahrhunderts eine Auseinandersetzung zwischen A. L. Crelle [1] und M. Ohm [2] darüber, ob diese Ausdehnung überhaupt möglich sei. Sogar die erste gedruckte Arbeit von K. Weierstraß [3] beschäftigte sich mit dieser Thematik. Er hatte sich zuvor persönlich mit Crelle darüber ausgetauscht, veröffentlichte seinen Text aber nicht in dessen Journal, sondern 1843 im Jahresbericht über das Progymnasium in Deutsch Crone.

Literatur

[1] A. L. Crelle, *Versuch einer allgemeinen Theorie der analytischen Facultäten nach einer neuen Entwickelungs-Methode [...]*, Reimer, Berlin, 1823.

[2] M. Ohm, *Versuch eines vollkommen consequenten Systems der Mathematik, Theil 2: Lehrbuch der niedern Analysis; 2.*, 2. Auflage Riemann und Jonas, Berlin, 1829.

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Mittwoch, Beginn: 11:00 Uhr **Seminarraum: 2.059**

Experimentelle Geometrie – Aus Erfahrung lernen

Prof. Dr. Anselm Lambert[1,*]

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Wie viele gute Ideen hat auch „Experimentelle Geometrie“ bereits eine lange Tradition. Blicke in die didaktische Literatur (nicht nur) des letzten Jahrhunderts offenbaren Vorschläge von bleibendem Interesse, gar solche, die bei Nutzung Neuer Medien und Werkzeuge ihr Potential noch erweitern.

Es ist also gewinnbringend für Theorie und Praxis des MU, Blicke in das zu werfen, was vor rund 100 Jahren an Volksschulen „Raumlehre“ und an Gymnasien „geometrische Propädeutik“ hieß und in Vorschlägen zur (leider bis heute immer noch nicht wirklich im Schulalltag angekommenen) Reformpädagogik seine Fusion suchte. Aus diesem Kontext werden im Vortrag unterschiedliche junggebliebene Beispiele vorgestellt, die ihren Beitrag zur derzeit wieder populär propagierten „neuen Aufgabenkultur“ leisten können.

Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 2.059**

dx, dy statt Grenzwerte? – Über den Einstieg in die Analysis.

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Sehr kurz gesagt: Leibniz hat die Infinitesimalien *und* die Grenzwerte erfunden. 200 Jahre lang rechnete man mit Infinitesimalien und dachte zugleich Grenzwerte – und fand nichts dabei. Man unterschied beide lange nicht, weil man sie nicht unterscheiden konnte. Es fehlten Logik und Mengenlehre, die heute die mathematischen Grundlagen bilden. Diese fehlen heute in der Schule und müssen fehlen. Die Hypothese: Schülerinnen und Schüler finden nichts dabei, mit infinitesimalen Zahlen zu rechnen und an propädeutische Grenzwerte zu denken. Der Effekt: Die unklaren propädeutischen Grenzwerte (vgl. [1]) erhalten mathematisch präzise Begleiter (see [2], Chapter 6).

References

[1] Thomas Bedürftig, Über die Grundproblematik der Grenzwerte, *Mathematische Semesterberichte* **65** (2018), 277–298.

[2] Thomas Bedürftig und Roman Murawski, *Philosophy of Mathematics*, Walter de Gruyter, Berlin/Boston, 2018.

Mittwoch, Beginn: 15:50 Uhr **Seminarraum: 2.059**

Analysis I: Standard oder nicht – Wie streng darf es sein?

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Die Pioniere der Analysis rechneten mit infinitesimalen, also „unendlich kleinen“ Größen und waren damit trotz mancher Vorbehalte ihrer Zeitgenossen sehr erfolgreich. Doch erst mit dem Grenzwertformalismus erhielt die Analysis Ende des 19. Jahrhunderts eine strenge Grundlage und wurde zur *Standardanalysis*, die heute in den Anfängervorlesungen gelehrt wird. Die heutige *Nichtstandard-Analysis* zeigt, dass es auch anders – nämlich durchaus infinitesimal – geht. Sie kommt jedoch in Einführungskursen nicht zur Anwendung, da sie ohne tiefgehende Vorkenntnisse aus Logik und Mengenlehre nicht mit vergleichbarer Strenge unterrichtet werden kann. So jedenfalls ist die verbreitete gegenwärtige Sichtweise in der universitären Lehre. Doch stimmt das wirklich? Eine genauere Analyse (siehe [1]) zeigt, dass die viel gepriesene Strenge der Standardanalysis zum Teil nur ein Mythos ist und dass überall dort, wo die Strenge in der Standardanalysis zu Gunsten der Einfachheit vernachlässigt wird, die Nichtstandard-Analysis hervorblitzt. Eine Chance für die Lehre?

References

[1] K. Kuhlemann, Zur Axiomatisierung der reellen Zahlen, *Siegener Beiträge zur Geschichte und Philosophie der Mathematik* **10** (2018), pp. 67–105.

Mittwoch, Beginn: 16:10 Uhr **Seminarraum: 2.059**

Leibniz Calculus - Historische Aspekte der Analysis dynamisch visualisiert

Hans-Jürgen Elschenbroich[1,*]

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Aus gutem Grund hieß das heute als Analysis bekannte Thema lange Zeit Infinitesimalrechnung. Differenziale, Differenzialquotienten und charakteristisches Dreieck zur Untersuchung von Änderungen und Steigungen sind historisch bedeutsame Zugänge zur Differenzialrechnung, die insbesondere mit Leibniz verbunden sind. Eine entsprechende Rolle haben in der Integralrechnung Indivisible zur Berechnung von Flächeninhalten und Rotationsvolumen.

Im Vortrag beschäftige ich mich neben historischen Bezügen schwerpunktmäßig damit, wie wir diese Ideen heute mit digitalen Werkzeugen (hier: GeoGebra) dynamisch visualisieren und für die Schule didaktisch nutzbar machen können.

References

[1] H.-J. Elschenbroich, Historische Aspekte der Analysis – dynamisch visualisiert, erscheint in G. Pinkernell & F. Schacht (Hrsg.), (2019). Digitalisierung fachbezogen gestalten. Hildesheim: Franzbecker Verlag.

Mittwoch, Beginn: 16:50 Uhr **Seminarraum: 2.059**

Zum Leben von Lothar Collatz: Aus der Phase 1933-1952

Ingo Althöfer[1,*]

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Lothar Collatz (1910-1990) ist berühmt für sein 3n+1-Problem. Auch hat er sehr viele akademische Nachkommen. Seine Zeit als Ordinarius in Hamburg (1952-1990) ist relativ gut dokumentiert. Im Vortrag werden Stationen aus seinem Leben davor beleuchtet, unter anderem:

1933 Verwaister Doktorand
1937 Dozentenlager mit schlimmem Obersturmbannführer

1940 Darmstädter Nullteilerinnen
1943 Die Erde ist keine Scheibe

1945 Im Allgäu: Gefunden und gesucht
1952 Hannoveraner Lothar-Bibel

Lokalkolorit hat der Vortrag, weil Collatz zwischen 1935 und 1943 an der TH Karlsruhe beschäftigt war. Der Vortrag ist in deutscher Sprache.

Mittwoch, Beginn: 17:10 Uhr **Seminarraum: 2.059**

How to find suitable problems for mathematically gifted students within enrichment courses

Karl Heuer[1], **Deniz Sarikaya**[2,*]

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In this talk we want to give some ideas how to develop *Low Threshold High Ceiling* tasks and open problem fields for gifted students. In the first part of the talk we reflect on general goals of the work in open problem fields and possible guidelines for students and teachers.

In the second part we shall give an overview of a possible open problem field, namely the construction of tilings of the plane. Starting from basic platonic tilings and continuing with Archimedian ones, we introduce the notion of 'periodicity' and even get to so-called Penrose tilings. We shall see how quickly we get from a high school problem to open mathematical research, which mostly can be tackled by elementary means.

The talk is based on work [1] used for enrichment programs for mathematically gifted children and on observations from working mathematicians. This mathematical problem field can be enriched by artistic, crafting, historical and cultural discourses. Possibilities for this include the art of Escher or Islamic architecture.

References

[1] W. Bedenknecht, K. Heuer and D. Sarikaya. Parkettierungen der Ebene mit Anschlussproblemen: Förderung mathematisch begabter Jugendlicher innerhalb des Klassenverbandes am Beispiel einer Projektwoche. (In German). Preprint: http://logic.las.tu-berlin.de/Members/Heuer/publications/Parkett_WBKHDS.pdf

Logik und Theoretische Informatik

Organisation: Hils, Kuske

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 2.066**

Automorphism groups of Hahn fields and the canonical lifting property

Michele Serra[1,*]

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Hahn fields are fields of generalised power series. In some particular cases, their automorphism groups have been studied successfully, e.g., Schilling described the (internal) automorphism group of the field of Laurent series, using methods from valuation theory. Inspired by his work, we extend the methods to more general Hahn fields.

Our results become much more effective if we focus on the special subfields satisfying what we will call the *canonical lifting property* (CLP). This allows first fundamental steps in describing the structure of the automorphism group, namely decomposing it canonically into a semidirect product.

We also investigate a wide class of subfields, introduced by Rayner, and give a criterion for them to satisfy the CLP.

This is part of my PhD project, supervised by Salma Kuhlmann.

References

[1] O. F. G. Schilling, Automorphisms of fields of formal power series, *Bull. Amer. Math. Soc.* **50** (1944), pp. 892–901.

Mittwoch, Beginn: 10:20 Uhr **Seminarraum: 2.066**

Ax-Kochen-Ershov principle and classification of theories of henselian valued fields.

Pierre Touchard[1,*]

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In the 60's, Ax and Kochen gave an approximate solution of the (disproved) Artin conjecture: they showed that for every integer d and for every prime p large enough, all homogeneous polynomials with coefficients in $\mathbb{Q}_p$ of degree d and with more than d^2 variables have a non trivial zero. This is the consequence of their results - independently proved by Ershov, and known as the Ax-Kochen-Ershov (AKE) principle: henselian valued fields of residue characteristic 0 are elementary equivalent if and only if their residue fields are elementary equivalent and their value groups are elementary equivalent. Since, many results echo this principle. In particular, model theorists try to reduce the problem of classification of theories of henselian valued fields to that of their residue fields and that of their value groups.

We will give a brief overview of the problem of classification of first order theories and see how the ideas behind the AKE principle have evolved to answer this problem.

Mittwoch, Beginn: 10:40 Uhr **Seminarraum: 2.066**

On a question of Babai and Sós, a model theoretic approach.

Daniel Palacín[1,*]

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In 1985, Babai and Sós asked whether there exists a constant $c > 0$ such that every finite group of order n has a product-free set of size at least cn, where a product-free set of a group is a subset that does not contain three elements x, y and z satisfying $xy = z$. Gowers showed that the answer is no in the early 2000s, by linking the existence of product-free sets of large density to the existence of low dimensional unitary representations. In this talk, I will explain how one can answer this question using model theoretic ideas.

Mittwoch, Beginn: 11:20 Uhr **Seminarraum: 2.066**

Finite Relation Algebras and Constraint Satisfaction Problems

Simon Knäuer[1,*], **Manuel Bodirsky**[2]

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Network satisfaction problems for finite relation algebras are classical computational problems, studied intensively since the 1990s. They are examples of infinite-domain constraint satisfaction problems. The major open research challenge in this context is to classify these problems with respect to their computational complexity.
We explain the connection between network satisfaction problems and constraint satisfaction and translate in this way open questions from the theory of relation algebras into questions about the model theory of homogeneous multigraphs. Furthermore, we discuss first results in the direction of a complexity classification.

Mittwoch, Beginn: 11:40 Uhr **Seminarraum: 2.066**

CSPs of ω-categorical algebras

Thomas Quinn-Gregson[1,*], **Manuel Bodirsky**[1]

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Given an algebra A, we are concerned with the following computational complexity problem:

1. Instance: a finite list E of equations and disequalities over A with variables from a finite set V.
2. Question: is there an assignment $\phi : V \to A$ such that E holds in A?

For example, if A is a semigroup then an instance could be $\{xy = z, zy = t, y \neq= t\}$. We are mainly concerned with ω-categorical algebras. The constraint satisfaction problem (CSP) for ω-categorical structures is well-studied, and we shall show that the algebras we consider give rise to CSPs with 'well behaved' templates. A number of algebras have already been considered; the atomless Boolean algebra is $\mathbb{NP}$-hard (Bodirsky, Hils, Krimkevitch) while the in

nite dimen- tional vector space over $\mathbb{F}_q$ is tractable (Bodirsky, Chen, Kára, von Oertzen). We extend the latter work by classifying the tractable ω-categorical abelian groups. A necessary condition for the tractability of a CSP over an ω-categorical structure is the existence of a pseudo-Siggers polymorphisms. We show that for semilattices and lattices, the existence of such a polymorphism is a useful constriction, and allows us to consider only semilattices and lattices which are bi-embeddable with their direct power. As a consequence, we are able to classify tractable ω-categorical semilattices.

Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 2.066**

Classification of Smooth digraphs modulo pp-constructability

Manuel Bodirsky[1], **Florian Starke**[1,*], **Albert Vucaj**[1]

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We call a digraph smooth if every vertex has at least one incoming and one outgoing edge. We consider the set of all finite smooth digraphs ordered by pp-constructability, i.e., $\mathbb{A} \geq \mathbb{B}$ iff $\mathbb{A}$ is pp-constructable from $\mathbb{B}$ (iff there is a minion homomorphism from Pol($\mathbb{B}$) to Pol($\mathbb{A}$)). In a recent result Barto, Kozik, and Niven showed that the core of a smooth digraph with a WNU is a disjoint union of directed cycles. Therefore we will mostly talk about disjoint unions of cycles. We will present a complete (and surprisingly nice) classification of this poset.

Mittwoch, Beginn: 15:50 Uhr **Seminarraum: 2.066**

Die Erstellung von Entscheidungsmodellen an Hand der Allgemeinen Dynamischen Logik

Bernhard Stoinski[1,*]

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Wenn man natürliche Systeme in einem Logikmodell abbilden möchte, so bedingt das eine Erweiterung um Komponenten der Dynamisierung und der Unschärfe. Die bekannten nichtklassischen Logikkonzepte reichen an dieser Stelle nicht aus. Die Allgemeine Dynamische Logik (ADL) stellt eine nichtklassische Logik dar, bei der die Konklusion sowohl ein reellwertiges Einzelergebnis oder einen Ergebnisbereich sein kann. Junktoren erfüllen bei der Dynamisierung eine besondere Aufgabe. Die zweistelligen Junktoren $\wedge$ und $\vee$ können mit Beschleunigung- oder Verzögerungswerte versehen werden. Die Folge ist, dass Verbindungen zwischen zwei Aussageatomen gewichtet in die Konklusion eingehen.

Neben dem zeitlichen Aspekt der Junktorenerweiterung besitzt die ADL auch eine Erweiterung der Konjunktion und der Disjunktion in der jeweiligen Bindungsstärke. Es können Aussageatome stärker oder schwächer verbunden werden. Dies führt zu unterschiedlich gewichteten Aussagen. In der ADL ist folgende Aussage möglich: $A \wedge B \neq A \wedge_+ B$. $\wedge_+$ ist dabei als starkes $\wedge$ definiert. Durch die Erweiterung der Aussageatome von reellwertigen Werten auf Mengen ist es möglich natürliche Systeme unscharf zu formulieren. Kalküle, die mittels der ADL erzeugt werden, können sowohl unscharf als auch gewichtet formuliert werden. Innerhalb eines Kalküls erhalten die Aussageaxiome durch einen Erfahrungswert eine zusätzliche Gewichtung bei der Konklusion.

Die ADL findet in der Software DyLogos als KI-Entscheidungssystem praktische Anwendung.

Mittwoch, Beginn: 16:10 Uhr **Seminarraum: 2.066**

De Jongh's Theorem for Intuitionistic Zermelo-Fraenkel Set Theory

Robert Passmann[1,*]

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We prove that the propositional logic of intuitionistic set theory IZF is intuitionistic propositional logic **IPC**. More generally, we show that IZF has the de Jongh property with respect to every intermediate logic that is complete with respect to a class of finite trees. The same results follow for constructive set theory CZF.

References

[1] Robert Passmann, De Jongh's Theorem for Intuitionistic Zermelo-Fraenkel Set Theory, `arXiv:1905.04972 [math.LO]`.

Mittwoch, Beginn: 16:30 Uhr **Seminarraum: 2.066**

The large cardinal strength of Löwenheim-Skolem theorems

Lorenzo Galeotti[1,*]

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Due to Compactness Theorem many objects that naturally occur in everyday mathematics are not first order axiomatizable. This led to the study of *strong logics* whose expressive power allows to work with these higher order mathematical objects.

Second order logic is of course one of the most well-known example of strong logic. Many other logics whose expressive power is in between first order logic and second order logic have been studied, see, e.g., [2].

While strong logics arise very naturally in mathematics they do not always preserve the model theoretical properties of first order logic. Particularly important from this prospective are Löwenheim-Skolem theorems. In [1] Bagaria and Väänänen develop a set theoretic framework which allows to asses the strength of downward Löwenheim-Skolem theorems of many strong logics. In this talk we will present a joint work with Khomskii and Väänänen in which we develop a similar framework which allows to study upward versions of Löwenheim-Skolem theorems for strong logics.

References

[1] J. Bagaria and J. Väänänen, On the symbiosis between model-theoretic and set-theoretic properties of large cardinals, *Journal of Symbolic Logic* **81(2)** (2016), pp. 584–604.

[2] J. Barwise and S. Feferman, *Model-Theoretic Logics*, Perspectives in Logic, Cambridge University Press, 2017.

Mittwoch, Beginn: 16:50 Uhr **Seminarraum: 2.066**

The Plato and Gödel hierarchies

Sam Sanders[1,*]

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We introduce the *Gödel hierarchy* to be found in e.g. [2], a linear order of logical systems claimed to capture all natural and foundationally important systems. *Second-order arithmetic* constitutes the medium range of the Gödel hiearchy, including the main 'Big Five' systems of *Reverse Mathematics* and associated equivalent theorems (see [1]). We formulate a parallel hierarchy based on *higher-order arithmetic*, dubbed the *Plato Hierarchy*, that yields the medium range of the Gödel hierarchy under the canonical 'ECF' embedding of second- into higher-order arithmetic. In this way, ECF maps convergence results pertaining to *nets* over Baire space to similar results about *sequences*, while Riemann integration theory is obtained from gauge integration theory via ECF. Equivalences involving these higher-order theorems yield the familiar equivalences from Reverse Mathematics.

References

[1] Stephen Simpson, *Subsystems of second order arithmetic*, 2009, Cambridge University press, pp. xvi+444

[2] Stephen Simpson, Reverse Mathematics and the Gödel hierarchy, *Kurt Gödel. Essays for his centennial*, 2010, Cambridge University Press, pp. 109–127,

Mittwoch, Beginn: 17:10 Uhr **Seminarraum: 2.066**

Some problems with formalisations of mathematical proofs by means of sentential-logical derivations and their solutions

Alexander Zimmermann[1,*]

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What, from a logical point of view, applies to grounding in general, applies to mathematical grounding and thus to mathematical proofs in particular. It is indispensable for an adequate logical formalisation of mathematical proofs to distinguish between the requirements on mathematical proofs and the requirements on mere derivations in a formal system. For, in mere derivations, transitions may occur that would never be accepted in mathematical proofs. Although relevance-logical systems filter out several unacceptable or problematic transitions, their axioms and rules are far from sufficient to guarantee adequate formalisations of mathematical proofs within such systems.

I will propose a definition that allows to formalise mathematical proofs as relations between sets of formulae and formulae in such a way that a set T of sentential-logical formulae grounds mathematically a sentential-logical formula A from a syntactical point of view, if and only if A is a syntactical sentential-logical consequence of T and specific additional syntactical requirements regarding T and A are fulfilled. These additional requirements are strictly developed within the syntactics of sentential-logical languages. The three most important of these requirements are new: to be atomically minimal, to be minimal in degree, and not to be conjunction-like. This approach has, among other things, the advantage to be independent of a special sentential-logical calculus. The next steps should be to do the same for predicate-logical formulae. By means of these definitions, it should be possible to formalise mathematical proofs adequately within formal-logical systems.

Numerik und Wissenschaftliches Rechnen

Organisation: Schröder, Starke

Montag, Beginn: 15:30 Uhr **Seminarraum: 0.019**

Discretization methods for manifold-valued function spaces

Oliver Sander[1,*], **Hanne Hardering**[1]

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Various interesting partial differential equations involve functions that map into a non-Euclidean manifold. The numerical treatment of such equations is challenging, because the underlying functions spaces are not linear. This prevents the use of many standard tools from numerical and functional analysis. At the same time, it has lead to the development of new discretization methods that do not rely on vector space structures. We present an overview over some of these methods, and show recent theoretical and numerical results.

Montag, Beginn: 16:10 Uhr **Seminarraum: 0.019**

Adaptive Iterative Linearization Galerkin Methods for Nonlinear PDE

Pascal Heid[1,*], **Thomas P. Wihler**[1]

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A wide variety of (fixed-point) iterative methods for the solution of nonlinear equations (in Hilbert spaces) exists. In many cases, such schemes can be interpreted as iterative local linearization methods, which can be obtained by applying a suitable linear preconditioning operator to the original (nonlinear) equation. Based on this observation, we will derive a unified abstract framework which recovers some prominent iterative schemes. Furthermore, in the context of numerical solutions methods for nonlinear partial differential equations, we propose a combination of the iterative linearization approach and the classical Galerkin discretization method, thereby giving rise to the so-called *iterative linearization Galerkin (ILG)* methodology. Moreover, still on an abstract level, based on elliptic reconstruction techniques, we derive a posteriori error estimates which separately take into account the discretization and linearization errors. Subsequently, we propose an adaptive algorithm, which provides an efficient interplay between these two effects.

References

[1] Pascal Heid and Thomas P. Wihler, *Adaptive Iterative Linearization Galerkin Methods for Nonlinear Problems*, arXiv.org, Report Nr. 1808.04990, 2018.

Montag, Beginn: 16:30 Uhr **Seminarraum: 0.019**

A convergent finite element boundary element scheme for Maxwell-Landau-Lifshitz-Gilbert equations

Jan Bohn[1,*], **Willy Dörfler**[1], **Michael Feischl**[2]

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We consider the Landau-Lifshitz-Gilbert-equation (LLG) on a bounded domain Ω with Lipschitz-boundary Γ coupled with the linear Maxwell equations on the whole space. As the material parameters outside of Ω are assumed to be constant, we are able to reformulate the problem to a MLLG system in Ω coupled to a boundary equation on Γ.
We define a suitable weak solution and propose a time-stepping algorithm which decouples the Maxwell part and the LLG part and which only needs linear solvers even for the nonlinear LLG part. The approximation of the boundary integrals is done with convolution quadrature. Under weak assumptions on the initial data and the input parameters we show convergence of the algorithm towards weak solutions, which especially guarantees the existence of solutions to the MLLG system.

References

[1] L. Banas, M. Page, and D. Praetorius, A convergent linear finite element scheme for the Maxwell-Landau-Lifshitz-Gilbert equations, *Electron. Trans. Numer. Anal.* **44** (2015), pp. 250-270.

[2] B. Kovács and C. Lubich, Stable and convergent fully discrete interior-exterior coupling of Maxwell's equations, *Numer. Math.* **137** (2017), pp. 91-117.

Montag, Beginn: 16:50 Uhr **Seminarraum: 0.019**

Quasi-optimal and pressure robust discretizations of the Stokes equations by new augmented Lagrangian formulations

Christian Kreuzer[1], **Pietro Zanotti**[2,*]

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We approximate the solution of the stationary Stokes equations with various conforming and nonconforming inf-sup stable pairs of finite element spaces on simplicial meshes. Based on each pair, we design a discretization that is quasi-optimal and pressure robust, in the sense that the velocity H^1-error is proportional to the best H^1-error to the analytical velocity. This shows that such a property can be achieved without using conforming and divergence-free pairs. We bound also the pressure L^2-error, only in terms of the best approximation errors to the analytical velocity and the analytical pressure. Our construction can be summarized as follows. First, a linear operator acts on discrete velocity test functions, before the application of the load functional, and maps the discrete kernel into the analytical one. Second, in order to enforce consistency, we employ a new augmented Lagrangian formulation, inspired by Discontinuous Galerkin methods.

Montag, Beginn: 17:10 Uhr **Seminarraum: 0.019**

Dörfler marking with minimal cardinality is a linear complexity problem

Carl-Martin Pfeiler[1,*], **Dirk Praetorius**[1]

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In his seminal work [1], Dörfler proposes a marking criterion, which allows to prove linear convergence of the usual adaptive finite element algorithm. Given refinement indicators $\eta(T)$ for all elements $T \in \mathcal{T}$ of a triangulation $\mathcal{T}$ and a marking parameter $0 < \theta \leq 1$, a set $\mathcal{M} \subseteq \mathcal{T}$ satisfies the *Dörfler marking* criterion, if

$$\theta \sum_{T \in \mathcal{T}} \eta(T)^2 \leq \sum_{T \in \mathcal{M}} \eta(T)^2 \,.$$

Later it was shown in [2] that the Dörfler marking criterion is not only sufficient to prove linear convergence, but even in some sense necessary. In the literature, different algorithms have been proposed to construct $\mathcal{M}$, where usually two goals compete: On the one hand, $\mathcal{M}$ should contain a minimal number of elements. On the other hand, one aims for linear costs with respect to the cardinality of $\mathcal{T}$. Unlike expected in the literature [2], we formulate and analyze an algorithm, which constructs a minimal set $\mathcal{M}$ at linear costs. In particular, Dörfler marking with minimal cardinality is a linear complexity problem.

References

[1] W. Dörfler, *SIAM Journal on Numerical Analysis* **33(3)** (1996), pp. 1106–1124.

[2] R. Stevenson, *Foundations of Computational Mathematics* **7(2)** (2007), pp. 245–269.

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 0.014**

Numerical analysis of Dirichlet control problems

Thomas Apel[1,*], **Mariano Mateos**[2], **Johannes Pfefferer**[3], **Arnd Rösch**[4]

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[3] *Technische Universität München, Garching bei München, Germany*
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The authors have been investigating Dirichlet control problems with L^2-regularization for several years. The talk will highlight some lessons learnt. These include

- superconvergence effects in graded meshes,
- the approximation of very weak solutions,
- regularity issues of the optimal control problem,
- approximation results for the optimal control problem.

The case of non-convex domains is always included.

Dienstag, Beginn: 10:40 Uhr **Seminarraum: 0.014**

Optimal Control of a Simplified Signorini Problem

Christof Haubner[1,*]

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In the context of optimal control we consider a simplified Signorini problem, an elliptic variational inequality of first kind with unilateral constraints on the boundary. The state is discretized using linear finite elements while a variational discretization is applied to the control. We derive a priori error estimates for the control and state based on strong stationarity and a quadratic growth condition. The convergence rates depend on $H1$ and $L2$ error estimates of the simplified Signorini problem.

Furthermore, we also discuss a non-standard regularization in the optimal control problem.

Dienstag, Beginn: 11:00 Uhr **Seminarraum: 0.014**

hp-adaptive basis functions of higher differentiability and error control for the Finite Cell Method

Paolo Di Stolfo[1,*], **Andreas Schröder**[1]

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The Finite Cell Method (FCM) [1] combines a fictitious domain approach with a finite element method. Its basic idea is to replace the possibly complicated physical domain by an enclosing domain of simple shape, for instance a rectangle or a cuboid, which can easily be meshed. The variational formulation of the problem and its finite element discretization are defined on the enclosing domain. The geometry of the physical domain is incorporated via an indicator function which necessitates the implementation of appropriate quadrature schemes.

In this talk, we address two aspects related to the FCM. First, we discuss *hp*-FEM basis functions of higher differentiability tailored to the simple structure of FCM meshes. Compared to the usual B-spline discretizations, the basis functions have a small support. Also, the basis allows for h- and p-anisotropic refinements, which enables exponential convergence of the energy error for non-smooth problems. Numerical experiments compare the performance of the C^k bases. Second, we present a reliable residual-based error estimator suitable for the FCM as well as numerical examples in 2D and 3D in the context of adaptivity.

References

[1] A. Düster, J. Parvizian, Z. Yang and E. Rank, The finite cell method for three-dimensional problems of solid mechanics, *Comp. Meth. Appl. Mech. Eng.* (2008) pp. 3768–3782.

Dienstag, Beginn: 11:20 Uhr **Seminarraum: 0.014**

Reconstruction-based a-posteriori error estimation in stress-based FEM for frictional contact problems

Bernhard Kober[1,*], **Gerhard Starke**[1]

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We are studying the application of the stress-based FEM described in [1] featuring next-to-lowest order Raviart-Thomas-Elements to the Signorini contact problem with Coloumb friction using a dual variational formulation similar to the one studied in [2].
We extend the a-posteriori error estimator in [4] to frictional contact and reconstruct a H^1-conforming displacement following the ideas in [3]. We prove reliablity of our error esitmator under similar assumptions as those made in [5] for uniqueness and test its efficiency by numerical experiments in two and three dimensions.

References

[1] D. Boffi, F. Brezzi, and M. Fortin. Reduced symmetry elements in linear elasticity. *Commun. Pure Appl. Anal.*, 8:95–121, 2009.

[2] A. Capatina. Variational Inequalities and Frictional Contact Problems. Springer, 2014.

[3] R. Stenberg. Postprocessing schemes for some mixed finite elements. *ESIAM: Math. Model. a. Num. Anal.*, 25:151–167, 1991.

[4] R. Krause, B. Müller and G. Starke. An Adaptive Least-Squares Mixed Finite Element Method for the Signorini Problem. *Numerical Methods Part. Diff. Eq.*, 33:276–289, 2017.

[5] Y. Renard. A uniqueness criterion for the Signorini problem with Coulomb friction. *SIAM J. Math. Anal.*, 38:452–467, 2006.

Dienstag, Beginn: 11:40 Uhr **Seminarraum: 0.014**

Computer Science of Future Numerics: Software Engineering for Continuous Data Processing

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Since introduction of the IEEE 754 floating point standard in 1985, numerical methods have become ubiquitous—and increasingly sophisticated. With growing code complexity of numerical libraries grows the need for rigorous Software Engineering methodology: as provided by Computer Science and state of the art regarding digital processing of discrete data, but lacking in the continuous realm [1,2]. We apply, adapt, and extend the classical concepts — specification, algorithmics, analysis, complexity, verification — from discrete bit strings, integers, graphs etc. to real numbers, converging sequences, smooth/integrable functions, bounded operators, and compact subsets: A new paradigm [3] formalizes mathematical structures as continuous *abstract data types* with rigorous computable semantics [4]. Following the last decades' seminal interplay between Discrete Mathematics and Computer Science, Future Numerics revolves around Computer Science bridging between Pure and Applied continuous Mathematics.

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Dienstag, Beginn: 16:00 Uhr **Seminarraum: 0.019**

Optimization of Phase-Field Damage Evolution

Winnifried Wollner[1,*], **Robert Haller-Dintelmann**[1], **Hannes Meinlschmidt**[2], **Masoumeh Mohammadi**[1], **Ira Neitzel**[3], **Thomas Wick**[4]

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Within this talk, we will address optimization problems governed by time-discrete phase-field damage processes. The presence of an irreversibility of the fracture growth gives rise to a nonsmooth system of equations. To derive optimality conditions we introduce an additional regularization and show that the resulting optimization problem is well-posed.

To tackle discretization errors, as well as convergence in the limit of the irreversibility penalty, an improved differentiability result is shown for the time discrete regularized damage process.

Based upon this, we can show that certain local minimizers of the optimization problem can be approximated by the proposed penalty approach. Further, we will give a short discussion of resulting discretization error estimates.

Dienstag, Beginn: 16:40 Uhr **Seminarraum: 0.019**

The Numerical Simulation of Intercalation Processes in Lithium Ion Batteries

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Lithium ion batteries are key technologies for mobile power devices, as for example in smartphones, laptops or electric vehicles. For the better understanding of the electrode materials we investigate the temporal evolution of the lithium concentration and stresses in a single particle of the electrode material during the (dis-)charge process. A phase-field model coupling chemical and mechanical processes resulting in a fourth-order PDE is used, see (Huttin and Kamlah., 2012).

In our talk we focus on the efficient numerical solution of this time-dependent PDE. The main challenges arise from the high nonlinear character and the spatial as well as the temporal properties of this equation, which includes the handling of an almost sharp moving phase boundary and processes on different time scales.

To solve the arising system numerically we employ a higher order standard finite element method together with an adaptive time integrator. However, a full resolution of three-dimensional particles, respecting the very thin interface zone, generates a huge amount of degrees of freedom. We therefore developed a fully parallelizable, highly efficient solver, which totally avoids the necessity of storing matrices. The implementation was done with the matrix-free framework within the open-source finite element library deal.II (Bangerth et al., 2007).

Dienstag, Beginn: 17:00 Uhr **Seminarraum: 0.019**

Convergence of an adaptive C^0-interior penalty Galerkin method for the biharmonic problem

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In this talk we present a basic convergence analysis for an adaptive C^0-interior penalty Galerkin method for the Biharmonic problem. Conforming discretisations of fourth order problems require C^1-elements which are typically very cumbersome to implement. For this reason mixed and non-conforming methods gained attraction. In this talk we consider the C^0-interior penalty Galerkin discretisation, which uses standard Lagrange Finite elements, ensures consistency and jumps of normal derivatives across inter element boundaries are penalised. Convergence theory of adaptive C^0-interior penalty Galerkin methods turns out to be a particular challenging task due to two reasons. First, the presence of the negative power of the mesh-size function h in the discontinuity penalisation term. Second, we have to deal with the fact that the Lagrange finite element spaces may possibly contain no proper C^1-conforming subspace. Based on recent convergence results of Kreuzer and Georgoulis [1], we develop a suitable limit space and use several embedding properties of (broken) Sobolev and BV spaces to prove convergence of the discrete approximations to the weak solution in the limit space. Coincidence with the exact solution follows thanks to properties of the marking strategy.

References

[1] C. Kreuzer and E. H. Georgoulis, *Convergence of adaptive discontinuous Galerkin methods*, Math. Comp. **87** (2018), no. 314, 2611–2640.

Dienstag, Beginn: 17:20 Uhr **Seminarraum: 0.019**

Asymptotic preserving multilevel DG for the interaction of light and matter

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The energy balance of light and matter imposes diffusive behavior in the esymptotic limit of high density. The numerical approximation of this limit is quite delicate and discretization methods must be designed with some care in order to achieve it. On the other hand, violation of the asymptotic limit by the numerical scheme yields qualitatively wrong approximations for even moderate densities.

We discuss the reasons for breakdown of the standard method and ways to preserve asymptotic behavior. In numerical experiments, we show that multilevel domain decomposition solvers work almost out of the box for asymptotic preserving discretizations. We present applications to light in dense nonabsorbing media as well as to local thermodynamic equilibrium between light and matter.

Dienstag, Beginn: 18:00 Uhr **Seminarraum: 0.019**

Tabment-Orientierte Programmierung

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Das Tabment ist eine Verallgemeinerung und Präzisierung der Begriffe strukturierte TABelle und strukturiertes dokuMENT. Es beinhaltet mehrere mathematischer Begriffe, wie Menge (m), Multimenge (Bag) (b), Liste (l), Tupel, Alternative, Zahl und Text. Jedes Tabment besitzt ein Schema und eine Tabmenttypdefinition (TTD).

Kurzdefinition **Schema:** Jedes Wort in Großbuchstaben ist ein Schema. Ist s ein Schema und W ein Wort, so sind auch (s), $s\ m$, $s\ b$, $s\ l$, $s\ ?$, Wm, Wb, Wl und $W?$ Schemata. Sind $s_1, s_2, \ldots, s_\mathrm{n}$ Schemata, so sind auch $(s_1, s_2, \ldots, s_\mathrm{n})$ (Tupel) und $(s_1|s_2|\ldots|s_\mathrm{n})$ (Alternative) Schemata.

Kurzdefinition **Tabment:** Jedes Tupel von n Tabmenten ist wieder Tabment. n Tabmente kann man zu Listen, Multimengen, Mengen und optionalen Kollektionen ($n < 2$) zusammenfassen. Ein Tabment t kann mit einem Wort W getaggt werden. Ist t ein Tabment mit dem Schema s_i und ist s ein Alternativschema, das s_i enthält, so entsteht hieraus eine Alternative. Die Computersprache o++o (siehe ottops.de) erlaubt es, trotz der allgemeinen Tabmentdefinition Anfragen und Berechnungen kompakt und übersichtlich zu formulieren. o++o-Programme sind im wesentlichen Terme, die die Magdeburger Schreibweise nutzen, nach der jedes Funktionssymbol dem ersten Argument folgt und einfach von links nach rechts und von oben nach unten gerechnet wird. Daher ergibt beispielsweise:

1 2 2 1 3 1 ++ : *rnd* 1 = 1.7 (Durchschnitt)

pi : 2 ... *pi*!0.001 *cos abs* ∗ 0.001 ++ = 0.999703589864 (Integral; näherungsweise)

−2 ... 2!0.01 polynom [1 -1 1] min = 0.75 (lokales Minimum; näherungsweise)

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 0.014**

Robust discretization of the Reissner–Mindlin plate with Taylor–Hood FEM

Mira Schedensack[1,*], **Dietmar Gallistl**[2]

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A shear-locking free finite element discretization of the Reissner–Mindlin plate model is introduced. The rotation is discretized with piecewise polynomials of degree $k + 2$ while the degree $k \geq 0$ is used for the displacement gradient. The method is closely related to the (generalized) Taylor–Hood pairing. In this case the general theory of saddle-point problems with penalty cannot exclude that the convergence speed for the rotation is limited by the lower rate expected for the displacement. However, in this talk, it is shown that the rotations are approximated at optimal order of accuracy.

Mittwoch, Beginn: 10:40 Uhr **Seminarraum: 0.014**

Rayleigh–Ritz approximation of the inf-sup constant for the divergence

Dietmar Gallistl[1,*]

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This contribution proposes a compatible finite element discretization for the approximation of the inf-sup constant for the divergence. The new approximation replaces the H^{-1} norm of a gradient by a discrete H^{-1} norm which behaves monotonically under mesh-refinement. By discretizing the pressure space with piecewise polynomials, upper bounds to the inf-sup constant are obtain ed. The scheme enables an approximation with arbitrary polynomial degrees. It can be viewed as a Rayleigh–Ritz method and it gives monotonically decreasing approximations of the inf-sup constant under mesh refinement. In particular, the computed approximations are guaranteed upper bounds for the inf-sup constant. The novel error estimates prove convergence rates for the approximation of the inf-sup constant provided it is an isolated eigenvalue of the corresponding non-compact eigenvalue problem; otherwise, plain convergence is achieved. Numerical computations on uniform and adaptive meshes are presented.

References

[1] D. Gallistl, Rayleigh-Ritz approximation of the inf-sup constant for the divergence, *Math. Comp.*, **88** (2019), pp. 73–89.

Mittwoch, Beginn: 11:00 Uhr **Seminarraum: 0.014**

Iteration complexity of Douglas-Rachford splitting applied to minimization problems on symmetric Hadamard manifolds

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The iteration complexity analysis of some optimization methods in the Riemannian setting have been presented in the literature in the last years; see, for instance, [1,2] and references therein. In this talk we will discuss the iteration complexity of the Douglas-Rachford method (DRM) applied to minimization problems where objetive function is $F(x) := \Phi(x) + \Psi(x)$, $x \in M$, where M is a Hadamard manifold and $\Phi, \Psi : M \to \mathbb{R} \cup \{+\infty\}$ are convex functions. A convergence proof was recently presented by Bergmann, Persch, Steidl in [5] for minimizing ROF-like functionals on Images with values in symmetric Hadamard manifolds. We base our analysis on their work, Numerical results will be included.

References

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Mittwoch, Beginn: 11:20 Uhr **Seminarraum: 0.014**

Approximation of Rate-Independent Evolution with Non-Convex Energies

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Rate-independent systems governed by non-convex energies provide a several mathematical challenges. Since solutions may in general show discontinuities in time, the design of a suitable, mathematically rigorous notion of solution is all but clear and several different solution concepts exist, such as weak, differential, and global energetic solutions. In the recent past a new promising solution concept was developed, the so-called parametrized solution. The principal idea is to introduce an artificial time, in which the solution is continuous, and to interpret the physical time as a function of the artificial time. A numerical scheme that allows to approximate this class of solutions is the so-called local time-incremental minimization scheme. We investigate this scheme (combined with a standard finite element discretization in space) in detail, provide convergence results in the general case, and prove convergence rates for problems with (locally) convex energies. Numerical tests confirm our theoretical findings.

Stochastik, Statistik und Finanzmathematik

Organisation: Holzmann, Winter

Montag, Beginn: 15:30 Uhr **Seminarraum: 2.067**

Least squares estimation of a completely monotone pmf: from Analysis to Statistics

Fadoua Balabdaoui[1,2,*], **Gabriella de Fournas-Labrosse**[2]

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We consider the class of completely monotone probability mass functions (pmf) from a statistical perspective. An element in this class is known to be a mixture of geometric pmfs, a consequence of the celebrated Hausdorff Theorem. We show that the complete monotone least squares estimator exists, is strongly consistent and converges weakly to the truth at the $\sqrt{n}$-rate. Furthermore,we fully describe its limit distribution as the unique solution of a well-posed minimization problem. Through a simulation study we assess the performance of the method under different scenarios.

Montag, Beginn: 16:10 Uhr **Seminarraum: 2.067**

Efficient Design of Large Sliced Latin Hypercube Samples

Rebecca Daum[1,*]

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The finite element method is widely used for engineering-motivated applications and allows for extensive parameter studies of complex problems. Therefore, sample designs for FEM simulations need to be suitable for a large sample size and a high-dimensional, possibly mixed parameter space with continuous and categorical parameters. Latin Hypercube Designs are often applied for FEM simulations. However, they do not consider categorical parameters.

To construct sample designs that combine the characteristics of Latin Hypercube Designs with categorical parameters and a uniform distribution of sample points, Ba *et al.* published the OSLHD algorithm [1]. A random starting solution is iteratively optimized regarding uniform distribution of sample points. For large samples in high-dimensional parameter spaces, the number of potential starting solutions is huge. This may result in bad convergence towards the optimal solution.

We compose optimized samples of smaller size to obtain a good starting solution for large samples. Subsequently, we analyze and compare both strategies regarding the quality of their starting solution and final solution and their convergence characteristics. We also compare different composition techniques in order to reduce the restrictions accompanying this approach.

References

[1] S. Ba, W. R. Myers and W. A. Brenneman, Optimal Sliced Latin Hypercube Designs, *Technometrics* **57** (2015), pp. 479–487.

Montag, Beginn: 16:30 Uhr **Seminarraum: 2.067**

Testing for affinity of the regression function in boundary regression

Jürgen Kampf[1,*], **Alexander Meister**[1]

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In this talk we consider a boundary regression model, i.e. the regression function $g : [0, 1] \to \mathbb{R}$ does not represent the expect value of the observations, but the endpoint of their support. A nonparametric estimator for g has been proposed in [1]. Here we would like to test, whether the regression function is affine. As test statistic we use the $\mathcal{L}^2$-distance T of the estimator $\hat{g}$ proposed in [1] to the space of affine functions.

Using a Lindeberg-Feller type central limit theorem for mixing sequences, we show that T is asymptotically normal distributed under the null hypotheses.

Moreover, we apply this test to demographic data [2]. We consider in each year the maximal life expectancy attained in any country of the world. This maximal life expectancy has an almost perfectly affine growth in time. Still our test will be able to detect non-affinity with high significance.

References

[1] P. Hall and I. v. Keilegom: Nonparametric "regression" when errors are positioned at end-points, *Bernoulli* **15** (2009), pp. 614–633.

[2] J. Oeppen and J. Vaupel: Broken limits to life expectancy, *Science* **296** (2002), pp. 1029–1031.

Montag, Beginn: 16:50 Uhr **Seminarraum: 2.067**

Donsker results for the smoothed empirical process

Eric Beutner[1], **Henryk Zähle**[2,*]

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The empirical probability measure $\widehat{\mu}_n$ of identically distributed real-valued random variables $X_1, \ldots, X_n$ with distribution μ is the random measure that uniformly allocates total mass one to the random atoms $X_1, \ldots, X_n$. The corresponding empirical process with index set $\mathcal{G}$ consisting of measurable functions is given by

$$\sqrt{n}\Big(\int g\, d\widehat{\mu}_n(\omega) - \int g\, d\mu\Big), \qquad g \in \mathcal{G},\, \omega \in \Omega$$

and plays a central role in the field of nonparametric statistics. Under suitable conditions this process converges in distribution to a non-degenerate limit process as $n \to \infty$, and much is already known about it.

The smoothed empirical process is defined analogously where $\widehat{\mu}_n$ is replaced by a smoothed version based on a kernel density estimator. In this talk I present new results on convergence in distribution of the smoothed empirical process for large index sets $\mathcal{G}$ under weak assumptions. The results cover both a MISE optimal choice of the bandwidth and short-range dependence of $X_1, \ldots, X_n$ $(, X_{n+1}, \ldots)$. The results continue to hold under long-range dependence when $\sqrt{n}$ is replaced by a suitable "non-central" rate.

Mittwoch, Beginn: 15:30 Uhr **Seminarraum: 2.067**

Coalescing-fragmentating Wasserstein dynamics

Max von Renesse[1,*], **Vitalii Konarovskyi**[1]

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The discussion will be devoted to a family of interacting particles on the real line which has a connection with the geometry of Wasserstein space of probability measures. We will consider a physical improvement of the classical Arratia flow, but now particles can split up and they transfer a mass that influences their motion. The particle system can be interpreted as an infinite dimensional version of sticky reflecting dynamics on a simplicial complex. The model is also a particular solution of the ill-posses Dean-Kawasaki equation, SPDE which arises in macroscopic fluctuation theory and glassy materials. In the talk, I am going to discuss the existence and properties of such a particle system. In particular, I will briefly consider a reversible case, where the construction is based on a new family of measures on the set of real non-decreasing functions as reference measures for naturally associated Dirichlet forms. In this case, the intrinsic metric leads to a Varadhan formula for the short time asymptotics with the Wasserstein metric for the associated measure-valued diffusion.

Mittwoch, Beginn: 16:10 Uhr **Seminarraum: 2.067**

The one-dimensional KPP equation driven by space-time white noise

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The one-dimensional KPP equation driven by space-time white noise,

$$\partial_t u = \partial_{xx} u + \theta u - u^2 + u^{\frac{1}{2}} dW, \qquad t > 0, x \in \mathbb{R}, \theta > 0, \qquad\qquad u(0,x) = u_0(x) \geq 0$$

is a stochastic partial differential equation (SPDE) that exhibits a phase transition for initial non-negative finite-mass conditions. Solutions to this SPDE can be seen as the high density limit of particle systems which undergo branching random walks with an extra death-term due to competition or overcrowding. They arise for instance as (weak) limits of approximate densities of occupied sites in rescaled one-dimensional long range contact processes.

If θ is below a critical value θ_c, solutions die out to 0 in finite time, almost surely. Above this critical value, the probability of (global) survival is strictly positive. Let $\theta > \theta_c$, then there exist stochastic wavelike solutions which travel with positive linear speed. For initial conditions that are "uniformly distributed in space", the corresponding solutions are all in the domain of attraction of a unique non-zero stationary distribution.

In my talk, I will introduce the model in question and give an overview of existing results, open questions and techniques involved in its analysis.

Mittwoch, Beginn: 16:30 Uhr **Seminarraum: 2.067**

A convolution inequality, yielding a sharper Berry-Esseen theorem for summands Zolotarev-close to normal

Lutz Mattner[1]
[1] *Universität Trier, Germany*

Theorem 1. *Let F_1, F_2, H_1, H_2 be probability distribution functions on $\mathbb{R}$, with H_1, H_2 having finite Lipschitz constants $\|H_1'\|_\infty, \|H_2'\|_\infty$. Then we have*

$$\|F_1 \star F_2 - H_1 \star H_2\|_\infty \;\le\; \left(\sqrt{\|H_2'\|_\infty \|F_1 - H_1\|_1} + \sqrt{\|H_1'\|_\infty \|F_2 - H_2\|_1}\right)^2.$$

Corollary. *Let $P \in \mathcal{P}_2$. Then* $\left\|\widetilde{P^{*2}} - \mathrm{N}\right\|_\mathrm{K} \;\le\; \frac{4}{\sqrt{2\pi}}\zeta_1(\widetilde{P} - \mathrm{N})$.

Theorem 2. *There exists a constant $c \in]0, \infty[$ satisfying*

$$\left\|\widetilde{P^{*n}} - \mathrm{N}\right\|_\mathrm{K} \;\le\; \frac{c}{\sqrt{n}}\zeta_1(\widetilde{P} - \mathrm{N}) \vee \zeta_3(\widetilde{P} - \mathrm{N}) \qquad \textit{for } P \in \mathcal{P}_3 \textit{ and } n \ge 2.$$

Notation: $F \star G :=$ distribution function of convolution $P * Q$ of corresponding laws P, Q. $\mathcal{P}_r :=$ set of all non-Dirac laws on $\mathbb{R}$ with finite rth moments, $\widetilde{P} :=$ standardisation of $P \in \mathcal{P}_2$, $\mathrm{N} :=$ standard normal law, Kolmogorov's distance $\|P - Q\|_\mathrm{K} := \|F - G\|_\infty$, Zolotarev's (1976) $\zeta_r(\widetilde{P} - \widetilde{Q}) := \sup\{\int f \,\mathrm{d}(\widetilde{P} - \widetilde{\mathrm{Q}}) : f^{(r-1)}$ Lipschitz with constant $1\}$, $\zeta_1(P - Q) = \|F - G\|_1$.

Motivation: Three up to now optimal (incomparable) improvements of the classical Berry-Esseen bound, namely vanishing if $\widetilde{P} = \mathrm{N}$, are due to Sazonov (1972) - Zolotarev (1973), Ulyanov (1976), Senatov (1998). Theorem 2 is simpler and strictly sharper than any of these.

Proof of Thm. 1 uses a non-standard extreme point reduction to prepare for Cauchy-Schwarz. The corollary follows using $\|\widetilde{P^{*2}} - \mathrm{N}\|_\mathrm{K} = \|\widetilde{P}^{*2} - \mathrm{N}^{*2}\|_\mathrm{K}$, and then simply yields Theorem 2 by another theorem of Zolotarev (1986, 1997), which is hence stronger than it looked so far. □

Mittwoch, Beginn: 16:50 Uhr **Seminarraum: 2.067**

The speed of biased random walk among random conductances

Noam Berger[1], **Nina Gantert**[1], **Jan Nagel**[2,*]
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We consider a random walk on the d-dimensional lattice in the random conductance model. Each edge of the lattice is assigned randomly a conductance and for a fixed realization of this environment, the random walker crosses an edge with a probability proportional to the conductivity of the edge. This model is one of the prime examples of a reversible process in an inhomogeneous medium. When we introduce a bias to the right, the process satisfies a law of large numbers with a nonzero effective speed. We are interested in properties of the speed as a function of the bias. For example, is the speed continuous, and is it increasing in the strength of the bias?

We will discuss general ideas how to deal with such a random medium and how it can lead to some atypical behavior. The talk is based on a joint work with Noam Berger and Nina Gantert.

Mittwoch, Beginn: 17:10 Uhr **Seminarraum: 2.067**

A new Space of Algebraic Measure Trees as State-Space for Stochastic Processes

Wolfgang Löhr[1,*], **Anita Winter**[1]

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In the talk, I present a new topological space of "continuum" trees, which extends the set of finite graph-theoretic trees to uncountable structures, which can be seen as limits of finite trees. Unlike previous approaches, we do not use the graph-metric but formalize the tree-structure by a tertiary operation on the tree, namely the branch-point map. The resulting space of algebraic measure trees has coarser equivalence classes than the older space of metric measure trees, but the topology preserves more of the tree-structure in limits, so that it is incomparable to, and not coarser than, the standard topologies on metric measure trees.

I also show that our new space can be very useful as state-space for stochastic processes in order to obtain (path-space) limits of tree-valued Markov chains.

Donnerstag, Beginn: 10:00 Uhr **Seminarraum: 2.067**

Affine processes under parameter uncertainty

Thorsten Schmidt[1,*], **Tolulope Fadina**[1], **Ariel Neufeld**[2]

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This paper develops a notion of affine processes under parameter uncertainty, called *nonlinear affine processes*. This is done as follows: given a set Θ of parameters for the process, we construct a corresponding nonlinear expectation on the path space of continuous processes. By a general dynamic programming principle, we link this nonlinear expectation to a variational form of the Kolmogorov equation, where the generator of a single affine process is replaced by the supremum over all corresponding generators of affine processes with parameters in Θ. This nonlinear affine process yields a tractable model for Knightian uncertainty, especially for modelling interest rates under ambiguity.

We then develop an appropriate Itô formula, the respective term-structure equations, and study the nonlinear versions of the Vasiček and the Cox–Ingersoll–Ross (CIR) model. Thereafter, we introduce the nonlinear Vasiček–CIR model.

This model is particularly suitable for modelling interest rates when one does not want to restrict the state space a priori and hence this approach solves the modelling issue arising with negative interest rates.

Numerical implementations relying on Machine-Learning techniques show that the introduced complexity still can be handled very efficiently.

Donnerstag, Beginn: 11:00 Uhr **Seminarraum: 2.067**

Deep versus Deeper Learning

Sophie Langer[1,*], **Michael Kohler**[1]

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Recent results in nonparametric regression show that deep learning, i.e., neural networks estimates with many hidden layers, are able to circumvent the so–called curse of dimensionality in case that suitable restrictions on the structure of the regression function hold. One key feature of the neural networks used in these results is that they are not fully connected. In this talk a new result is presented, which shows that similar results also hold for fully connected multilayer feedforward neural networks, provided the number of neurons per hidden layer is fixed and the number of hidden layers tends to infinity for sample size tending to infinity.

Donnerstag, Beginn: 11:20 Uhr **Seminarraum: 2.067**

Predictive Inference Based on Markov Chain Monte Carlo Output

Fabian Krüger[1], **Sebastian Lerch**[2,*], **Thordis L. Thorarinsdottir**[3], **Tilmann Gneiting**[2]

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In Bayesian inference, predictive distributions are typically in the form of samples generated via Markov chain Monte Carlo or related algorithms. We conduct a systematic analysis of how to make and evaluate probabilistic forecasts from such simulation output. Based on proper scoring rules, we develop a notion of consistency that allows to assess the adequacy of methods for estimating the stationary distribution underlying the simulation output. We then provide asymptotic results that account for the salient features of Bayesian posterior simulators, and derive conditions under which choices from the literature satisfy our notion of consistency. Importantly, these conditions depend on the scoring rule being used, such that the choices of approximation method and scoring rule are intertwined. While the logarithmic rule requires fairly stringent conditions, the continuous ranked probability score yields consistent approximations under minimal assumptions. These results are illustrated in a simulation study and an economic data example. Overall, mixture-of-parameters approximations which exploit the parametric structure of Bayesian models perform particularly well.

Donnerstag, Beginn: 11:40 Uhr **Seminarraum: 2.067**

Elicitability and Identifiability of Systemic Risk Measures and other Set-Valued Functionals

Tobias Fissler[1,*], **Jana Hlavinová**[2], **Birgit Rudloff**[2]

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A functional T is called elicitable if there is a loss function $L(x, y)$ such that $T(F) = \arg\min_x \mathbf{E}_F[L(x, Y)]$. Similarly, T is identifiable if it is the unique zero of an expected identification function $V(x, y)$. Elicitability and identifiability are key properties for meaningful forecast ranking and validation, but also lead to M- and Z-estimators, respectively.

This talk is concerned with set-valued functionals, e.g., quantiles, the expected region of a flood, or systemic risk measures introduced in [1]. We introduce a thorough distinction between selective forecasts, specifying single points in the set of interest, and exhaustive forecasts, describing the entire set. This induces two corresponding types of elicitability and identifiability, which turn out to be mutually exclusive [2]. We construct selective identification functions and exhaustive scoring functions for systemic risk measures studied in [1]. In a simulation study, we consider comparative backtests of Diebold-Mariano type as well as Murphy diagrams.

References

[1] Z. Feinstein, B. Rudloff, S. Weber, Measures of systemic risk, *SIAM J. Financial Math.* **8** (2017), pp. 672–708.

[2] T. Fissler, J. Hlavinová and B. Rudloff, Elicitability and Identifiability of Systemic Risk Measures and other Set-Valued Functionals, *Preprint* (2019), http://arxiv.org/abs/1907.01306

Studierendenkonferenz

Organisation: Kühnlein, Loose

Montag, Beginn: 15:30 Uhr **Seminarraum: 3.069**

Composition series for spherical principle series in rank one

Christian Arends[1,*]

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In the case of a connected semisimple Lie group with finite centre we consider a specific class of representations, the so-called *spherical principal series representations*. These representations (together with the non-spherical ones) are of great importance since they lead to a classification of all unitary irreducible representations of G. In order to achieve this classification explicitly, one needs to describe the irreducible subrepresentations of the considered representations.

In the talk we will introduce these representations in the case of $G = \mathrm{SL}(2, \mathbb{R})$, describe some Lie-theoretic facts and definitions in this case, and illustrate a procedure to determine the irreducible subrepresentations.

Montag, Beginn: 15:50 Uhr **Seminarraum: 3.069**

A global structure theorem for quasi-isometric ergodic dynamical systems

Nikolai Edeko[1,*], **Henrik Kreidler**[1]

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Ergodic theory and topological dynamics are two separate but related branches of the theory of dynamical systems whose interactions with other fields such as Ramsey theory and number theory continue to be very fruitful. In my talk, I give a brief introduction to these areas and, motivated by a number-theoretic problem, explain two classical structure theorems for dynamical systems. I then discuss how the apparent similarities between these two results may be turned into a global structure theorem.

Montag, Beginn: 16:10 Uhr **Seminarraum: 3.069**

On the space of initial value pairs satisfying the dominant energy condition strictly

Jonathan Glöckle[1,*]

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An initial value pair (g, K) on a manifold M consists of a Riemannian metric g and a symmetric $(0,2)$-tensor K. They typically arise as follows: If M is a spacelike hypersurface of a Lorentzian manifold, take g to be the induced metric and K the second fundamental form. When the Lorentzian manifold satisfies the dominant energy condition, the induced pair (g, K) satisfies a certain inequality, which reduces to $\mathrm{scal}^g \geq 0$ if $K \equiv 0$.

In this talk, we want to study the space $\mathcal{I}^+(M)$ of all initial value pairs that satisfy this inequality strictly. In order to do so, we introduce a Lorentzian α-invariant $\overline{\alpha}\colon \pi_k(\mathcal{I}^+(M)) \to KO^{-n-k}(*)$ for n-dimensional closed spin manifolds M. By comparing this to the classical α-invariant, which is known to detect non-trivial homotopy groups in the space of positive scalar curvature metrics, we will be able to conclude that $\overline{\alpha}$ is non-trivial.

Montag, Beginn: 16:30 Uhr **Seminarraum: 3.069**

Symplectic geometry of Weinstein domains

Yoanna Kirilova[1,*]

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Contact geometry is often considered to be the odd dimensional counterpart to symplectic geometry, since contact manifolds sometimes arise naturally as boundaries of symplectic manifolds. What structures on a symplectic manifold do we need in order to determine if the boundary carries a natural contact structure? To give an example we need the following definition - a Liouville vector field is a vector field X_L on a symplectic manifold (W, ω) satisfying $\omega = \mathcal{L}_{X_L}\omega$. It can be shown that if (W, ω) is a compact manifold with boundary and X_L a Liouville vector field on W pointing transversely outward at the boundary, ∂W inherits a contact structure.

What about the converse? If (M, ξ) is a contact manifold, does there exist a symplectic filling for M, that is a compact symplectic manifold (W, ω), such that $M = \partial W$ and the contact structure on M is compatible with the symplectic structure on W? The answer is not straightforward. To begin with, there are different types of symplectic fillings depending on what it means for the contact structure to be compatible with the symplectic structure - weak, strong and Weinstein fillings. In my talk I will introduce the three diffretent types of symplectic fillings and sketch the proof of the following theorem:

Theorem: If M is an aspherical contact manifold of dimension $n \geq 5$, then it does not admit a Weinstein filling.

This result will be used to compare weak and Weinstein fillable contact manifolds.

Montag, Beginn: 16:50 Uhr **Seminarraum: 3.069**

Symbolic dynamics and transfer operators for hyperbolic surfaces

Charlotte Pfeifer[1,*]

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An important problem in mathematics is to understand how geometric and spectral properties of Riemannian manifolds are related. For hyperbolic surfaces, great progress towards a deep understanding of the relation between their geodesics and Laplace eigenfunctions had been made over the last decade, using transfer operator techniques. However, also the newly developed approaches and techniques do not apply to all hyperbolic surfaces. In this talk, we will discuss an extension of such transfer operator techniques to a specific hyperbolic surface that could not be treated before, thereby showing a structural approach that generalizes to a much larger class of hyperbolic surfaces.

Montag, Beginn: 17:10 Uhr **Seminarraum: 3.069**

A variant of Wall's bordism exact sequence for spin manifolds

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This master thesis relates *Spin*- and $Spin^c$-bordism in a similar way as M. F. Atiyah ([1]) and C. T. C. Wall ([2]) related oriented and non-oriented bordism. The heart piece builds the following long exact sequence relating *Spin*- and $Spin^c$-bordism by a geometrically constructed operator ∂^1:

$$\ldots \longrightarrow \Omega_k^{Spin} \longrightarrow W_k \xrightarrow{\partial^1} \Omega_{k-2}^{Spin} \longrightarrow \Omega_{k-1}^{Spin} \longrightarrow \ldots$$

Where W_k is a subgroup of $\Omega_k^{Spin^c}$. Various other sequences get deduced and a structural result about the $Spin^c$-bordism theory gets proven. Namely that there is a geometric splitting for $k \geq 4$

$$\Omega_k^{Spin^c} \cong W_k \oplus \Omega_{k-4}^{Spin^c}$$

To derive these results the *$Spin^c$-bordism with coefficients* theory gets introduced and a duality theorem gets found by a Pontrjagin-Thom construction. Lastly, the developed theory and results get interpreted homotopy theoretically.

References

[1] M. F. Atiyah, Bordism and cobordism, *Proc. Cambridge Philos. Soc.* **57** (1961), pp. 200–208.

[2] C. T. C. Wall, Determination of the cobordism ring, *Annals of Mathematics. Second Series* **72** (1960), pp. 292–311.

Dienstag, Beginn: 10:00 Uhr **Seminarraum: 3.069**

Spaces and Moduli Spaces of Riemannian Metrics with Positive Scalar Curvature

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A fundamental problem in Riemannian geometry is the question, whether a given manifold can be curved in a specific way, i.e. whether it admits a Riemannian metric satisfying certain curvature conditions. If yes, one can further ask how many there are and how they are related to each other. This leads to the following construction: For a given manifold one considers the space of all Riemannian metrics satisfying the required conditions. The moduli space is then obtained by identifying metrics which are isometric. To understand the topology of these spaces is a very hard problem in general.

We will consider spaces and moduli spaces of Riemannian metrics with positive scalar curvature. Methods from surgery theory and the index theory of Dirac operators have led to various results on the number of path components of these spaces. The goal of this talk is to explain this approach. For that we will focus on a result given in [1], which states that both spaces have an infinite number of path components for certain manifolds with finite fundamental group whose dimension is odd and at least five. We will furthermore consider applications and extensions of this theorem.

References

[1] B. Botvinnik and P. B. Gilkey, The eta invariant and metrics of positive scalar curvature *Mathematische Annalen* 302.3 (1995), pp. 507–517.

Dienstag, Beginn: 10:20 Uhr **Seminarraum: 3.069**

Endpoint geodesics on symmetric spaces

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Symmetric spaces are among the most prominent examples of Riemannian manifolds since they exhibit many beautiful features. They can be viewed from different points of view, one of them a Lie theoretic one, which describes them as special homogeneous spaces. With this approach it is possible to find a formalism for isometric embeddings of certain symmetric spaces. Geodesics on symmetric spaces are well understood, but it is often an interesting problem to consider the geodesic equation as a boundary value problem. This endpoint geodesics problem plays an important role in many applications. With the isometric embedding mentioned above, it is possible to solve this problem. The talk will give a brief introduction to symmetric spaces and then present results on endpoint geodesics.

Dienstag, Beginn: 10:40 Uhr **Seminarraum: 3.069**

A specific N-particle system of Fleming-Viot Type: Recurrence-transience properties

Alexander Klump[1,*]

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We introduce a particle process of N individuals which perform Brownian motion in one or more dimensions up to an exponential time with rate λN. At this time the particle with the minimal fitness jumps on an uniformly chosen remaining particle, where fitness is measured by the function $s(x) = 1/||x||$. We can prove that the localisation of the jumps strongly counteracts the transient behaviour of the Brownian motion in the sense that the process is (neighbourhood-)positive-recurrent for all choices of parameters.

Dienstag, Beginn: 11:00 Uhr **Seminarraum: 3.069**

Hawkes Processes in Insurance: Risk Modelling and Optimal Investment

Anatoliy Swishchuk[1], **Rudi Zagst**[2], **Gabriela Zeller**[3,*]

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For certain classes of insurance claims, an interesting phenomenon to study is temporal clustering of claim payments, for instance caused by a claim payment arrival that induces a stream of subsequent payments. In order to capture this characteristic, we introduce a risk model based on a self-exciting Hawkes process and show that it is suitable to model empirical insurance data. We review a law of large numbers and functional central limit theorem proved by [1] for this model and derive an approximation of the risk process which allows analytical calculation of ruin probabilities. The approximation enables us to apply results by [2] on asset-liability management to study the influence of the self-exciting property of a Hawkes process on optimal investment strategies for an insurer in an incomplete market. In particular, we highlight that not only the expected number and size, but also the potential temporal clustering of incoming claims has to be taken into account in order to avoid breaching given risk limits.

References

[1] A. Swishchuk, Risk model based on general compound Hawkes processes. *Available on arXiv: https://arxiv.org/abs/1706.09038.*

[2] S. Xie, Z. Li, S. Wang, Continuous-time portfolio selection with liability: Mean-variance model and stochastic lq approach, *Insurance: Mathematics and Economics*, vol. **42**(3), pp. 943–953.

Dienstag, Beginn: 11:20 Uhr **Seminarraum: 3.069**

Motivation von SchülerInnen beim Absolvieren eines MathCityMap-Mathtrails

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Das *MathCityMap*-Projekt (MCM) verfolgt das Ziel, SchülerInnen die Allgegenwärtigkeit der Mathematik in ihrer Lebenswelt aufzuzeigen. Es gründet auf der Idee des mathematischen Wanderpfades und unterstützt diese durch den Smartphone-Einsatz im Unterricht.

Ziel der Arbeit ist es, (1) die Motivation von SchülerInnen beim Absolvieren eines MCM-Mathtrails mit ihrer Motivation im regulären Mathematikunterricht zu vergleichen und (2) gruppenspezifische Motivationsunterschiede zu untersuchen. Die Operationalisierung erfolgt über einen, auf dem Intrinsic Motivation Inventory (IMI) nach Deci und Ryan beruhenden Kurzfragebogen. Diesen beantworteten die SchülerInnen (N = 53) einmal im regulären Unterricht sowie nach jeder bearbeiteten MCM-Aufgabe.

Mittels statistischer Testverfahren (t-Test, ANOVA, $\alpha = 0{,}05$) können sowohl bei der Betrachtung aller SchülerInnen als auch bei der geschlechterspezifischen Untersuchung keine signifikanten Motivationsunterschiede zwischen Unterricht und MCM festgestellt werden. Hingegen scheint die Motivation der Leistungsstärkeren zu sinken (mittlere Effektstärke), während die Motivation der Leistungsschwächeren bei MCM signifikant höher ausfällt als im Unterricht (starker Effekt). Daher fallen die motivationalen Unterschiede zwischen leistungsstärkeren und -schwächeren SchülerInnen im MCM-Projekt signifikant geringer aus als im Unterricht. Insgesamt scheinen – aus motivationaler Sicht – vor allem leistungsschwächere SchülerInnen vom MCM-Projekt zu profitieren.

Dienstag, Beginn: 11:40 Uhr **Seminarraum: 3.069**

Ebene Euklidische Geometrie. Eine Grundlage für den Geometrieunterricht der allgemeinbildenden Sekundarstufe I und II

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Die Ebene Euklidische Geometrie ist zur Vermittlung der mathematischen Grunderfahrungen in der allgemeinbildenden Sekundarstufe I und II von zentraler Bedeutung. Eine dahingehende Aufbereitung der Unterrichtsinhalte erfordert von Lehrkräften ein axiomatisch–deduktives Verständnis der Ebenen Euklidischen Geometrie, angepasst an fachbezogene und –didaktische Anforderungen des Schulcurriculums. Allerdings erfahren Lehrkräfte eine entsprechende universitäre Ausbildung oftmals nicht oder nur unzureichend; zudem vernachlässigen bestehende Facharbeiten zur Ebenen Euklidischen Geometrie die fachdidaktischen Aspekte. Aufgrund dessen entwickelte ich in meiner Masterarbeit (*Ebene Euklidische Geometrie. Eine Grundlage für den Geometrieunterricht der allgemeinbildenden Sekundarstufe I und II, 2018*) eine Axiomatisierung der Ebenen Euklidischen Geometrie, die mathematische Stringenz mit den fachbezogenen und –didaktischen Anforderungen an Lehrkräfte verknüpft.
Die hier in aller Kürze skizzierte Problemstellung und fachwissenschaftliche Vorgehensweise in meiner Masterarbeit, möchte ich im Vortrag erläutern sowie weitere aus der Arbeit hervorgehende Forschungsansätze beschreiben.

Dienstag, Beginn: 16:00 Uhr **Seminarraum: 3.069**

Existence and uniqueness of solutions of stochastic functional differential equations with non-Lipschitz coefficients

Sarah Geiß[1,*]

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Assuming a local one-sided Lipschitz condition, M.-K. v. Renesse and M. Scheutzow proved in [1] the existence and uniqueness of (local and global) solutions of stochastic functional differential equations with bounded memory $r > 0$ of the type

$$\mathrm{d}X(t) = f(X_t)\mathrm{d}t + g(X_t)\mathrm{d}B(t),$$

where $X_t = \{X(t+u), -r \leq u \leq 0\}$ denotes a $C([-r,0], \mathbb{R}^d)$ valued stochastic process.

In my master's thesis (supervised by professor M. Scheutzow) I generalized this result by weakening the condition to a local one-sided *non-Lipschitz* condition. The most important technique for the proof consists in generalizing the stochastic Gronwall lemmata of [1].

References

[1] M.-K. von Renesse and M. Scheutzow, Existence and uniqueness of solutions of stochastic functional differential equations, *Random Oper. Stoch. Equ.* **18** (2010), pp. 267– 284.

Dienstag, Beginn: 16:20 Uhr **Seminarraum: 3.069**

Dissipative Lösungen der Ericksen–Leslie-Gleichungen zur Beschreibung von Flüssigkristallen

Lukas Geuter[1,*]

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Ob im Smartphone oder Computerbildschirm, *Liquid Crystal Displays* (kurz: LCDs) sind aus unserem Alltag kaum mehr wegzudenken. Doch so zahlreich wie die technischen Anwendungen von Liquid Crystals, zu Deutsch Flüssigkristallen, so zahlreich sind auch die Schwierigkeiten in deren mathematischer Untersuchung.

Ein verbreitetes Modell zur Beschreibung des Flusses von Flüssigkristallen sind die sogenannten Ericksen–Leslie-Gleichungen. Dieses System von nichtlinearen nichtlinear gekoppelten partiellen Differentialgleichungen erbt insbesondere die Problematik der Einzigkeit von Lösungen der berühmten Navier–Stokes-Gleichungen. Statt nun zu hoffen Einzigkeit im eigentlich Sinne zu zeigen - und damit gegebenenfalls ein Millennium-Problem zu lösen - kann man auch versuchen zu erweitern, was es für eine Lösung bedeutet, eindeutig zu sein. Dies führt auf den Begriff der *schwach-starken* Einzigkeit.

In diesem Vortrag wird das verallgemeinerte Lösungskonzept der sogenannten *Dissipativen Lösungen* vorgestellt, das auf dem Prinzip der schwach-starken Einzigkeit beruht.

Dienstag, Beginn: 16:40 Uhr **Seminarraum: 3.069**

On Cherny's results in infinite dimensions: A theorem dual to Yamada–Watanabe

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We prove that joint uniqueness in law and the existence of a strong solution imply pathwise uniqueness for variational solutions to stochastic partial differential equations of the form

$$dX_t = b(t, X)dt + \sigma(t, X)dW_t, \ \ t \geq 0,$$

and show that for such equations uniqueness in law is equivalent to joint uniqueness in law. Here, W is a cylindrical Wiener process in a separable Hilbert space U and the equation is considered in a Gelfand triple $V \subseteq H \subseteq E$, where H is some separable (infinite-dimensional) Hilbert space. This generalizes the corresponding results of A. Cherny for the case of finite-dimensional equations (c.f. [1]).

References

[1] A. Cherny, On strong and weak uniqueness for stochastic differential equations, *Theory Probab. Appl.* **46(3)** (2002), pp. 406-419.

Dienstag, Beginn: 17:00 Uhr **Seminarraum: 3.069**

Weyl-Asymptotik für PDOs auf einem Gitter

Enrico Reiß[1,*], **Markus Klein**[1], **Elke Rosenberger**[1]

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Pseudo-Differentialoperatoren (PDO) erlauben die Formalisierung von Quantisierungsheuristiken aus der Quantenmechanik, wobei aus dem Symbol zum Phasenraum $\mathbb{R}^n \times \mathbb{R}^n$ der quantenmechanische Operator erzeugt wird. Für den semiklassischen Grenzwert, bei dem das Plancksche Wirkungsquantum h als kleiner Parameter aufgefasst wird, sind unter dem Stichwort *Weyl-Asymptotik* Aussagen darüber bekannt, wie die Anzahl der Eigenwerte eines elliptischen Operators durch das Phasenraumvolumen des Symbols approximiert werden kann.

Eine Familie von Differenzenoperatoren für Gitterfunktionen zum Gitter $\epsilon\mathbb{Z}^n$ fällt in die Klasse der PDOs, wenn das Symbol als diskret im Ortsraum und periodisch im Impulsraum angenommen wird. Techniken aus dem kontinuierlichen Fall liefern im Diskreten eine analoge Eigenwertasymptotik im Grenzwert $\epsilon \to 0$. Hierfür herangezogen werden eine Variante des Theorems von Calderon-Vailloncourt, geeignete Spurklassekriterien und ein sich aus der Helffer-Sjöstrand-Formel ergebender Funktionalkalkül für Gitteroperatoren. Für eine Verbesserung der Fehlerterme in Ordnungen von ϵ rückt die Theorie der Fourierintegraloperatoren in den Fokus.

References

[1] M. Dimassi and J. Sjöstrand, *Spectral Asymptotics in the Semi-Classical Limit*, Number 268 in London Mathematical Society Lecture Note Series, New York, 1999.

[2] M. Klein and E. Rosenberger, Tunneling for a class of difference operators: Complete Asymptotics, in *Ann. Henri Poincaré 19 (2018),* pp. 3511–3559.

Dienstag, Beginn: 17:20 Uhr **Seminarraum: 3.069**

Noncommutative Geometry and the Quantum Hall Effect

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Noncommutative geometry is a rather new and fascinating subject, mainly developed by Alain Connes [1]. We will give a basic introduction to the subject, starting with C*-algebras and Gelfand duality. Noncommutative geometry has deep connections to physics. We will discuss one of them, namely the mathematical proof of the quantization of the quantum Hall effect, found by Bellisard, van Elst and Schulz-Baldes [2].
The quantum Hall effect itself is an extremely important effect from physics, to which two Nobel prizes have been dedicated.

References

[1] A. Connes, Noncommutative geometry, in Academic Press, Inc., San Diego, CA, 1994, pp. xiv+661.

[2] J. Bellissard, A. v. Elst, and H. Schulz-Baldes. The noncom- mutative geometry of the quantum Hall effect, in J. Math. Phys. 35.10 (1994). Topology and physics, pp. 5373–5451.

Dienstag, Beginn: 17:40 Uhr **Seminarraum: 3.069**

Binary quadratic forms and Apollonian circle packings

Radu Toma[1,*]

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If f is a positive definite binary quadratic form with integer coefficients, how many numbers smaller than some positive X does f represent and with what multiplicity? For forms with fundamental discriminants, V. Blomer and A. Granville [1] answered this by giving asymptotics uniform in the discriminant. These results have an important application in a question regarding Apollonian circle packings. J. Bourgain and E. Fuchs [2] make use of the uniformity in the discriminant to prove that the integers appearing as curvatures in an arbitrary integer Apollonian circle packing form a set of positive density inside the natural numbers.

As it was given, the proof in [2] requires a generalisation of the asymptotics in [1], since we need to consider quadratic forms with non-fundamental discriminants and restrict to counting proper representations. My talk will sketch the way we can obtain the necessary results after giving a general introduction to these topics.

References

[1] V. Blomer and A. Granville, Estimates for representation numbers of quadratic forms, *Duke Mathematical Journal* **135** (2006), pp. 261 – 302

[2] J. Bourgain and E. Fuchs, A proof of the positive density conjecture for integer Apollonian circle packings, *J. Amer. Math. Soc.* **24** (2011), pp. 945–967

Mittwoch, Beginn: 10:00 Uhr **Seminarraum: 3.069**

A Riesz Decomposition Theorem for Schrödinger Operators on Graphs

Florian Fischer[1,*], **Matthias Keller**[1]

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In the classical potential theory on the Euclidean space and in the potential theory of transient Markov chains a unique decomposition of superharmonic functions into a harmonic and a potential part is well-known. In this talk the basic concepts and ideas to gain such a decomposition for Schrödinger operators on graphs will be shown. The talk will show results of F. F.'s master's thesis supervised by M. K.

Mittwoch, Beginn: 10:20 Uhr **Seminarraum: 3.069**

What does it mean for an infinite graph to be Hamiltonian?

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The study of *Hamiltonian graphs*, i.e. finite graphs having a cycle that contains all vertices of the graph, is a central theme of finite graph theory. For infinite graphs such a definition cannot work, since cycles are finite. We shall debate possible concepts of Hamiltonicity for infinite graphs and eventually follow the topological approach by Diestel and Kühn [1,2], which allows to generalise several results about being a Hamiltonian graph to locally finite graphs, i.e. graphs where each vertex has finite degree.

An *infinite cycle* of a locally finite connected graph G is defined as a homeomorphic image of the unit circle $S^1 \subseteq \mathbb{R}^2$ in the Freudenthal compactification $|G|$ of G. Now we call G *Hamiltonian* if there is an infinite cycle in $|G|$ containing all vertices of G.

We shall examine how we can force graphs to be Hamiltonian via forbidden induced subgraphs. We extended to locally finite graphs several sufficient conditions for finite graphs to be Hamiltonian. Our results are about claw- and net-free graphs, claw- and bull-free graphs, but also about further graph classes being structurally richer. In this talk we introduce, debate and motivate the topological viewpoint and sketch the proofs for the results mentioned above.

References

[1] R. Diestel and D. Kühn, On infinite cycles I, *Combinatorica* **24** (2004), pp. 69–89.

[2] R. Diestel and D. Kühn, On infinite cycles II, *Combinatorica* **24** (2004), pp. 91–116.

Mittwoch, Beginn: 10:40 Uhr **Seminarraum: 3.069**

Simplicial complexes associated to 2-generated Artin groups

Mireille Soergel[1,*]

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We consider two combinatorial approaches to non-positive curvature of Artin groups. First we describe the systolic complex Y constructed by Huang and Osajda in [2] and secondly the simplicial complex $X(\mathcal{G})$ described by Bestvina in [1]. In the case of two-generated Artin groups, we show how those two complexes relate to each other.

References

[1] M. Bestvina, Non-positively curved aspects of Artin groups of finite type, *Geometry & Topology* **3** (1999), pp. 269–302.

[2] J. Huang and D. Osajda, Large-type Artin groups are systolic, *Proceedings of the London Mathematical Society*, to appear (2019).

Mittwoch, Beginn: 11:00 Uhr **Seminarraum: 3.069**

Bolzano-Weierstraß Properties in Ordered Fields of Uncountable Base Number

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The κ-reals, introduced by Galeotti [2] are the natural generalisation of the reals to an uncountable cardinal κ. Carl, Galeotti, and Löwe [1] studied the Bolzano-Weierstraß theorem for the κ-reals and proved that they do not satisfy the (regular) κ-Bolzano-Weierstraß theorem and they characterise the validity of the weak κ-Bolzano-Weierstraß theorem for strongly inaccessible κ.

We improve on the results by Carl, Galeotti, and Löwe by giving a sharpened analysis on when the (regular) κ-Bolzano-Weierstraß theorem fails for non-Archimedean fields and improving their analysis of the weak κ-Bolzano-Weierstraß theorem to arbitrary uncountable cardinals κ.

References

[1] M.Carl, L.Galeotti, B.Löwe, The Bolzano-Weierstraß Theorem in Generalised Analysis, *Houston J. Math* **44** (2018), no. 4, pp. 1081–1109.

[2] L.Galeotti, Computable Analysis Over the Generalized Baire Space, (2015), MSc Thesis, University of Amsterdam, Amsterdam.

Mittwoch, Beginn: 11:20 Uhr **Seminarraum: 3.069**

The infinitesimal topos as a classifying topos

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Some of the toposes from algebraic geometry have long been known to classify certain geometric theories: The (big) Zariski topos classifies local rings, the étale topos classifies separably closed local rings. There are other important topologies on the Zariski site yielding further subtoposes of the big Zariski topos corresponding to further adjectives before the words "local rings".

The case of the crystalline topos and infinitesimal topos is different in that they are not subtoposes of the Zariski topos. For the classified theory this means that there must be additional structure instead of only additional axioms. Indeed, we present the result that the big infinitesimal topos classifies nilpotent thickenings of local rings.

As an important tool we use geometric theories of presheaf type (meaning that the classifying topos can be given as a presheaf topos) as these allow for a convenient description of their classifying topos in terms of their Set-based models. To this end, we utilize different techniques to exhibit intermediate theories as theories of presheaf type.

Mittwoch, Beginn: 11:40 Uhr **Seminarraum: 3.069**

Ikegami's Theorem for zero-dimensional Polish spaces

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The research area *set theory of the real numbers* deals with so called *regularity properties* of sets of real numbers. One example of a regularity property is Lebesgue measurability. It is well known that all Borel sets and all analytic sets (continuous images of Borel sets) are Lebesgue measurable, but the question whether all sets of the second level of the projective hierarchy are Lebesgue measurable cannot be answered in ZFC. The same is true for the most other regularity properties.

Therefore, the statement "all sets of the second level of the projective hierarchy are regular" can be viewed as a set theoretical axiom whose logical strength can be investigated. There are many characterization theorems for statements of this kind; e.g., Solovay (1970), Judah & Shelah (1989), works by Brendle, Halbeisen and Löwe (1999, 2005, 2011).

In his 2010 dissertation, Ikegami proved a general characterization theorem for a wide class of regularity properties on Baire space; this theorem is now known as *Ikegami's Theorem*. In my master's thesis I generalized Ikegami's Theorem to regularity properties on zero-dimensional Polish space. An application for the generalized theorem is for example the amoeba regularity.

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