WELCOME

Dear Colleagues,

Welcome to Chemnitz and thank you for joining "*Fractal Geometry and Stochastics 7*"!

This conference is the seventh meeting within the conference series under this name. Since its initiation in 1994 by Christoph Bandt, Siegfried Graf and Martina Zähle the series has grown into a leading platform that connects researchers working in fractal geometry and related fields.

Unlike more specialized meetings, our conference follows the tradition of the series and aims to represent a broad spectrum of topics including

- Classical fractal geometry (dimension theory, geometric measure theory, structure of fractals)
- Analysis, stochastics and mathematical physics on fractals and metric measure spaces
- Stochastic models with fractal properties - in particular networks, graphs and trees
- Dynamical systems and ergodic theory
- Multifractals and local dimension theory
- Random geometries and random fractals.

We are proud to present 11 keynote and 11 invited talks by highly renowned experts and promising young talents who will comment on exciting new trends and latest developments in their fields and explain their own recent research. In addition there will be three parallel sessions hosting selected contributed talks on a wide range of topics, and a specially featured poster session.

Our primary goal is to connect researchers sharing similar interests, regardless of their background or career stage. Any fruitful mathematical conversation between friends newly made or reunited old friends and any new idea for joint projects will be a great success.

We are delighted to have you all on board and expect your contributions with curiosity and excitement. We are looking forward to the week and wish you a productive meeting and an enjoyable stay in Chemnitz!

Uta Freiberg, *Michael Hinz*, *Maarit Järvenpää* and *Steffen Winter*

Conference Venue

The conference takes place in the *Turmbau building* (C22) at campus *Reichenhainer Straße* of the *University of Technology Chemnitz*, which is characterized by its small tower located between two flat buildings.

The best way to get there from the city centre is to take trams number 3, C13, C14, or C15 in direction of *Thalheim*, *Aue*, or *Technopark* and get off at the stations *Rosenbergstr* or *TU Campus*.

For a street map of the relevant part of Chemnitz see the inside of the front and back cover.

Session Format and Talk Style

For the sake of lively discussion, please respect the following maximal talk times allocated to your presentations:

Keynote lectures: 40 minutes talk time (plus 10 minutes discussion);
Invited talks: 35 minutes talk time (plus 5 minutes discussion)
Contributed talks: 25 minutes talk time (plus 5 minutes discussion).

All lecture rooms are equipped with a computer and a video projector. For the keynote and invited talks, three large blackboards will be available. In the parallel sessions, each room will be equipped with four smaller blackboards suitable for a blackboard presentation. Please upload the slides of your talk (preferably in pdf-format) to the computer in the lecture room well before the start of the session allocated to your presentation. It is also possible to send the file by email to fgs7@math.tu-chemnitz.de (preferably on the day before your session).

Poster Session

Posters are displayed for the duration of the conference.

There is a dedicated **Poster Session** on Monday starting at 17:00 h. Abstracts of the posters can be found in this booklet starting from page 45.

Please take note of the **Best Poster Award**. Your conference booklet contains a ballot slip for your choice of the three best posters. Please hand in your completed ballot slip by the coffee break on Wednesday morning. The ballot box will be placed in the main lecture hall.

Excursion

On Wednesday afternoon, there will be a hike and a guided city tour (approx. 90 min., English) through Chemnitz. During registration, you will be asked if you would like to join either activity. Start times and locations will be announced during the conference.

Coffee Breaks and Conference Dinner

During **coffee breaks** water, coffee and tea will be available.

On Thursday evening you are cordially invited to participate in the **conference dinner** to celebrate a hopefully inspiring and enjoyable conference. It starts at 7.00pm and takes place at the **Michaelis** at *Düsseldorfer Platz 1* in the city center. The three-course dinner, which you will choose upon registration on Monday morning, is included in the conference fee. Drinks are at your own expense.

Lunch Options

Lunch break is from 12.30 h to 14.00 h. There are several options for lunch on campus or close to it:

- *Mensa 55* – the Mensa of the university is located on the first floor of the building. It offers a selection of at least four dishes, including at least one vegetarian and one vegan option. Please note that there is only one check-out available for cash payments. On the ground floor of the same building, you will find a cafeteria that serves a variety of sandwiches, burgers, pizza, cakes, and coffee. Cash payment is also accepted here.
- *Bäckerei Voigt* – a bakery located near the Mensa.
- *Campus Döner & Pizza* – a kebab and pizza place located across from Bäckerei Voigt.
- *Mylo* – a Vietnamese place very close to the conference venue.
- *Yilmaz Kebap Haus* – a kebab and pizza place close to the conference venue.
- *Asia Imbiss* – an Asian fast food restaurant at the Pegasus center.

The following two options are in walking distance (ca. 20 minutes):

- *Papa Milo* – Arabic food; close to the Südbahnhof.
- *Nomad* – a restaurant serving breakfast and lunch with a fusion cuisine menu; close to the Südbahnhof.

Monday, 23 September 2024

09:30 – 09:40	**Welcome**	
09:40 – 10:30	**KN Varju**	*Self-similar measures*
coffee break		
11:00 – 11:50	**KN Luo**	*On core entropy of polynomials and angle-doubling dynamics*
11:50 – 12:30	**IT Algom**	*On random walks and Fourier decay*
lunch break		
14:00 – 14:40	**IT Radunović**	*On support measures and complex dimensions of fractals*
14:40 – 15:20	**IT Rapaport**	*Dimension of Bernoulli convolutions in* $\mathbb{R}^d$
coffee break		
16:00 – 17:00	**Parallel Sessions**	*see next page*
17:00 – 18:30	**Poster Session**	*see page 45*

Program of the Parallel Sessions

Parallel Session 1 (Room B101)

16:00 – 16:30	**Kolossváry**	*Dimension interpolation on planar carpets*
16:30 – 17:00	**Rutar**	*Box dimensions of infinitely generated self-conformal sets*

Parallel Session 2 (Room B201)

16:00 – 16:30	**Kern**	*Hausdorff dimension of stable Lévy processes with drift*
16:30 – 17:00	**Louckx**	*Harmonizable Multifrational Stable Field: Wavelet representation and sample path behavior*

Parallel Session 3 (Room B003)

16:00 – 16:30	**Kajino**	*On singularity of p-energy measures among distinct values of p for some p.-c.f. self-similar sets*
16:30 – 17:00	**Shimizu**	*Construction of self-similar energy forms and self-similar energy measures on the Sierpinski carpet*

Keynote lecture	Peter Varju	09:40 – 10:30

Self-similar measures

Peter Varju
(University of Cambridge)

Given a finite collection of contractive similarity transformations $f_1, \ldots, f_n : \mathbf{R}^d \to \mathbf{R}^d$ and a probability vector $p_1, \ldots, p_n$, there is a unique probability measure μ on $\mathbf{R}^d$ with the property $\mu = p_1 f_1(\mu) + \ldots + p_n f_n(\mu)$. Such measures are called self-similar. We will discuss recent developments about the dimension and absolute continuity with respect to Lebesgue measure of these measures.

Keynote lecture	Jun Luo	11:00 – 11:50

On core entropy of polynomials and angle-doubling dynamics

Jun Luo
(Sun Yat-sen University)

We introduce a universal approach of defining the core entropy for all polynomials of degree at least two. Particularly, in degree two we address the basic properties of the core entropy function. This function is well-defined on the whole Mandelbrot set. Among others, we will show how it is related to the angle-doubling map on the unit circle.

Invited Talk	Amir Algom	11:50 – 12:30

On random walks and Fourier decay

Amir Algom
(University of Haifa)

In recent years there has been an explosion of interest and progress on the Fourier decay problem for fractal measures. In this talk I will discuss some of these results, focusing mainly on how ideas and methods from random walks and spectral theory of transfer operators play a key role in their proof.

Based on joint works with Federico Rodriguez Hertz and Zhiren Wang.

Invited Talk **Goran Radunović** **14:00 – 14:40**

On support measures and complex dimensions of fractals

Goran Radunović
(University of Zagreb)

In this talk our goal is to relate and unify two theories each of which give rise to a generalized Steiner formula for arbitrary compact sets. The first one being the Steiner-like formula of Hug, Last and Weil given in terms of the support measures of compact sets and the second one arising from the theory of complex fractal dimensions (by Lapidus and collaborators) and the associated distance zeta function. In its original form, the Steiner-like formula of Hug, Last and Weil may not be very operational if applied to fractal sets. Hence, in order to remedy this and extract finer information for such sets, we introduce and study tightly related geometric functions called the basic functions (of compact sets) and appropriate critical scaling exponents which we relate to the Minkowski dimension of the given set. On the other hand, we show how the distance zeta function decomposes into a sum of Mellin transforms of the newly introduced basic functions which allows one to study them in even finer detail by using the machinery and tools of the theory of complex dimensions. This provides a first step in the unification of these two theories and shows how the complex dimensions are generated by the basic functions. Appropriate functional equations for the corresponding basic zeta functions are also derived which turn out to be very useful in explicit computations. Furthermore, we also comment on the connection to the theory of fractal curvature measures as well as provide interesting examples to support our results.

This is a joint work in progress with S. Winter.

Invited Talk **Ariel Rapaport** **14:40 – 15:20**

Dimension of Bernoulli convolutions in $\mathbb{R}^d$

Ariel Rapaport
(Technion)

Let $(\lambda_1, ..., \lambda_d) = \lambda \in (0,1)^d$ be with $\lambda_1 > ... > \lambda_d$ and let μ_λ be the distribution of the random vector $\sum_{n\geq 0} \pm (\lambda_1^n, ..., \lambda_d^n)$, where the $\pm$ are independent fair coin-tosses. Assuming $P(\lambda_j) \neq 0$ for all $1 \leq j \leq d$ and nonzero polynomials with coefficients $\pm 1, 0$, we show that $\dim \mu_\lambda = \min\{d, \dim_L \mu_\lambda\}$, where $\dim_L \mu_\lambda$ is the Lyapunov dimension. This extends to higher dimensions a result of Varjú from 2018 regarding the dimension of Bernoulli convolutions on the real line. Joint work with Haojie Ren.

Parallel Session 1 (B101) István Kolossváry 16:00 – 16:30

Dimension interpolation on planar carpets

István Kolossváry
(Alfréd Rényi Institute of Mathematics)

There are plenty of sets whose dimension differs depending on the notion of dimension considered. The idea of dimension interpolation is to gain more nuanced geometric understanding of these sets by introducing a one parameter family of dimensions that interpolate in a meaningful way between two well-studied notions. In the talk I will speak about intermediate dimensions and the Assouad spectrum. Moreover, results will be presented on the exact form of these interpolations as a function of the parameter for planar carpets in the Bedford-McMullen and Gatzouras-Lalley class. Based on joint works with A. Banaji, J.M. Fraser and A. Rutar.

Parallel Session 1 (B101) Alex Rutar 16:30 – 17:00

Box dimensions of infinitely generated self-conformal sets

Alex Rutar
(University of Jyväskylä)

It is well-known that the box dimension of a (finitely generated) self-conformal set always exists. In contrast, in the infinitely generated case, almost nothing about the lower box dimension is known. In this talk, under the open set condition, I will present some recent results (joint with Amlan Banaji) giving a sharp asymptotic formula for the covering numbers $N_r(\Lambda)$ of an infinitely generated self-conformal set in terms of the Hausdorff dimension of Λ and the covering numbers $N_r(F)$. Here, F denotes the set of fixed points of the maps in the IFS. To give one particular consequence, the box dimension of Λ exists if and only if

$$\overline{\dim}_{\mathrm{B}} F \leq \max\{\dim_{\mathrm{H}} \Lambda, \underline{\dim}_{\mathrm{B}} F\}.$$

In particular, the box dimension of Λ need not exist. This can even occur within special classes of self-conformal sets, such as for sets of continued fraction with restricted digits.

Parallel Session 2 (B201) Peter Kern 16:00 – 16:30

Hausdorff dimension of stable Lévy processes with drift

Peter Kern
(Heinrich Heine University Düsseldorf)

We determine the Hausdorff dimension of the graph and the range of isotropic stable Lévy processes with arbitrary Borel-measurable drift function in terms of the parabolic Hausdorff dimension of the graph of the drift function.

Parallel Session 2 (B201) Christophe Louckx 16:30 – 17:00

Harmonizable Multifrational Stable Field: Wavelet representation and sample path behavior

Christophe Louckx
(University of Lille)

Multifractional fields and processes are Gaussian or non-Gaussian extensions of the well-known Fractional Brownian Motion. Usually, they have non-stationary increments and their local sample path behavior is different from one point to another. In my talk, I will present some results of my working paper on Harmonizable Multifrational Stable Field (HMSF) in collaboration with Antoine Ayache (University of Lille, France). This is a real-valued non-Gaussian stochastic field extending the real harmonizable multifrational stable process introduced in (M. Dozzi and G. Shevchenko, Stoch. Process. Appl., 2011), and studied in the latter article under the restrictive condition that the stability parameter belongs to the interval (1,2). In my talk study of HMSF will be made through another strategy relying on wavelets methods which will allow to drop this restrictive condition. It is to certain extent inspired by the strategies which were introduced in (A. Ayache and G. Boutard, J. Theoret. Probab., 2017) and (A. Ayache and Y. Xiao, Preprint 2023). First, by using Fourier methods, I will introduce a wavelet-type random series representation for HMSF and show that it is almost surely uniformly convergent on each compact subset of the Euclidian space. Then, thanks to this representation I will obtain sharp uniform and local moduli of continuity for HMSF. Also, I will obtain an estimate of the behavior of HMSF in a neighborhood of infinity.

Parallel Session 3 (B003) **Naotaka Kajino** **16:00 – 16:30**

On singularity of p-energy measures among distinct values of p for some p.-c.f. self-similar sets

Naotaka Kajino
(Kyoto University)

For each $p \in (1, \infty)$, a *p-energy form* $(\mathcal{E}_p, \mathcal{F}_p)$, a natural L^p-analog of the standard Dirichlet form for $p = 2$, was constructed on the (two-dimensional standard) Sierpiński gasket K by Herman–Peirone–Strichartz [Potential Anal. **20** (2004), 125–148]. As in the case of $p = 2$, it satisfies the *self-similarity (scale invariance)*

$$\mathcal{E}_p(u) = \sum_{j=1}^{3} \rho_p \mathcal{E}_p(u \circ F_j), \qquad u \in \mathcal{F}_p,$$

where $\{F_j\}_{j=1}^3$ are the contraction maps on $\mathbb{R}^2$ defining K through the equation $K = \bigcup_{j=1}^3 F_j(K)$ and $\rho_p \in (1, \infty)$ is a scaling factor determined uniquely by $(K, \{F_i\}_{i=1}^3)$ and p. While the construction of $(\mathcal{E}_p, \mathcal{F}_p)$ has been extended to general p.-c.f. self-similar sets by Cao–Gu–Qiu (2022), to Sierpiński carpets by Shimizu (2024) and Murugan–Shimizu (2024+) and to a large class of infinitely ramified self-similar fractals by Kigami (2023), very little has been understood concerning properties of important analytic objects associated with $(\mathcal{E}_p, \mathcal{F}_p)$ such as p-harmonic functions and p-energy measures, even in the (arguably simplest) case of the Sierpiński gasket. This talk is aimed at presenting the result of the speaker's on-going joint work with Ryosuke Shimizu (Waseda University) that, *for a class of p.-c.f. self-similar sets with very good geometric symmetry, the p-energy measure $\mu^p_{\langle u \rangle}$ of any $u \in \mathcal{F}_p$ and the q-energy measure $\mu^q_{\langle v \rangle}$ of any $v \in \mathcal{F}_q$ are mutually singular for any $p, q \in (1, \infty)$ with $p \neq q$*. The keys to the proof are (1) new explicit descriptions of the global and local behavior of p-harmonic functions in terms of ρ_p, and (2) the highly non-trivial fact that *$\rho_p^{1/(p-1)}$ is strictly increasing in $p \in (1, \infty)$*, whose proof relies heavily on (1).

Parallel Session 3 (B003) Ryosuke Shimizu 16:30 – 17:00

Construction of self-similar energy forms and self-similar energy measures on the Sierpinski carpet

Ryosuke Shimizu
(Waseda University)

In this talk, I will propose a new way of constructing the $(1, p)$-Sobolev space, p-energy functional and p-energy measures on the Sierpinski carpet for all $1 < p < \infty$. I will also explain some results related to the Ahlfors regular conformal dimension, which coincides with the critical value p whether our $(1, p)$-Sobolev space is embedded in the set of continuous functions. This is based on joint work with Mathav Murugan (The University of British Columbia).

Tue

Tuesday, 24 September 2024

09:00 – 09:50	**KN Falconer**	*70 Years of Fractal Projections*
09:50 – 10:30	**IT Sahlsten**	L^2 *flattening in Fourier decay*
coffee break		
11:00 – 11:50	**KN Bandt**	*Automata-generated compact spaces and the scenery flow of self-similar sets*
11:50 – 12:30	**IT Jordan**	*Multifractal analysis for self-affine measures with diagonal matrices*
lunch break		
14:00 – 15:30	**Parallel Sessions**	*see next page*
coffee break		
16:00 – 16:50	**KN Pramanik**	*Numbers - are they normal?*
dinner		

Program of the Parallel Sessions

Parallel Session 1 (Room B101)

14:00 – 14:30	**Seuret**	*Multifractality of the von Koch function*
14:30 – 15:00	**Rible**	*Multifractal properties of a trace of a generic function of an inhomogeneous Besov space*
15:00 – 15:30	**Zhang**	*Multivariate multifractal analysis of Lévy funtions*

Parallel Session 2 (Room B201)

14:00 – 14:30	**Tanaka-Ishii**	*Correlation Dimension of Large Language Models*
14:30 – 15:00	**Ferdania**	*Exploring the Morphology of Mitochondria in Breast Cancer Cells through Fractal Analysis in Fluorescence Imaging*
15:00 – 15:30	**Prehl**	*Randomised mixed labyrinth fractals*

Parallel Session 3 (Room B003)

14:00 – 14:30	**Kigami**	*Conductive homoneneity of polygon-based self-similar sets*
14:30 – 15:00	**Alonso Ruiz**	*Where may p-energies come from? On a quest to find them in Cheeger spaces*
15:00 – 15:30	**Anttila**	*On Constructions of Fractal Spaces Using Replacement and the Combinatorial Loewner Property*

Keynote lecture	Kenneth Falconer	09:00 – 09:50

70 Years of Fractal Projections

Kenneth Falconer
(University of St Andrews)

In 1954 John Marstrand published a paper that included a proof of what is now referred to as Marstrand's Projection Theorem. Since then numerous generalisations, specialisations and variants of this theorem have been developed. The talk will some of these, and present some old and new results on this theme.

Invited Talk	Tuomas Sahlsten	09:50 – 10:30

L^2 flattening in Fourier decay

Tuomas Sahlsten
(University of Helsinki)

We present a unified approach to bound the decay rate of Fourier transforms of fractal measures based on the L^2 flattening phenomenon in $\mathbb{R}^d$ together with sufficient separation of random frequencies sampled by the dynamics. The method applies simultaneously to Diophantine self-similar-, non-linear self-conformal- and non-linear non-conformal measures as well as the Patterson-Sullivan measures of convex co-compact hyperbolic manifolds generalising many recent results to higher dimensions and avoiding e.g. renewal theory and the discretised sum-product theorem. Consequences include new equidistribution theorems for vectors on fractals, fractal uncertainty principles and new bounds for the essential spectral gap of scattering resonances on hyperbolic manifolds. Joint work with Simon Baker (Loughborough) and Osama Khalil (Chicago)

Keynote lecture	**Christoph Bandt**	**11:00 – 11:50**

Automata-generated compact spaces and the scenery flow of self-similar sets

Christoph Bandt
(University of Greifswald)

Neighbor graphs and neighborhood graphs have been used by various authors to study topological and geometrical properties of self-similar and self-affine sets. We consider such finite-state automata in a much more general context including graph-directed constructions, Kleinian limit sets, certain Julia sets, and all simplicial complexes. Our automata describe the quotient map from a symbolic space onto a topological space. In the abstract setting we define the dynamical boundary, which is again an automata-generated space, and the dynamical interior, which is a certain type of manifold. The interior of the Sierpinski triangle, for instance, is the Appolonian gasket with its rich group of homeomorphisms. For finite type self-similar sets this viewpoint leads to new methods of visualization and new parameters for description. A slightly modified version of the scenery flow is given by a Markov chain.

Invited Talk	**Thomas Jordan**	**11:50 – 12:30**

Multifractal analysis for self-affine measures with diagonal matrices

Thomas Jordan
(University of Bristol)

Multifractal analysis typically involves defining level sets in terms of some local quantity and seeing how some suitable notion of dimension (usually Hausdorff). In this talk we will look at this for the local dimension of self-affine measures where the matrices in the system are diagonal. We will show how even very simple examples can yield phase transitions and for the Lalley-Gatzouras family in $\mathbb{R}^2$ we will look at the problem of whether the level sets satisfy a variational principle. That is whether their Hausdorff dimension is given by the superemum of dimension of Bernoulli measures supported on the set. This is joint work with Istvan Kolossvary and Alex Rutar.

Parallel Session 1 (B101) **Stéphane Seuret** **14:00 – 14:30**

Multifractality of the von Koch function

Stéphane Seuret
(Université Paris-Est Créteil)

Everyone knows the famous Von Koch snowflake, introduced by von Koch in his article published in Acta Math. in 1906. In the same article, and actually this was one of the main purposes of the article, von Koch built a continuous nowhere differentiable function using a simple geometric construction, enriching the class of such functions (like the Weierstrass, Takagi, etc function, mainly based on Fourier series). It turns out that this function has not been studied before, and we prove that it enjoys a rich multifractal structure relying on the study of an interesting dynamical system. This is a joint work with Z. Buczolich and Y. Demichel.

Parallel Session 1 (B101) **Quentin Rible** **14:30 – 15:00**

Multifractal properties of a trace of a generic function of an inhomogeneous Besov space

Quentin Rible
(Université Paris-Est Créteil)

To provide a framework for modeling phenomena with a known multifractal spectrum, Julien Barral and Stéphane Seuret have introduced inhomogeneous Besov spaces $B^{\mu}_{p,q}(\mathbb{R}^D)$. Let $D = d+d'$ be an integer. This talk will present these spaces and discuss the multifractal properties of traces $f_a : x \in \mathbb{R}^d \mapsto f(x,a) \in \mathbb{R}$ for any function and for generic functions of these spaces.

Parallel Session 1 (B101) **Qian Zhang** **15:00 – 15:30**

Multivariate multifractal analysis of Lévy funtions

Qian Zhang
(Université Paris-Est Créteil)

We study the sets of points where a Lévy function and a translated Lévy function share a given couple of Hölder exponents. The multivariate multifractal spectrum, i.e., the function which, for each couple, associates the Hausdorff dimension of the corresponding set, is estimated and we study its dependency on the translation parameter. Besides, we determine the univariate multifractal Legendre spectra and the multivariate multifractal Legendre spectra of shifted Lévy functions. This allows to explore how the validity of the multivariate multifractal formalism depends on the shift parameter.

Parallel Session 2 (B201) Kumiko Tanaka-Ishii 14:00 – 14:30

Correlation Dimension of Large Language Models

Kumiko Tanaka-Ishii
(Waseda University)

The correlation dimension of large language models (LLM) is measured by applying the Grassberger-Procaccia algorithm. This method, previously studied only in a Euclidean space, is reformulated in a statistical manifold. LLM exhibits a multifractal, with global self-similarity and a universal dimension around 6.5, which is smaller than those of simple discrete random sequences and larger than that of a Barabási-Albert process. Our findings provide an understanding of the long memory and self-similar nature of natural language. Our method is applicable to any probabilistic model of real-world discrete sequences, and we show an application to music data. The original paper of this talk is co-authored with Dr. Duxin of Waseda University, published as follows from Physical Review Research. https://journals.aps.org/prresearch/abstract/10.1103/PhysRevResearch.6.L022028

Parallel Session 2 (B201) Fitri Ferdania 14:30 – 15:00

Exploring the Morphology of Mitochondria in Breast Cancer Cells through Fractal Analysis in Fluorescence Imaging

Fitri Ferdania
(University of Birmingham)

Fractal geometry is a powerful mathematical tool used extensively in texture analysis to quantify and characterise complex patterns and structures within images. It operates on the principle that many natural and synthetic textures exhibit self-similarity across different scales, meaning patterns at smaller scales resemble those at larger scales. Two pivotal measurements in fractal geometry, box-counting dimension and lacunarity, play crucial roles in assessing the complexity and irregularity of structures and quantifying the distribution of gaps within the objects, respectively. In this research, we delve into the application of fractal geometry techniques to examine fluorescence image data of mitochondria in breast cancer cells subjected to various treatments. These treatments include the chemotherapy drug (Paclitaxel), mitochondria division inhibitor (MDivi-1), hypoxia-induced chemical (CoCl2), and mitochondria elongation inhibitor (MYLS22). By employing box-counting di mension and lacunarity as analytical tools, our research endeavours to unveil distinct patterns and characteristics associated with different treatments, aiming to enhance our understanding of the corresponding mitochondrial dynamics.

Parallel Session 2 (B201) **Janett Prehl** **15:00 – 15:30**

Randomised mixed labyrinth fractals

Janett Prehl
(TU Chemnitz)

Fractals, introduced by Benoit Mandelbrot in the early 1980s, allow the analysis of physical properties of natural geometries and structures in non-integer dimensions. It has been shown recently, that utilizing fractals structures, for instance for gas sensors made of carbon nanotubes increase their efficiency or give new insights to complex quantum phenomena. Here, we are interested how the effect of randomness, as observed in real materials, alter the topology and thus dynamics of the resulting fractal structures in comparison to the pure cases. We focus on a special class of Sierpinski carpets, i.e., the labyrinth fractals [1], that can be used for dendritic networks or porous materials. Therefore, we mix two fractal patterns, with different properties, i.e., shortest path and random walk dimension, randomly together at different mixing ratios. Surprisingly, we found that even in cases where the initial patterns exhibit the same non-integer dimensions the resulting randomised fractals give a different property [2].

[1] L.L. Cristea and B. Steinsky, Proc. Edinburgh Math. Soc. 54.4 (2011) 329.
[2] J. Prehl, D. Dick, and L.L. Cristea, to be submitted to J. Math. Physics. (2024).

Parallel Session 3 (B003) Jun Kigami 14:00 – 14:30

Conductive homoneneity of polygon-based self-similar sets

Jun Kigami
(Kyoto University)

We introduce a new class of self-similar sets called locally symmetric polygon-based self-similar sets and consider the construction of Sobolev spaces on them. This is a joint work with Y. Ota.

Parallel Session 3 (B003) Patricia Alonso Ruiz 14:30 – 15:00

Where may p-energies come from? On a quest to find them in Cheeger spaces

Patricia Alonso Ruiz
(University of Jena)

The classical p-energy is a functional that arises by integrating the pth power of the gradient. Is associated operator is the p-Laplacian, that serves as the basis of many non-linear problems in PDE. Being defined in terms of a gradient, one runs into trouble when the underlying space has no straightforward notion of the latter. Can one still find a natural notion of p-energy in the absence of a gradient? Motivated by this question, we present a way to construct p-energy forms in the framework of Cheeger spaces without involving their differential structure. Instead, we exploit characteristic features of Cheeger spaces such as the doubling property and a (p, p)-Poincaré inequality with respect to Lipschitz functions.

Parallel Session 3 (B003) **Riku Anttila** **15:00 – 15:30**

On Constructions of Fractal Spaces Using Replacement and the Combinatorial Loewner Property

Riku Anttila
(University of Jyväskylä)

The combinatorial Loewner property was introduced by Bourdon and Kleiner as a quasisymmetrically invariant substitute for the Loewner property for general fractals and boundaries of hyperbolic groups. While the Loewner property is somewhat restrictive, the combinatorial Loewner property is very generic – Bourdon and Kleiner showed that many familiar fractals and group boundaries satisfy it. If X is quasisymmetric to a Loewner space, it has the combinatorial Loewner property. Kleiner conjectured in 2006 that the converse to this holds for self-similar fractals – the hope being that this would lead to the existence of many exotic Loewner spaces. We disprove this conjecture and give the first examples of spaces which are self-similar and combinatorially Loewner and which are not quasisymmetric to Loewner spaces. In the process we introduce a self-similar replacement rule, called a linear replacement rule, which is inspired by the work of Laakso. This produces a new rich class of fractal spaces, where closed form computations of potentials and their conformal dimensions are possible. These spaces exhibit a rich class of behaviors from analysis on fractals in regards to diffusions, Sobolev spaces, energy measures and conformal dimensions. These behaviors expand on the known examples of Cantor sets, gaskets, Vicsek sets, and the often too difficult carpet-like spaces. Especially the counter examples to Kleiner's conjecture that arise from this construction are interesting, since they open up the possibility to study the new realm of combinatorially Loewner spaces that are not quasisymmetric to Loewner spaces.

Keynote lecture	Malabika Pramanik	16:00 – 16:50

Numbers - are they normal?

Malabika Pramanik
(University of British Columbia)

They say the only normal people are the ones you don't know very well. What about numbers? Which ones are normal, and how well do we know them? The notion of mathematical normality is related to the occurrence of different digits in a number. Roughly speaking, a normal number is one in which every block of digits appears with the same limiting frequency. For example, 0.12345678910111213.. is normal in base 10, but 0.1212121212... is not. Normality of numbers is connected to many areas of mathematics, like diophantine approximation, ergodic theory, geometric measure theory, analysis, fractal geometry and computer science. We will discuss a few open problems about normal numbers that lie at the intersection of harmonic analysis and measure theory, and mention some recent progress on them.

Wednesday, 25 September 2024

09:00 – 09:50	**KN Tyson**	*Distortion of dimension by Sobolev and quasi-symmetric mappings*
09:50 – 10:30	**IT Koivusalo**	*Dynamical subsets in iterated function systems*

coffee break

11:00 – 11:50	**KN Sumi**	*Mean stability and bifurcations in random dynamical systems of polynomial automorphisms on* $\mathbb{C}^2$
11:50 – 12:30	**IT Morris**	*Linear images of self-affine fractals*

lunch break

13:30 – 18:30 **Excursions/ Free time**

dinner

Keynote lecture | **Jeremy Tyson** | **09:00 – 09:50**

Distortion of dimension by Sobolev and quasisymmetric mappings

Jeremy Tyson
(University of Illinois at Urbana-Champaign)

We discuss the distortion of metric notions of dimension by mappings in various regularity classes, including mappings with first-order Sobolev regularity as well as homeomorphisms with well-behaved metric distortion (e.g. quasiconformal or quasisymmetric mappings). The study of quasiconformal distortion of Hausdorff dimension originated in the work of Gehring and Väisälä in the 1970s. We discuss Sobolev distortion of Hausdorff dimension as well as other notions (Minkowski dimension, Assouad dimension, and various interpolating quantities such as the Assouad spectrum). For families of subsets indexed by a suitable probability measure, we obtain almost sure dimension distortion estimates which improve on the universal estimates which hold for all source sets of a given dimension. Beyond the classical Euclidean setting, such questions are of interest in other ambient environments such as sub-Riemannian Carnot groups and metric measure spaces satisfying the Poincaré inequality.

Invited Talk | **Henna Koivusalo** | **09:50 – 10:30**

Dynamical subsets in iterated function systems

Henna Koivusalo
(University of Bristol)

The classical shrinking target problem concerns the following set-up: Given a dynamical system (T, X) and a sequence of targets $(B_n) \subset X$, we investigate the size of the set of points $x \in X$ for which $T^n(x) \in B_n$ for infinitely many n. There are many natural variants of this problem, some of which are much harder than the original shrinking target problem and require a vastly different toolkit. For example, one might be interested in the size of the liminf set of eventually always hitting points; or the size of a dynamical covering set, a limsup set of points hitting infinitely many target sets translated along orbits. In this talk I will discuss some of these problems in the context of iterated function systems, finishing with a hot-off-the-press result on dynamical covering sets (joint with Balazs Barany and Sascha Troscheit).

Keynote lecture **Hiroki Sumi** **11:00 – 11:50**

Mean stability and bifurcations in random dynamical systems of polynomial automorphisms on $\mathbb{C}^2$

Hiroki Sumi
(Kyoto University)

We consider random dynamical systems of polynomial automorphisms of $\mathbb{C}^2$ (complex generalized Hénon maps and their conjugate maps) on $\mathbb{C}^2$. We show that a generic such system has the "mean stability" and satisfies that (1) for every initial value z, for almost every sequence of maps in the system, the Lyapunov exponents of the sequence at z are negative, and (2) there exist only finitely many minimal sets of the system and those minimal sets are attracting. Note that those phenomena (1)(2) cannot hold for any deterministic dynamical system of iterations of a single complex generalized Hénon map. To show the above results, we investigate the bifurcations in families of random dynamical systems of polynomial automorphisms on $\mathbb{C}^2$. We see many phenomena (so-called randomness-induced phenomena) in random dynamical systems which cannot hold for any deterministic dynamical system of a single map. In this talk we see "randomness-induced order". In fact, many kinds of maps in one system cooperate together automatically so that they make the chaoticity of the system much weaker and give the system a kind of order. We call such a phenomenon "cooperation principle". Note that even if the random dynamical system has such an order, the system still has a kind of complexity. Thus it is an interesting problem to observe the gradation between chaos and order for such systems. For the study of complex-one-dimensional random dynamical systems, see H. Sumi, Negativity of Lyapunov Exponents and Convergence of Generic Random Polynomial Dynamical Systems and Random Relaxed Newton's Methods, Commun. Math. Phys. 384, 1513–1583 (2021).

Invited Talk **Ian Morris** **11:50 – 12:30**

Linear images of self-affine fractals

Ian Morris
(Queen Mary University of London)

In this talk I will describe how Falconer's classical results on the Hausdorff dimension of self-affine fractals can be extended to the images of those sets under arbitrary linear projections. I will also describe some consequences for the *exceptional projections* of self-affine sets in the sense of Marstrand's projection theorem. This is joint work with Çağrı Sert.

Thursday, 26 September 2024

09:00 – 09:50	**KN Velani**	*Shrinking targets and recurrence*
09:50 – 10:30	**IT Chen**	*Heat kernel gradient bounds on the Vicsek set*
coffee break		
11:00 – 11:50	**KN Mendivil**	*Generalized Assouad-like dimensions*
11:50 – 12:30	**IT Rozanova-Pierrat**	*Inverse and scattering problems on extension domains*
lunch break		
14:00 – 15:30	**Parallel Sessions**	*see next page*
coffee break		
16:00 – 17:00	**Parallel Sessions**	*see next page*
20:00	**conference dinner**	

Parallel Session 1 (Room B101)

14:00 – 14:30	**Feng**	*Critical exponents and dimension for generalised limit sets*
14:30 – 15:00	**Samuel**	*From Sturmians to random substitutions and their Rauzy Fractals*
15:00 – 15:30	**Usuki**	*On a lower bound of the number of integers in Littlewood's conjecture*
16:00 – 16:30	**Leppänen**	*Rate of memory loss in non-stationary dynamical systems with some hyperbolicity*
16:30 – 17:00	**Suzuki**	*Dimension spectrum of digit frequency sets for beta-expansions*

Parallel Session 2 (Room B201)

14:00 – 14:30	**Máthé**	*Nikodym type sets avoiding lines in many directions*
14:30 – 15:00	**Banaji**	*Fourier decay for nonlinear pushforwards of self-similar measures*
15:00 – 15:30	**Rakhmonov**	*The quotient set of the quadratic distance set over finite fields and other related topics*
16:00 – 16:30	**Agrawal**	*Dimension of set-valued functions and their distance sets*
16:30 – 17:00	**de Orellana**	*The continuity of exceptional estimates for orthogonal projections*

Parallel Session 3 (Room B003)

14:00 – 14:30	**Stollmann**	*Strong convergence of operators on varying spaces*
14:30 – 15:00	**Epperlein**	*Hölder Continuity of the Joint Spectral Radius*
15:00 – 15:30	**Schefer**	*Continuity Equations on metric Graphs and Fractals*
16:00 – 16:30	**Teplyaev**	*Convergence of eigenvalues and diffusions in non-smooth settings*
16:30 – 17:00	**Herrmann**	*Products of Fractals, Coefficients and Stochastic Calculus*

Keynote lecture	**Sanju Velani**	**09:00 – 09:50**

Shrinking targets and recurrence

Sanju Velani
(University of York)

Let (X, d) be a compact metric space and $(X, \mathcal{A}, \mu, T)$ be a probability measure preserving system. Furthermore, given a real, positive function $\psi : \mathbb{N} \to \mathbb{R}_{\geq 0}$ let

$$R(\psi) := \left\{x \in X : d(T^n x, x) < \psi(n) \text{ for infinitely many } n \in \mathbb{N}\right\}$$

denote the associated recurrent set, and given a point $x_0 \in X$ let

$$W(\psi) := \left\{x \in X : d(T^n x, x_0) < \psi(n) \text{ for infinitely many } n \in \mathbb{N}\right\}$$

denote the associated shrinking target set. Under certain mixing properties it known that if $\sum_{n\in\mathbb{N}} \psi(n)$ diverges then both the recurrent and shrinking target sets are of full μ-measure. The purpose of this talk is discuss the potential quantitative strengthening of these full measure statements.

This is ongoing work with Bing Li (SCUT) and David Simmons (York).

Invited Talk	**Li Chen**	**09:50 – 10:30**

Heat kernel gradient bounds on the Vicsek set

Li Chen
(Aarhus University)

In this talk, we discuss functional inequalities and gradient bounds for the heat kernel on the Vicsek set. The Vicsek set has both fractal and tree structure, whereas neither analogue of curvature nor obvious differential structure exists. We introduce Sobolev spaces in that setting and prove several characterizations based on a metric, a discretization or a weak gradient approach. We also obtain general L^p Poincaré inequalities and pointwise gradient bounds for the heat kernel. These properties have important applications in harmonic analysis like Sobolev inequalities and the Riesz transform. Moreover, several of our techniques and results apply to more general fractals and trees.

Keynote lecture	Franklin Mendivil	11:00 – 11:50

Generalized Assouad-like dimensions

Franklin Mendivil
(Acadia University)

The Assouad and quasi-Assouad dimensions quantify a set's most extreme local box-counting behaviour over some (moving) range of scales. This is also true for various refinements of these dimensions such as the θ-Assouad spectrum and the Assouad-like ϕ-dimensions, which provide more specific control over the range of scales considered. These same Assouad-like dimensions are also available to quantify Borel measures. In this talk I will introduce the ϕ-dimensions and tell a story of how we used them in the context of cut-out subsets of $[0,1]$ (in particular random rearrangements of them) and then in studying random self-similar Moran constructions.

Invited Talk	Anna Rozanova-Pierrat	11:50 – 12:30

Inverse and scattering problems on extension domains

Anna Rozanova-Pierrat
(Centrale Supélec)

I will present recent results obtained in collaboration with G. Claret, M. Hinz and A. Teplyaev, mostly presented in the preprint https://hal.science/hal-04505158 We use the well-posedness of transmission problems on classes of two-sided Sobolev extension domains to give variational definitions for (boundary) layer potential operators and Neumann-Poincaré operators. These classes of domains contain Lipschitz domains, and also domains with fractal boundaries. Although our variational formulation does not involve any measures on the boundary, we recover the classical results in smooth domains by considering the surface measure on the boundary. We discuss properties of these operators and generalize basic results in imaging beyond the Lipschitz case (see works of H. Ammari, H. Kang and J.K. Seo for the Lipschitz case). In addition, in the case of a bounded extension domain with the outside corkscrew condition, the generalization of the Dirichlet-to-Neumann (or Poincaré-Stek lov) operator allows us to generalize Alessandrini's (1991) stability result for the Calderon inverse conductivity problem.

Parallel Session 1 (B101) Tianyi Feng 14:00 – 14:30

Critical exponents and dimension for generalised limit sets

Tianyi Feng
(University of St Andrews)

There is a beautiful and well-studied relationship between the Poincaré exponent and the fractal dimensions of the limit set of a Kleinian group. Motivated by this, given an arbitrary discrete subset of the unit ball we define a critical exponent and investigate how it relates to the fractal dimensions of the associated generalised limit set. This is a joint work with Jonathan Fraser.

Parallel Session 1 (B101) Tony Samuel 14:30 – 15:00

From Sturmians to random substitutions and their Rauzy Fractals

Tony Samuel
(University of Birmingham and University of Exeter)

Aperiodic sequences and sequence spaces form prototypical mathematical models of quasicrystals. The most quintessential examples include subshifts of Sturmian words and substitutions, which are ubiquitous objects in ergodic theory and aperiodic order. Two of the most striking features these shift spaces have, are that they have zero topological entropy and are uniquely ergodic. Random substitutions are a generalisation of deterministic substitutions, and in stark contrast to their deterministic counterparts, subshifts of random substitutions often have positive topological entropy and exhibit uncountably many ergodic measures. Moreover, they have been shown to provide mathematical models for physical quasicrystals with defects. We will begin by talking about subshifts generated by Sturmian words and ways to measure their complexity beyond topological entropy, and show how this measure of complexity can be used to build a classification via Jarník sets. We will then build a bridge between these subshifts and subshifts of random substitutions. We will conclude with some recent dynamical results on subshifts of random substitutions and ways to visualise these subshifts. Namely, we will present a method to build a new class of Rauzy fractals.

Parallel Session 1 (B101) **Shunsuke Usuki** **15:00 – 15:30**

On a lower bound of the number of integers in Littlewood's conjecture

Shunsuke Usuki
(Kyoto University)

Littlewood's conjecture is a famous and long-standing open problem which states that, for every (α, β) in $\mathbb{R}^2$, $n\|n\alpha\|\|n\beta\|$ can be arbitrarily small for some integer n. This problem is closely related to the action of diagonal matrices on $\mathrm{SL}(3,\mathbb{R})/\mathrm{SL}(3,\mathbb{Z})$, and a groundbreaking result was shown by Einsiedler, Katok and Lindenstrauss from the measure rigidity for this action, saying that Littlewood's conjecture is true except on a set of Hausdorff dimension zero. I will explain about a new quantitative result on Littlewood's conjecture which gives, for every (α, β) in $\mathbb{R}^2$ except on sets of small Hausdorff dimension, an estimate of the number of integers n which make $n\|n\alpha\|\|n\beta\|$ small. The keys for the proof are the measure rigidity and further studies on behavior of empirical measures for the diagonal action.

Parallel Session 1 (B101) **Juho Leppänen** **16:00 – 16:30**

Rate of memory loss in non-stationary dynamical systems with some hyperbolicity

Juho Leppänen
(Tokai University)

We study the notion of statistical memory loss in non-stationary dynamical systems described by time-dependent compositions $T_n \circ \cdots \circ T_1$, where each map $T_i : X \to X$ is a self-map of a bounded metric space equipped with a reference probability measure m. Memory is said to be lost (in the strong sense) if for any two sufficiently regular initial densities ρ_0 and ρ_0',

$$\lim_{n\to\infty} \int |\rho_n - \rho_n'| \, dm \to 0,$$

where ρ_n and ρ_n' denote the time-evolutions of ρ_0 and ρ_0', respectively. This notion was introduced by Ott, Stenlund, and Young (Math. Res. Lett., 2009) in a context of uniformly expanding maps, and subsequently explored in the literature by several authors. Estimates on the rate of memory loss are important tools for obtaining more advanced limit theorems, such as concentration inequalities and quantitative central limit theorems.

In (Korepanov & Leppänen, Comm. Math. Phys., 2021), we developed a coupling approach to analyze the rate of memory loss in non-uniformly expanding non-stationary dynamical systems. We considered an abstract framework where the time-dependent trajectory makes frequent returns to a reference set $Y \subset X$, with first return dynamics that have "good" distortion properties. We derived polynomial (stretched exponential) rates of memory loss depending on the tails of return times, which were assumed to decay at a uniform polynomial (stretched exponential) rate with respect to the chosen sequence of maps $T_1, T_2, \ldots$. In work in progress (joint with A. Korepanov), we further expand our approach to handle non-uniformly decaying tails of return times. This enables us to obtain sharper estimates on the rate of memory loss for sequences in which "good maps" occur sufficiently frequently. Our framework includes piecewise expanding interval maps exhibiting neutral fixed points and/or singularities, and we apply our results to derive (nearly) sharp rates of memory loss for random ergodic compositions of such maps.

Parallel Session 1 (B101) — Shintaro Suzuki — 16:30 – 17:00

Dimension spectrum of digit frequency sets for beta-expansions

Shintaro Suzuki
(Tokyo Gakugei University)

We consider the digit frequency set of the digit 1 for beta-expansions and give a formula for its Hausdorff dimension using the largest positive zero of a certain analytic function associated to the (greedy) expansion of 1. The strategy of the proof is to refine the thermodynamic formalism for beta-shifts, which also yields an explicit formula for an invariant probability measure satisfying conditional variational principle for a simple locally constant function.

Parallel Session 2 (B201) **András Máthé** **14:00 – 14:30**

Nikodym type sets avoiding lines in many directions

András Máthé
(University of Warwick)

A Nikodym set E in the plane is set of full Lebesgue measure with the property that for every point x in E there is a line that goes though x but no other point of E. By a theorem of Davies, we can even require such lines in a dense set of directions (of continuum cardinality) around each point of E. Recently Dabrowski, Goering and Orponen showed that we cannot require the family of such lines to have positive Hausdorff dimension. They proved that for any planar Borel set E, if for each point $x \in E$ there is a t-dimensional family of lines that go through x but no other point of E, then the Hausdorff dimension of E is at most $2-t$. It turns out that their result is sharp. I will present a construction and explain how it is related to projection theorems and the size of the exceptional set of directions.

Parallel Session 2 (B201) **Amlan Banaji** **14:30 – 15:00**

Fourier decay for nonlinear pushforwards of self-similar measures

Amlan Banaji
(Loughborough University)

Determining when the Fourier transform $\widehat{\nu}(\xi)$ of a fractal measure ν on $\mathbb{R}^n$ decays to zero as $|\xi| \to \infty$, and estimating the speed of decay if so, is an important problem. In this talk, we will explain that the Fourier transform of the pushforward of a non-atomic self-similar measure on $\mathbb{R}$ under a sufficiently smooth non-linear map $F\colon \mathbb{R} \to \mathbb{R}$ decays like $|\widehat{F_*\mu}(\xi)| \le C|\xi|^{-\eta}$, even if μ itself has no Fourier decay. This result can be partially extended to pushforwards of self-similar measures on $\mathbb{R}^n$ under non-linear maps $F\colon \mathbb{R}^n \to \mathbb{R}^m$, though there are some additional subtleties in this case. This is based on two projects, joint with Simon Baker and Han Yu respectively.

Parallel Session 2 (B201) Firdavs Rakhmonov 15:00 – 15:30

The quotient set of the quadratic distance set over finite fields and other related topics

Firdavs Rakhmonov
(University of St Andrews)

Let $\mathbb{F}_q^d$ be the d-dimensional vector space over the finite field $\mathbb{F}_q$ with q elements. For each non-zero r in $\mathbb{F}_q$ and $E \subset \mathbb{F}_q^d$, we define $W(r)$ as the number of quadruples $(x, y, z, w) \in E^4$ such that $Q(x-y)/Q(z-w) = r$, where Q is a non-degenerate quadratic form in d variables over $\mathbb{F}_q$. When $Q(\alpha) = \sum_{i=1}^d \alpha_i^2$ with $\alpha = (\alpha_1, \ldots, \alpha_d) \in \mathbb{F}_q^d$, Pham (2022) recently used the machinery of group actions and proved that if $E \subset \mathbb{F}_q^2$ with $q \equiv 3 \pmod 4$ and $|E| \geq Cq$, then we have $W(r) \geq c|E|^4/q$ for any non-zero square number $r \in \mathbb{F}_q$, where C is a sufficiently large constant, c is some number between 0 and 1, and $|E|$ denotes the cardinality of the set E. In this talk, I'll discuss the improvement and extension of Pham's result in two dimensions to arbitrary dimensions with general non-degenerate quadratic distances. As a corollary of our results, we also generalize the sharp results on the Falconer type problem for the quotient set of distance set due to Iosevich-Koh-Parshall. Furthermore, we provide improved constants for the size conditions of the underlying sets.

Parallel Session 2 (B201) Ekta Agrawal 16:00 – 16:30

Dimension of set-valued functions and their distance sets

Ekta Agrawal
(Indian Institute of Information Technology Allahabad)

Dimension estimation of any sets or graphs of real and vector valued functions remains a vibrant area of research in the literature. In recent years, set-valued functions have played a significant role in applied areas such as mathematical modeling, game theory, control theory, and many more. In this talk, we derive several results for the bounds estimation of fractal dimension, like Hausdorff, and the box dimension for the graph of continuous set-valued functions defined on compact interval of real line. Further, some bounds on the dimension estimation of the distance set of graphs of these functions are also discussed. In the end, we shed some light on a celebrated Falconer's distance-set conjecture.

Parallel Session 2 (B201) Ana E. de Orellana 16:30 – 17:00

The continuity of exceptional estimates for orthogonal projections

Ana E. de Orellana
(University of St Andrews)

Since Marstrand's work on orthogonal projections, exceptional set estimates for such projections have been widely studied. Salem sets, i.e. sets for which the Fourier and Hausdorff dimension coincide, have no such exceptions, but using the Fourier dimension alone to improve exceptional set estimates leads to discontinuous bounds. In this talk we will see what conditions we need on the Fourier decay of measures to ensure continuity of the bounds.

Parallel Session 3 (B003) Peter R.M. Stollmann 14:00 – 14:30

Strong convergence of operators on varying spaces

Peter R.M. Stollmann
(TU Chemnitz)

This is a report on joint work with Ali BenAmor, Batu Güneysu and Thomas Kalmes. We use an old concept of continuous fields of Hilbert spaces to extend and unify a wide variety of results on strong convergence of operators that are defined on different spaces.

Parallel Session 3 (B003) Jeremias Epperlein 14:30 – 15:00

Hölder Continuity of the Joint Spectral Radius

Jeremias Epperlein
(Universität Passau)

The joint spectral radius was introduced by Rota and Strang as a generalization of the usual spectral radius from single matrices to compact matrix sets. It has a variety of applications, e.g. in the control of switched linear systems, regularity of wavelets or coding theory. In the context of fractal geometry, Barnsley and Vince characterized the joint spectral radius of an irreducible matrix set as the eigenvalue of the corresponding linear IFS. Endowed with the Hausdorff metric, the space of compact sets of real or complex square matrices of a given dimension becomes a complete metric space. The joint spectral radius maps from this space to the nonnegative reals. We show that this dependence of the joint spectral radius on the matrix set is pointwise Hölder continuous. This generalizes earlier results by Wirth, which showed that, restricted to irreducible matrix sets, the joint spectral radius is even Lipschitz continuous. But just as in the case of the usual spectral radius, we can not hope for Lipschitz continuity in the reducible case. This is joint work with Fabian Wirth.

Parallel Session 3 (B003) Waldemar Schefer 15:00 – 15:30

Continuity Equations on metric Graphs and Fractals

Waldemar Schefer
(Bielefeld University)

In this talk we study first order differential operators on fractals that take functions into functions. These operators generalize first order derivatives on p.c.f. fractals introduced by M. Hino as the derivatives of energy finite functions with respect to an energy-dominant reference function. Here we may also allow energy-dominant differential one-forms as reference elements. In general the domains of such first order differential operators are larger than the domain of the underlying Dirichlet form. We prove an integration by parts formula and well-posedness results for continuity equations on fractals. As a key tool we use recent work of W. Arendt, I. Chalendar, R. Eymard on boundary quadruples.

Parallel Session 3 (B003) Alexander Teplyaev 16:00 – 16:30

Convergence of eigenvalues and diffusions in non-smooth settings

Alexander Teplyaev
(University of Connecticut)

Dirichlet form analysis provides powerful tools for studying diffusions and spectral analysis in non-smooth settings, with Mosco convergence being a standard approach for examining approximations. However, Mosco convergence alone may not suffice to understand finer properties, such as the convergence of eigenvalues and small deviations of diffusion processes. This talk will present recent results that strengthen the Mosco convergence of Dirichlet forms in non-smooth spaces, including fractals, domains with fractal boundaries, and sub-Riemannian spaces. The presentation includes joint work with Michael Hinz, Anna Rozanova-Pierrat, Gabriel Claret, Luke Rogers, Marco Carfagnini, and Masha Gordina.

Parallel Session 3 (B003) Simon Herrmann 16:30 – 17:00

Products of Fractals, Coefficients and Stochastic Calculus

Simon Herrmann
(Bielefeld University)

We consider products of strongly local regular Dirichlet spaces with energy dominant reference measures and with Kusuoka-Hino index one. Examples are products of p.c.f. self-similar fractals. We discuss fiber-wise constructed first order structures, diffusion operators with non-diagonal coefficients and links to stochastic calculus. For the special case of stationary starting distributions, we show how the Fukushima decompositions for suitable coordinate functions can be understood as, roughly speaking, limits of stochastic differential equations.

Friday, 27 September 2024

09:00 – 09:50	**KN Wang**	*The Brownian loop measure on Riemann surfaces and applications to length spectrums*
09:50 – 10:30	**IT Andres**	*Gaussian vs. Sub-Gaussian Behaviour of Random Conductance Models*

coffee break

11:00 – 11:40	**IT Troscheit**	*Quasi-isometric equivalence of Galton-Watson trees and statistically self-similar sets*
11:40 – 12:30	**KN Zähle**	*Lipschitz-Killing curvatures for different classes of fractals*

lunch break

Keynote lecture	Yilin Wang	09:00 – 09:50

The Brownian loop measure on Riemann surfaces and applications to length spectrums

Yilin Wang
(IHES)

Lawler and Werner introduced the Brownian loop measure on the Riemann sphere in studying Schramm-Loewner evolution. It is a sigma-finite measure on Brownian-type loops, which satisfies conformal invariance and restriction property. We study its generalization on a Riemannian surface (X, g). In particular, we express its total mass in every free homotopy class of closed loops on X as a simple function of the length of the geodesic in the homotopy class for the constant curvature metric conformal to g. This identity provides a new tool for studying Riemann surfaces' length spectrum. One of the applications is a surprising identity between the length spectrums of a compact surface and that of the same surface with an arbitrary number of cusps. This is a joint work with Yuhao Xue (IHES).

Invited Talk	Sebastian Andres	09:50 – 10:30

Gaussian vs. Sub-Gaussian Behaviour of Random Conductance Models

Sebastian Andres
(Technische Universität Braunschweig)

The random conductance model (RCM) is a well-established model for a random walk in random environment which has been object of intensive study in the last 15 years. One particular question of interest is whether homogenization occurs, in the sense that the deformities in the random medium are 'smoothed out', so that only an averaged effect remains. Central probabilistic questions in this context include functional central limit theorems for the random walk or local limit theorems for its heat kernel. On the other hand, there are situations when due to trapping effects the local inhomogeneities of the medium persist in the scaling limit and some kind of anomalous, sub-Gaussian behaviour is seen, which is typically observed for Brownian motions on fractal spaces, for instance. In this talk we will give a detailed review those results. In the last part we will discuss some recent results for RCMs with long-range jumps. This last part is based on a joint work in progress with Martin Slowik (Mannheim).

Invited Talk	Sascha Troscheit	11:00 – 11:40

Quasi-isometric equivalence of Galton-Watson trees and statistically self-similar sets

Sascha Troscheit
(Uppsala University)

The Galton-Watson tree, a fundamental model of random trees, is characterised by a single-root vertex from which each descendant vertex independently generates a random number of offspring, with identical distribution. This model underpins numerous critical phenomena and arises in e.g. the study of stochastically self-similar sets. Drawing on the seminal work of Basu, Sidoravicius, and Sly, which established the almost sure bi-Lipschitz equivalence of two independent percolations on the lattice $\mathbb{Z}^d$, we prove the almost sure quasi-isometric equivalence of a large family of Galton-Watson trees. This also implies quasi-symmetric equivalence of a large class of stochastically self-similar sets under some separation conditions. The proof has interesting links to the "car-parking problem" on trees which I will also present in this talk. Based on joint work with Jayadev Athreya.

Keynote lecture	Martina Zähle	11:40 – 12:30

Lipschitz-Killing curvatures for different classes of fractals

Martina Zähle
(Universität Jena)

In this talk we will present some new results for fractal versions of classical Lipschitz-Killing curvatures, including the Minkowski content as marginal case. In the classical differential geometric context they form a complete system of certain geometric invariants. Recent extensions of former fractal notions and relationships concern a large class of random code-tree based fractals with dependencies as well as domains with deterministic piecewise self-similar boundaries. It turned out that such random fractals, including the V-variable model, show a different stochastic behavior than random recursive constructions. However, the formulas for the mean values obtained by approximation with parallel sets in all cases are structurally the same as those for deterministic self-similar sets. (*Joint work with Jan Rataj and Steffen Winter.*)

Poster Contributions

Posters are displayed for the duration of the conference.

There is a dedicated **Poster Session** on Monday starting at 17:00 h.

Please take note of the *Best Poster Award*. Your conference booklet contains a ballot slip for your choice of the three best posters. Please hand in your completed ballot slip by the coffee break on Wednesday morning. The ballot box will be placed in the main lecture hall.

Poster 1 **Nicolas Arevalo**

The Lyapunov spectrum as the Newton-Raphson method for countable Markov interval maps

Nicolas Arevalo
(Pontificia Universidad Católica de Chile)

We consider MRL maps (Markov-Renyi-Lüroth), a class of interval maps with infinitely many branches that can have parabolic fixed points. In this talk, I will present you with some recent results of the Lyapunov spectrum of MRL maps (Multifractal analysis of Lyapunov exponents). One of them is that it coincides with a function directly related to the Newton-Raphson method applied to the topological pressure of $-t \log |T'|$.

Poster 2 **Micky Barthmann**

Vector-valued pointwise ergodic theorems for operators

Micky Barthmann
(TU Chemnitz)

The pointwise ergodic theorem of Birkhoff has been generalized in many directions. One direction of generalization has been to consider linear operators that are more general than Koopman operators, such as Dunford-Schwartz operators, i.e., $L^1 - L^\infty$ contractions on a σ-finite measure space. Another direction of generalization is to consider (finite) measure preserving systems that have stronger mixing properties than ergodicity, as was done for example in the Wiener-Wintner Theorem. I will discuss a uniform vector-valued Wiener-Wintner Theorem for a class of operators that includes compositions of ergodic koopman operators and contractive multiplication operators. This is based on joint work with Sohail Farhangi.

Poster 3 **Laura Breitkopf**

Equidistribution of cusp points of Hecke triangle groups

Laura Breitkopf
(University of Bremen)

In the framework of infinite ergodic theory, we derive equidistribution results for suitable weighted sequences of cusp points of Hecke triangle groups encoded by group elements of constant word length with respect to a set of natural generators. This is a generalization of the corresponding results for the modular group whose cusp points are related to the Stern-Brocot sequence that can be constructed from the Farey mapping. We will introduce generalizations of the Farey mapping and discuss how their dynamical properties yield the equidistribution results. We rely on advanced results from infinite ergodic theory and transfer operator techniques developed for AFN-maps.

Poster 4 **Ryan Bushling**

Packing Dimension of Lineal Extensions and the Generalized Kakeya Conjecture in the Plane

Ryan Bushling
(University of Washington - Seattle)

Let $E \subseteq \mathbb{R}^2$ be a union of 1-Hausdorff-dimensional subsets of lines and let F be the set formed by extending every such subset to a full line. We show that $\dim_{\mathrm{P}} F = \dim_{\mathrm{P}} E$. As a corollary to the main estimate, one obtains a sharp lower bound on $\dim_{\mathrm{P}} E$ in terms of the packing dimension of its direction set, resolving a strong form of the generalized Kakeya conjecture for packing dimension in the plane. Joint work with Jake Fiedler.

Poster 5 **Harsha Gopalakrishnan**

Non-uniqueness of renormalization operator

Harsha Gopalakrishnan
(Indian Institute of Technology, Tirupati)

In this work, I will address whether the renormalization operator defined on the set of all finite energies is unique for a fixed harmonic extension. The answer is found to be negative, and its explanation is given using the Vicsek fractal. This also implies that the harmonic extension algorithm need not depend on the renormalization factor. However, this is not always true since we present a case in Vicsek fractal, in which the harmonic extension depends on the renormalization factor.

Poster 6 **Peter Kern**

Hölder continuity and p-variation of Weierstrass-type functions.

Peter Kern
(Heinrich Heine University Düsseldorf)

We study Hölder continuity and p-variation along b-adic partitions of Weierstrass-type functions. Compared to the well-known Weierstrass function, in these functions the power function is replaced by a submultiplicative function, and the Lipschitz continuous sine and cosine functions are replaced by a general Hölder continuous function. Our results extend some recent results of Schied and Zhang.

Poster 7 **Tetsuo Kurosawa**

Loop-erased random walks on random fractals

Tetsuo Kurosawa
(Tokyo Metropolitan Univercity)

We introduce random pre-branched Koch curves and construct loop-erased random walks on these graphs. For almost every environment $\overline{\nu}$, the loop-erased random walk on the random pre-branched Koch curve converges almost surely to a continuous process X as the edge length tends to 0. The limit process is also self-avoiding while the sample path almost surely has Hausdorff dimension greater than 1.

Poster 8 **Jonas Lippold**

A Family of non Minkowski-Measurable Fractals

Jonas Lippold
(TU Chemnitz)

A long-standing conjecture of Lapidus states that, under certain conditions, self-similar fractal sets are not Minkowski measurable if and only if they are of lattice type. In $\mathbb{R}^1$ the Lapidus conjecture has been confirmed. But in higher dimensions it remains unclear whether the considered lattice type self-similar sets are not Minkowski measurable. In this work, a family of lattice type subsets in $\mathbb{R}^2$ which fail to be Minkowski measurable are presented, supporting the conjecture. Furthermore, an argument on why this sets are not covered by previous results is given.

Poster 9 **Ridip Medhi**

A Unified approach to Ergodicity of Iterated Function Systems

Ridip Medhi
(Research Scholar)

The concept of Iterated Function System (IFS) has been pivotal in fractal geometry, with Hutchinson's classical hyperbolic IFS laying its groundwork. Despite extensive generalizations and extensions of IFS in the literature, the ergodicity of these generalized IFSs remains largely unexplored. Drawing from a detailed analysis of proofs of the ergodic theorem for hyperbolic and weakly hyperbolic IFS, this study introduces the notion of ergodicity-inducing weakly contractive IFS. This framework provides a unified theorem guaranteeing the ergodicity of invariant measures across a spectrum of IFSs, including those whose ergodic properties haven't been thoroughly investigated previously.

Poster 10 **Mridul Patel**

Redefining fractal through Suzuki type generalized φ-contraction mapping

Mridul Patel
(RMIT University)

This article presents a novel approach for generating a fractal interpolation function, also known as the attractor of an iterated function system, using the Suzuki-type generalized φ-contraction mappings. The methodology of constructing α-fractal functions is explained using the Suzuki iterated function system (S-IFS). In addition, we use the method of fractal perturbation of a given function to construct the associated fractal operator, which is associated with the α-fractal function and study some of its properties. Finally, it discusses an analysis of forecasting stock returns through the Suzuki-type fractal interpolation function.

Poster 11 **Hui-An Shen**

A geometric treatment of lossy compression of log-concave random variables

Hui-An Shen
(University of Bern and IP Paris)

Rate-distortion theory concerns the lossy compression of a random sequence subject to a tolerable distortion under a fidelity criterion. The rate-distortion function $R(D)$ characterizes the fundamental limit of lossy compression, in terms of the minimal bits per symbol (R) for a given distortion level D. Using the Shannon-McMillan-Breiman (SMB) Theorem, the rate-distortion function can be understood as the normalized exponential growth rate of the covering number of the typical set, which we refer to as the geometric derivation of the rate-distortion function. Sakrison 1968 provided a geometric derivation for the Gaussian-quadratic rate-distortion function, however, a geometric derivation for most other problems are still missing. We illustrate the difficulty of upper bounding the rate-distortion function geometrically, with two well-known classical approaches in information theory and dimension theory respectively. In particular, we consider firstly Sakrison's geometric random coding approach, and secondly, upper bounding the covering number under different relative scales (similar to the Assouad dimension) and under bi-Lipschitz maps, and illustrate how both approaches fail to provide a straightforward geometric derivation beyond the Gaussian-quadratic rate-distortion problem. Finally, we circumvent these difficulties by using a deviation inequality for concentration in normed spaces (Paouris and Valettas 2018), and show the geometric derivation of the rate-distortion function can be generalized to sources of a symmetric continuous log-concave density with their matched distortion metrics.

Poster 12 **Sven van Golden**

Dimensions of infinitely generated self-affine sets

Sven van Golden
(University of Birmingham and Leiden University)

In recent years much work has been done towards finding the fractal dimensions of the limit sets of finite affine iterated function systems, also known as self-affine sets. Of particular interest are conditions under which the Hausdorff dimension of such sets equals the affinity dimension, a value introduced by Falconer in 1988. Even more recently, this concept has been extended to self-affine sets generated by infinite iterated function systems. In this joint work with C. Kalle, S. Kombrink and T. Samuel we consider self-affine sets generated by countably infinite iterated function systems where each affine map has diagonal linear parts. We introduce a family of such self-affine sets in the plane that arise from the restricted digit sets for signed Lüroth expansions. Moreover, we study their vertical fibres to find conditions under which their Hausdorff dimensions equal the affinity dimension.

Poster 13 **Charlie Wilson**

Limitations of deducing measures of limsup sets from finite intersections and implications to Borel-Cantelli type inequalities

Charlie Wilson
(Exeter University)

Finding the measure of a limsup set is generally a difficult problem but one nonetheless of great interest in a wide array of areas. Early results by Borel-Cantelli and more recently Erdös-Chung, Frolov and Feng-Li-Shen have provided bounds for the measure of the limsup set in terms of measures of its constituent sets and their intersections. Despite progress being made to give stronger bounds we cannot expect to find a complete form. That is, the measure of the limsup set cannot always be deduced from the measures of sets and pairwise intersections. We go further and construct counterexamples wherein we have 2 sequences of sets whose individual measures all the way up to k-wise intersection measure $\mu(A_{i_1} \cap A_{i_2} \cap ... \cap A_{i_k})$ are comparable but one sequence will have limsup measure 1 and the other 0. We later to go on to see that if we control all finite intersections (not just up to k intersections) then we do indeed fix the limsup measure. This result has ramifications reaching as far as Number Theory, Diophantine approximation, Graph theory and Probability theory.

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