Mathematics Münster Midterm Conference

Münster, Germany
March 25 - 27, 2024

Organizers

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MM Mathematics Münster Cluster of Excellence

The Cluster of Excellence "Mathematics Münster: Dynamics - Geometry - Structure" is celebrating its Midterm Conference. Our goal is to draw a picture of current developments in mathematics and get an overview of important results. True to the Cluster's mission of linking all aspects of mathematics in Münster, from pure to applied, the midterm conference will encompass a broad spectrum of mathematics presented by distinguished speakers. We are delighted to welcome you to Münster for this event.

General Information

Venue. The conference is scheduled to be held at the University of Münster, Germany, in the Schloss, located in close proximity to the city center at Schlossplatz 2, 48149 Münster. The presentations will take place in the Aula of the Schloss and Room S10. Coffee breaks will be hosted in the Schloss's main hall.

Program and Registration. The workshop will start the morning of Monday, 25 March, and run until the afternoon of Wednesday, 27 March. The schedule can be found on the next page. Registration will be in the main hall of the Schloss between 8:15 and 9:00.

Check In at the Registration. Starting Monday morning from 8 am. Please ensure you have the QR code from your registration ticket accessible. It can be stored in your mobile wallet, or you may print out the ticket for presentation.

Poster Session and Reception. The poster session and the reception will take place on Monday right after talks in the afternoon in the same location as the coffee breaks.

Womens Breakfast. All registered participants, speakers and organizers are welcome to join the Womens Scientific Breakfast which will take place in the Senaatsaal at the Schloss on Tuesday, 8.30 – 10 am. One main goal of this breakfast is to connect female/FLINTA mathematicians who are well established in their career with those who are at the beginning of this path and provide time for an exchange.
Please let Carolin Gietz know if you would like to join.

Wifi. If your institution is part of the eduroam community you can simply connect to the "eduroam" network. Otherwise you can connect to the "GuestOnCampus" network. Starting any web browser will then redirect you to a login page where you have to accept the terms of use and then click "log in for free". On the latter network there is a 1GB per device per day data limit and the connection is not encrypted.

Conference Photo. The conference photo will take place on Tuesday at the beginning of the lunch break (12.00) in front of the Schloss.

Lunch Break. During the conference, a food truck will be stationed outside the Schloss from 12:30 to 2:00 pm, offering lunch for purchase. Additionally, there are several nearby restaurants where you can enjoy lunch.

Conference Dinner. The conference dinner will be on Tuesday at 7pm at the LUX Restaurant (Domplatz 10, 48143 Münster). All registered participants are welcome at the dinner, the food and water will be covered from the conference budget.

Sightseeing. Below is a list of further suggestions for Wednesday afternoon (and not only).

- self guided walking tours
  `www.gpsmycity.com/gps-tour-guides/munster-2897.html`
- Münster hop on/hop off bus (with headphones in English)
  `www.muensterbus.ms/de/stadtrundfahrt-hop-on-hop-off/`
- art and culture:
  `www.stadt-muenster.de/en/tourismus/art-and-culture`
- biking to Vogelschutzgebiet 'Rieselfelder Münster' (bird reserve)

Grocery on Sunday. Note that on Sunday grocery stores will be closed. It will be possible to get basic groceries at the "REWE To Go" at the gas station at Steinfurter Str. 1-3, and also at the main train station. Restaurants and some of the bakeries will remain open.

Restaurants. Below is a list of restaurants (relatively) close to the math department.

- Mensa am Ring (university canteen), Domagkstraße 61 (closed on Monday and weekends)
- Ristorante Milano (Italian), Wilhelmstraße 26 (closed on Monday)
- Aleppo Grill (Kebab, oriental), Steinfurter Straße 33a (cheap and easy)
- Il Gondoliere (Italian), Von-Esmarch-Straße 28 (closed on Monday)
- Buddha Palace (Indian), Von-Esmarch-Straße 18
- Gustav Grün (Green Fast Food, vegan), Wilhelmstraße 1
- Áro (Green Fast Food, with vegan options), Neutor 3
- Nordstern (German, roast chicken, serves food 4pm til late), Hoyastraße 3
- Krawummel (vegan), Ludgeristraße 62 (further)

Schedule

	Monday	Tuesday	Wednesday
08:15-09:00	Registration	08:30 Women's breakfast	
09:00-09:45	Opening		Dafermos
09:45-10:30	Randal-Williams	10:00 Serra	White
10:30-11:00	Coffee Break	10:45 Coffee Break	Coffee Break
11:00-11:45	Fintzen	11:15 Bach	Schratz
11:45-12:30	Guionnet	12:00 Lunch	Buckmaster
12:30-14:30	Lunch		Lunch
14:30-15:15	Zeidler	14:00 Geffen	Weber
15:15-16:00	Chernikov	14:50 Bandeira	Arzhantseva
16:00-16:30	Coffee Break	15:35 Coffee Break	Coffee Break
16:30-17:15	Poster Blitz	16:15 Biquard	Loeffler
17:15-18:00	Poster Session		
18:00:-19:00	and Reception		
19:00-22:00		Dinner	

Book of Abstracts

Talks

Wednesday 15:15 – 16:00

Metric approximations of infinite groups

Goulnara Arzhantseva

University of Vienna

We discuss various still open questions on approximations of finitely generated groups, focusing on finite-dimensional approximations such as residual finiteness and soficity. We survey our results on the existence and stability of metric approximations. We suggest a few conjectures, e.g. on Gromov hyperbolic groups and their infinite monster limits. The setting is rather general and the involved concepts are transversal to various areas of mathematics.

Tuesday 11:15 – 12:00

Information theory with kernel methods

Francis Bach

PSL Research University

Estimating and computing entropies of probability distributions are key computational tasks throughout data science. In many situations, the underlying distributions are only known through the expectation of some feature vectors, which has led to a series of works within kernel methods, with applications to generative modeling and probabilistic inference. In this talk, I will explore the particular situation where the feature vector is a rank-one positive definite matrix, and show how the associated expectations (a covariance matrix) can be used with information divergences from quantum information theory to draw direct links with the classical notions of Shannon entropies.

Tuesday 14:50 – 15:35

Globally Synchronizing Graphs

Afonso Bandeira

ETH Zürich

In the 1600s, Christiaan Huygens realized that two pendulum clocks (an invention of his!) placed in the same wooden table eventually fall into synchrony. Since then, synchronization of coupled oscillators has been an important subject of study in classical mechanics and nonlinear dynamics. The Kuramoto model, proposed in the 1970s, has become a prototypical model used for rigorous mathematical analysis in this field. A realization of this model consists of a collection of identical oscillators with interactions given by a network, which we identify respectively with vertices and edges of a graph.
In this talk we discuss which graphs are globally synchronizing, meaning that all but a measure-zero set of initial conditions converge into the fully synchronized state. We show that large expansion of the underlying graph is a sufficient condition (but far from necessary) and solve a conjecture of Ling, Xu and Bandeira stating that Erdos-Renyi random graphs are globally synchronizing above their connectivity threshold.
Time permitting, we will discuss connections with studying the non-convex landscape of the Burer-Monteiro algorithm for Community Detection in the Stochastic Block Model.
Joint work with Pedro Abdalla (ETHZ), Martin Kassabov (Cornell), Victor Souza (Cambridge), Steven H. Strogatz (Cornell), Alex Townsend (Cornell).

Tuesday 16:15 – 17:00

Einstein 4-manifolds and their limits

Olivier Biquard

Sorbonne University

Riemannian Einstein metrics are important but still mysterious objects. Despite a number of deep convergence results, all 4-dimensional constructions rely on special integrability properties (in particular on complex geometry). I will describe some of these ideas and give recent results.

Wednesday 11:45 – 12:30

Singularities in fluid: Self-similar analysis, computer assisted proofs and neural networks

Tristan Buckmaster

New York University

In this presentation, I will provide an overview of how techniques involving self-similar analysis, computer assisted proofs and neural networks can be employed to investigate singularity formation in the context of fluids.

Monday 15:15 – 16:00

Recognizing groups in Erdős geometry and model theory

Artem Chernikov

University of Maryland

Erdős-style geometry is concerned with difficult questions about simple geometric objects, such as counting incidences between finite sets of points, lines, etc. These questions can be viewed as asking for the possible number of intersections of a given algebraic variety with large finite grids of points. An influential theorem of Elekes and Szabó indicates that such intersections have maximal size only for varieties that are closely connected to algebraic groups. Techniques from model theory - variants of Hrushovski's group configuration and of Zilber's trichotomy principle - are very useful in recognizing these groups, and led to far reaching generalizations of Elekes-Szabó in the last decade. I will overview some of the recent developments in this area, in particular explaining how all of this is not just about polynomials and works for definable sets in o-minimal structures.

Wednesday 9:45 – 10:30

Extremal and near-extremal black holes

Mihalis Dafermos

Princeton University

Extremal (maximally rotating or maximally charged) and near-extremal black holes are of intense interest both for real astrophysics and in the context of fashionable speculations in high energy physics. They remain perhaps the most misunderstood objects in classical general relativity. In this talk, I will first introduce extremal black holes to a general mathematical audience. I will then discuss the stability problem for extremal (and near-extremal) black holes and describe a new conjectural picture of the moduli space of solutions of the Einstein equations describing gravitational collapse.

Monday 11:00 – 11:45

An introduction to representations of p-adic groups

Jessica Fintzen

University of Bonn

An explicit understanding of the category of all (smooth, complex) representations of p-adic groups provides an important tool not just within representation theory, but also for the construction of an explicit and a categorical local Langlands correspondence, and has applications to the study of automorphic forms, for example.
In my talk I will introduce p-adic groups and explain that the category of representations of p-adic groups decomposes into subcategories, called Bernstein blocks. I will then provide an overview of what we know about the structure of these Bernstein blocks. In particular, I will sketch how to use a joint project in progress with Jeffrey Adler, Manish Mishra and Kazuma Ohara to reduce a lot of problems about the (category of) representations of p-adic groups to problems about representations of finite groups of Lie type, where answers are often already known or easier to achieve.

Tuesday 14:00 – 14:45

Essential freeness, allostery, and classifiability of crossed product C*-algebras

Shirly Geffen

University of Münster

We will review different notions of freeness of dynamical systems, accompanied by examples. We will explore the notion of almost finiteness, as introduced by Kerr, in the setting of essentially free actions. This notion is one of the main tools in establishing classifiability of crossed product C*-algebras of actions of countable amenable groups on compact, metrizable spaces. Very recently, Joseph produced the first examples of minimal actions of amenable groups which are topologically free and not essentially free. While our general machinery does not give any information for his examples, as those are not almost finite, we develop ad-hoc methods to show that his actions have classifiable crossed products.
This is joint work with Eusebio Gardella, Rafaela Gesing, Grigoris Kopsacheilis, and Petr Naryshkin.

Monday 11:45 – 12:30

About Universality Classes in Random Matrix Theory

Alice Guionnet

Ecole Normale Supérieure de Lyon

Wigner's surmise states that the spectrum of the Hamiltonian of heavy nuclei is distributed like that of a large random matrix. Since it was proposed by Wigner in 1956, the eigenvalue distribution of large random matrices has been used as a toy model to study the distribution of more complex mathematical objects such as random tiles or the longest increasing subsequence of a random perturbation. However, this universality phenomenon generally concerns distributions derived from Gaussian matrices, known as the Gaussian ensembles. In this talk, we will discuss more general universality classes that appear in the theory of random matrices.

Wednesday 16:30 – 17:15

Euler systems and the Bloch-Kato conjecture

David Loeffler

UniDistance Suisse

The Bloch-Kato conjecture, relating special values of L-functions to algebraic data, is one of the most important open problems in number theory; it includes the Birch-Swinnerton-Dyer conjecture for elliptic curves as a special case. I will describe some recent breakthroughs establishing special cases of this conjecture (and related problems such as the Iwasawa main conjecture) using the method of Euler systems.

Monday 9:45 – 10:30

Cohomology of moduli spaces: a case study

Oscar Randal-Williams

University of Cambridge

I will explain recent work of Bergström–Diaconu–Petersen–Westerland, and of Miller–Patzt–Petersen–R-W, which uses methods which have been developed over the last 25 years for studying the topology of certain moduli spaces in order to answer a question in arithmetic statistics (the function field analogue of a conjecture of Conrey–Farmer–Keating–Rubinstein–Snaith on moments of quadratic L-functions). My focus will be on the translation of this question to a problem in topology, and some of the modern methods which go into solving this problem.

Wednesday 11:00 – 11:45

Resonances as a computational tool

Katharina Schratz

Sorbonne University

A large toolbox of numerical schemes for dispersive equations has been established, based on different discretization techniques such as discretizing the variation-of-constants formula (e.g., exponential integrators) or splitting the full equation into a series of simpler subproblems (e.g., splitting methods). In many situations these classical schemes allow a precise and efficient approximation. This, however, drastically changes whenever nonsmooth phenomena enter the scene such as for problems at low regularity and high oscillations. Classical schemes fail to capture the oscillatory nature of the solution, and this may lead to severe instabilities and loss of convergence. In this talk I present a new class of resonance based schemes. The key idea in the construction of the new schemes is to tackle and deeply embed the underlying nonlinear structure of resonances into the numerical discretization. As in the continuous case, these terms are central to structure preservation and offer the new schemes strong geometric properties at low regularity.

Tuesday 10:00 – 10:45

Stable phase transitions: open questions and new results

Joaquim Serra

ETH Zürich

Surface tension and similar forces lead to area-minimizing interfaces in some physical phenomena, observable at macroscopic scales. However, this principle of surface area minimization does not uniformly apply across all scales, as the underlying physical energies often vary with scale.
For example, describing a soap film as an area-minimizing surface becomes implausible at scales comparable to 5 nanometersthe size of a soap molecule. Similarly, the Allen-Cahn energy (i.e., scalar Ginzburg-Landau) exhibits scale-dependent behavior that mirrors area minimization only at larger scales.

The regularity theory for absolute energy-minimizing minimal surfaces has been successfully extended to several scale-dependent models, including Allen-Cahn. Yet, extending these results to all stable configurations, which represent the states observable in nature, poses significant challenges.
In the talk, I will discuss the pressing open questions and the latest findings regarding stable phase transitions in three-dimensional environments.

Wednesday 14:30 – 15:15

Noise, differential equations and quantum fields

Hendrik Weber

University of Münster

Stochastic Analysis is concerned with solving differential equations in the presence of highly irregular random noise terms. The field has evolved from the foundational works by Itô in the 1940s and its method are used today in numerous modelling contexts. In the first half of this talk I will present my personal take on some of this history and some of the key ideas used. In the second half, I will discuss exciting developments of the last 10 years that show how methods developed for stochastic differential equations allow to give a new perspective on the classical problem to rigorously construct Quantum Fields.

Wednesday 9:45 – 10:30

Simple amenable C*-algebras

Stuart Andrew White

University of Oxford

Ill give an overview of recent progress in the structure and classification of simple amenable C*-algebras, making parallels to the Connes-Haagerup classification of amenable von Neumann algebras and drawing examples from group actions.

Monday 14:30 – 15:15

Metric inequalities under lower scalar curvature bounds

Rudolf Zeidler

University of Münster

We will explain geometric situations where a lower bound on the scalar curvature of a Riemannian manifold leads to quantitative distance estimates and rigidity results. The study of these has been prompted by several conjectures of Gromov from the recent years. Intuitively, these results can be seen as analogues for scalar curvature of comparison geometry statements such as the Bonnet-Myers theorem for Ricci curvature. However, unlike classical comparison geometry involving stronger curvature conditions, such results for scalar curvature typically rely on an additional topological assumption such as the non-existence of positive scalar curvature metrics on certain submanifolds. Along the way we will thus also provide a brief introduction to obstructions to the existence of positive scalar curvature metrics on closed manifolds.

Poster Session

Non-split sharply 2-transitive groups of odd characteristic

Marco Amelio

Until recently, the existence of non-split sharply 2-transitive groups (i.e., sharply 2-transitive groups without a normal abelian subgroup) was an open problem. The first examples of such groups were exhibited by Rips, Segev and Tent in 2017 and by Rips and Tent in 2019. It is possible to associate to every sharply 2-transitive group a characteristic that is either 0 or a positive prime number. The first of these examples were in characteristic 2, while the others were in characteristic 0, leaving the problem open for odd characteristics. This poster outlines the adaptation of the construction in characteristic 0 to build examples of non-split sharply 2-transitive groups in odd characteristics using methods of geometric small cancellation.

Hyperbolic evolution equations in black hole spacetimes

Marios Apetroaie, Allen Fang, Christopher Kauffman, Milos Provci, Alex Tullini

A fundamental theme in the study of general relativity is the analysis of non-linear wave equations in black hole geometries. Given a fixed solution to a non-linear wave equation (such as the Einstein equations themselves), one can consider it as the time evolution of some initial data prescribed on a hypersurface Σ_τ and ask the question of stability: Does the time evolution of perturbed data on Σ_τ remain close to the original solution? Any analysis of this question must account for the characteristic geometric aspects of black holes, including the presence of trapped null geodesics, superradiance, and the presence of black hole event horizons.

Our poster discusses the analysis of various problems which arise in this context. This includes stability results for the covariant wave equation with additional first order terms in the Kerr spacetime and for the Einstein vacuum equations in the Kerr-de Sitter spacetime, as well as mechanisms of instability in the Kerr-anti-de Sitter and extremal Reissner-Nordström spacetimes. In each case, we briefly discuss how the specific geometry of the black hole affects the long time behaviour of the solution. Portions of this presentation were developed as joint work with Gustav Holzegel.

Cohomology Theories for Arithmetic Schemes

Konrad Bals

Cohomology theories transfer geometric objects (e.g. manifolds, schemes, etc.) into algebraic structures. In the presence of arithmetic structures on the geometric object there is a very rich pool of such cohomology theories. They connect this arithmetic with their algebraic structure and are ultimately closely related to algebraic K-theory studied in abstract algebraic topology. Using input from algebraic topology we compute periodic cyclic homology, which behaves good over characteristic 0, and investigate into the construction of a new cohomology theory capturing characteristic 0 and characteristic p information for all primes p simultaneously.

Differential Geometry Meets Applied Mathematics - Shape Spaces and Manifold Learning

Sascha Beutler, Juliane Braunsmann

Differential geometry is useful to describe many structures appearing in applications. In this poster, we present two examples highlighting the intersection of differential geometry and applied mathematics. The first example shows how to treat the space of closed, parametric immersed curves as a manifold and how to compute geodesics in this space numerically by introducing a suitable discretization, which provably converges to the continuous model. The second example leverages geometric properties of data, such as distances and geodesic averages, to learn an embedding from high dimensions into lower dimensions with desirable properties. For this purpose, a regularization functional is introduced and analyzed mathematically.

A domain of dependence stabilization method for hyperbolic PDEs on cut cell meshes

Gunnar Birke

Cut cell meshes are an attractive alternative to traditional mesh generation algorithms, shifting complexity from mesh generation to the numerical scheme. In the hyperbolic setting in particular one has to overcome the small cell problem: Explicit time stepping methods require a time stepping size proportional to the smallest cell in the mesh which in general will be infeasible. The domain of dependence method is a stabilized discontinuous Galerkin scheme designed to overcome the small cell problem. We present it's current state and outline directions for future research.

High-dimensional cohomology of arithmetic Chevalley groups

Benjamin Brück, Robin J. Sroka

Understanding the cohomology of arithmetic groups such as $\mathrm{SL}_n(\mathbb{Z})$ or $\mathrm{Sp}_{2n}(\mathbb{Z})$ is a fundamental problem, which connects many areas of mathematics. It is motivated by questions in number theory, has applications in algebraic K-theory, and is closely related to the cohomology of moduli spaces such as $\mathscr{A}_g$. However, computing these invariants is notoriously difficult – even in the simplest case: the rational cohomology. Low cohomological degrees are accessible by classical homological stability techniques and computer calculations, but little is known in high degrees. In this project, we study these high-degree rational cohomology groups for a well-behaved class of arithmetic groups.

Automorphisms of spherical buildings

Sira Busch

Buildings are combinatorial and geometric structures, which were initially introduced by Jacques Tits to study semisimple algebraic groups. They turned out to be a very useful tool and became an object of study on their own. In general, one does not know, if there exist non-trivial automorphisms for a given building. Tits showed that all thick, irreducible spherical buildings of rank at least 3 have a rich automorphism group. Every spherical buildings correspond to either a projective space, a polar space or a parapolar space. In my research I use the tools of incidence geometry to give direct constructions for non-trivial automorphisms and investigate their properties and the properties of the generated automorphism groups.

A priori bounds for the generalised Parabolic Anderson Model

Guilherme de Lima Feltes

We show a priori bounds for solutions to $(\partial_t - \Delta)u = \sigma(u)\xi$ in finite volume in the framework of Hairer's Regularity Structures [Invent Math 198:269–504, 2014]. We assume $\sigma \in C_b^2(\mathbb{R})$ and that ξ is of negative Hölder regularity of order $-1-\kappa$ where $\kappa < \bar{\kappa}$ for an explicit $\bar{\kappa} < 1/3$, and that it can be lifted to a model in the sense of Regularity Structures. Our main results guarantee non-explosion of the solution in finite time and a growth which is at most polynomial in $t > 0$. Our estimates imply global well-posedness for the 2-d generalised parabolic Anderson model on the torus, as well as for the parabolic quantisation of the Sine-Gordon Euclidean Quantum Field Theory (EQFT) on the torus in the regime $\beta^2 \in (4\pi, (1+\bar{\kappa})4\pi)$. We also consider the parabolic quantisation of a massive Sine-Gordon EQFT and derive estimates that imply the existence of the measure for the same range of β. Finally, our estimates apply to Itô SPDEs in the sense of Da Prato-Zabczyk [*Stochastic Equations in Infinite Dimensions*, Enc. Math. App., Cambridge Univ. Press, 1992] and imply existence of a stochastic flow beyond the trace-class regime.

This is joint work with A. Chandra (Imperial College) and H. Weber (Münster).

Simplicity of certain dynamical C*-algebras

Shirly Geffen, Dan Ursu

The theory of operator algebras began almost 100 years ago with a series of papers by Murray and von Neumann titled "On Rings of Operators". This was motivated from several perspectives, including group representations, dynamics, and serving as part of the rigorous framework for quantum mechanics.
Operator algebras (C*-algebras and von Neumann algebras) should be thought of as the infinite-dimensional analogue of *-subalgebras of the algebra of n by n complex matrices, together with some additional analytic structure that gives us a handle on infinite-dimensional phenomena.
One of the most important classes of operator algebras are those arising out of groups and dynamics, originally studied by Murray and von Neumann. In this poster, I will very briefly present some results obtained by Shirly Geffen and I, which aim to study the basic structural theory of such constructions and characterize precisely when a large class of such algebras are simple.

Smooth Representations and Six Functor Formalisms

Claudius Heyer, Lucas Mann

Recent developments in the smooth representation theory of p-adic Lie groups in natural characteristic suggest that many problems specific to the mod p setting can be resolved by passing to the derived category. This new viewpoint brings the mod p theory closer to the classical theory, and in fact many phenomena can be described independently of the characteristic of the coefficient field. This becomes particularly visible by the existence of a six functor formalism in the classical and modular settings. This abstract formalism has easy but highly non-trivial consequences for representation theory. In the poster we will present some of these.

Evolution of zeros of random polynomials undergoing the heat flow and differentiation

Jonas Jalowy

Start with a random polynomial with independent coefficients and look at the empirical distribution of its (complex) zeros. How do these zeros evolve, when we apply the heat flow operator (or other differential operators) to the polynomial?
In one example of Weyl polynomials undergoing the heat flow, the limiting zero distribution evolves from the circular law into the elliptic law until it collapses to the Wigner semicircle law.
This poster outlines our results on the limiting zero distribution in the most general case and describes the dynamics of the zeros. Even though the problem seems innocent at first glance, it features fascinating phenomena and surprising connections to other areas such as free probability, random matrices, (optimal) transport, particle systems and PDE's. This is based on joint work with Brian Hall, Ching Wei Ho and Zakhar Kabluchko.

Model-theoretic tilting - Arbitrary rank welcome

Margarete Ketelsen

Building on work of Jahnke-Kartas and Anscombe-Jahnke-K., we aim to extend the tilting construction (as introduced by Fontaine) to certain valued fields of mixed characteristic - in particular value groups of arbitrary rank are possible. We work with the theories rather than with the models, and define a model-theoretic tilt for completions of the theory of henselian and semitame valued fields of mixed characteristic.

Adaptive and certified model hierarchy for parametric problems

Hendrik Kleikamp, Felix Schindler

Many physical, chemical, biomedical, or technical processes can be described by means of parameterized partial differential equations (PDEs) or dynamical systems. A numerical treatment of such problems is usually very computationally demanding and thus requires the development of efficient approximation schemes. On this poster, we present an adaptive and certified model hierarchy that is built on a full order model (FOM), a reduced basis reduced order model (RB-ROM), and a machine learning surrogate (ML-ROM). The model hierarchy is adaptive in the sense that the RB-ROM and the ML-ROM are adapted on-the-fly during a sequence of parametric requests to the model. To allow for a certification of the results, as well as to control the adaptation process, we employ rigorous a posteriori error estimates for the RB-ROM and the ML-ROM. The model is therefore able to fulfill fixed or adaptively chosen error tolerances for every requested parameter. At the same time, the fastest available model that is sufficiently accurate is used for the evaluation of the hierarchy. In this context, for instance deep neural networks or kernel interpolation methods have been applied successfully in a certified manner. Applications of the methods include parameterized time dependent PDEs, large scale parameter optimization problems as well as linear-quadratic optimal control problems.

Toral symmetries of collapsed ancient homogeneous Ricci flows

Anusha M. Krishnan

Ricci flow solutions that are defined for all negative times, are called ancient, and have a special significance since they arise as blowup limits at singularities of the flow. Several instances in the literature suggest that ancient solutions to the Ricci flow have a higher degree of symmetry than initially assumed. In recent work (joint with F. Pediconi and S. Sbiti), we show that under certain assumptions, collapsed homogeneous ancient solutions to the Ricci flow have additional toral symmetry.

Branched transport models

Julius Lohmann

Branched transport can be seen as a Plateau problem on normal 1-currents with prescribed boundary. The minimality of such currents is assessed with respect to a concave function $\tau\colon [0,\infty) \to [0,\infty)$ (with $\tau(0) = 0$) describing the cost $\tau(m)$ to install a line segment of unit length and mass m. The subadditivity of τ leads to the appearence of complex ramified structures. On my poster, I will explain this model in more detail. Further, I will state the main result of my PhD thesis, a reformulation of the branched transport problem as a generalization of the so-called urban planning problem. It is a bilevel optimization in which the outer minimization is over street systems with location-dependent friction coefficient. This model provides a different view on branched transport the total frictional cost for transportation and the costs for maintaining the street system are minimized. It can be used to define generalized Nash equilibrium problems involving competition between public transportation companies. I will give an example of such a game hoping to discuss it with the interested researcher. Moreover, the urban planning formulation motivates the study of a generalization of branched transport in which multiplicities of junctions and traffic congestion are penalized. This idea is part of current research (with Tuomo Valkonen) and will be sketched as an outlook.

Rational Witt Spaces and their Relation to Diamonds and the Fargues-Fontaine Curve

Judith Lutz

Rational Witt Spaces are a candidate for a modified version of field-valued points of the integers. Their definition is global: one replaces the structure sheaf of a scheme by the rational Witt vectors of the structure sheaf. In the local case, for the rational Witt space of a p-adic number field, the rank one valuation ring valued points give after some modification a bijection to the points of the Fargues-Fontaine curve and thus also to the associated diamond. This can be carried further to rings of finite type over the p-adic integers.

Steady vortex sheets with surface tension

David Meyer, Lukas Niebel, Christian Seis

We study the existence of traveling wave solutions to the two-phase Euler equations with surface tension, describing the steady evolution of air bubbles in water. The mathematical model is a free boundary value problem that features a vortex sheet on the surface of the bubble. We construct two families of bubbles of different topologies: these are, on the one hand, toroidal vortices of large diameters and small cross sections, and, on the other hand, spherical (dipole) vortices of non-constant curvature.

Operator algebraic properties of topological full groups

Spyridon Petrakos

We study the properties of operator algebras arising from topological full groups and their actions. Each of these discrete groups is attached to a dynamical system or, more generally, an étale groupoid, and many of its properties can be derived from the properties of the underlying object. This interplay between dynamical and algebraic properties turns the class of topological full groups and their subgroups into a very rich and flexible source of finitely generated simple infinite groups, both in the amenable and non-amenable world, and, thus, into a good testing ground for standing conjectures in operator algebra theory, as well as an interesting class of groups to study in itself.

Space and Time Localization in Model Order Reduction

Stephan Rave, Julia Schleuß

Model order reduction techniques like Reduced Basis (RB) methods have become a powerful tool to efficiently compute the solutions of parametrized PDEs in multi-query applications like optimization or inverse problems.

Nevertheless, especially for large-scale problems, the training of suitable RB surrogate models becomes prohibitively expensive. Therefore, we exploit localization strategies to efficiently construct localized RB models in a parallel and locally adaptive manner. More precisely, for elliptic and parabolic PDEs, we consider the compact transfer operator that maps outer boundary values / initial values to local solutions of the PDE in an inner subdomain / at a later point in time. Thanks to the rapid decay of the singular values of these transfer operators, the corresponding local solution spaces are well amenable to approximation, and it can be proven that the leading left singular vectors span an approximation space which is optimal in the sense of Kolmogorov. We employ randomized SVDs, which only require applying the transfer operator to a few random boundary / initial values. To couple the local approximation spaces and construct a global approximation, we employ ideas from multiscale and domain decomposition methods. Numerical experiments demonstrate the efficiency of the proposed methods.

Percolation and the geometry of infinite groups.

Konstantin Julian Recke

We study the interplay between geometric properties of groups and the probabilistic behavior of invariant percolation processes on their Cayley graphs, i.e. the behavior of random subgraphs whose distribution is invariant under translations. This interplay was previously well understood only for the property of amenability. We make progress beyond the amenable case by providing percolation characterizations of two other relevant properties of groups: the Haagerup property and Kazhdans property (T). As a probabilistic application, we give a new proof of the fact that there is no unique infinite cluster in Bernoulli percolation at the uniqueness threshold on groups with relative property (T). We also describe a new relationship between percolation and the equivariant L^1-compression of the group. The key ingredient to our results is a new and unifying construction, which we believe to be of independent interest. This is based on joint work with Chiranjib Mukherjee (Münster).

Eigenfamilies on spheres and other compact manifolds

Oskar Riedler

The eigenfamilies of Gudmundsson and Sakovich are special families of maps $(M, g) \to \mathbb{C}$, where (M, g) is a Riemannian manifold. They are used to generate harmonic morphisms, proper r-harmonic maps, and minimal co-dimension 2 submanifolds.

A wealth of examples have been constructed on special manifolds, e.g. on all classical symmetric spaces, but their general structure theory has so far not been investigated. This poster presents recent work on the classification of eigenfamilies on the round sphere, and results about the structure of eigenfamilies on compact manifolds.

Analysis of gradient methods in the training of neural networks

Adrian Riekert

We study gradient flow (GF) processes in the training of deep artificial neural networks (ANNs) and prove under certain structural assumptions on the considered supervised learning problem that every non-divergent GF trajectory converges with a polynomial rate of convergence to a critical point. The proof relies on a generalized Kurdyka-Lojasiewicz (KL) inequality for the risk function. We also consider simplified shallow ANN training situations where only the bias parameters are trained. In this case we prove that GF with only one random initialization converges with high probability to a good critical point, i.e., with a small risk value. This shows that the risk converges with high probability to zero as the training time and the number of ANN parameters tends to infinity.