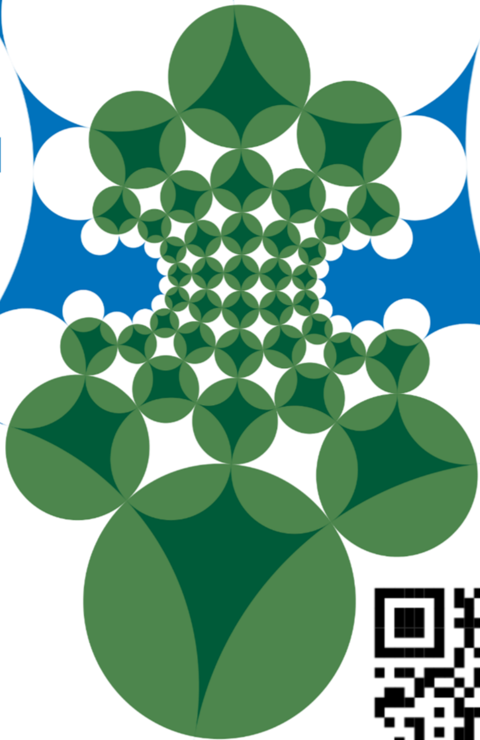
7th BMS Student Conference

February 20-22, 2019

Berlin Mathematical School



Location

MA 141
Maths Building
TU Berlin

bmsstudconf.github.io/2019/

Welcome!

It is our pleasure to welcome you to Berlin and the 7th BMS Student Conference! The conference is organized by students for students, aiming to connect current and prospective students of mathematics (and related disciplines) in Berlin. Its main goals are to help current students learn about each other's interests and to help prospective students get to know better Berlin's mathematical landscape as well as the social environment at the BMS.

In this booklet, you can find information about the conference, including a schedule of events, list of abstracts, and map of the TU campus. Most of the information is also available on the conference webpage.

We would like to thank Professor Martina Juhnke-Kubitzke and Professor Olga Holtz for accepting our invitations, the student speakers for contributing to our conference, and all participants for joining us at this event. We are also grateful to the BMS for supporting this initiative and to all of our fellow students who helped with the organization; in particular, we would like to thank Alexander Fairley for designing the conference poster and cover page of this booklet.

If you have any questions or concerns, please do not hesitate to contact us. We wish you a great time at our conference!

Organizers:

Simona Boyadzhiyska	(FU Berlin)
Candan Güdücü	(TU Berlin)
Michael Rothgang	(HU Berlin)
Massimo Secci	(TU Berlin)
Nicola Vassena	(FU Berlin)

Website:

https://bmsstudconf.github.io/2019/

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Schedule

Time	Wednesday 20/02	Thursday 21/02	Friday 22/02
09:30 – 10:00	Registration		
10:00 – 10:25	Opening (10:15 – 10:30)	Registration	
10:30 – 10:55	**von Lindheim**	**Skrodzki**	**Lagoda**
11:00 – 11:25	**Güdücü**	**Boyadzhiyska**	**Klose**
11:30 – 12:00	Coffee break	Coffee break	Coffee break
12:00 – 12:25	**Yürük**	**Juhnke-Kubitzke** (Invited speaker)	**Codenotti**
12:30 – 12:55	**Fairley**		**Tonelli Cueto**
13:00 – 14:30	Lunch	Lunch	Closing & Lunch
14:30 – 14:55	**Kreutzer**	**Holtz** (Invited speaker)	
15:00 – 15:25	**Tóbiás**		
15:30 – 16:00	Coffee break	Coffee break	
16:00 – 16:25	**Maestro Pérez**	**Olarte**	
16:30 – 16:55		**Padilla**	
17:30 – 18:30	Tränenpalast tour		
19:00 –		Wine & Cheese	

Venue

The conference will take place at the Mathematics building (MA) of the Technische Universität Berlin, Straße des 17. Juni 136, in lecture hall MA141.

How to get to TU Berlin

The university can be reached by public transportation. There are several options available:

- U-Bahn line U2[1], at the stop U Ernst-Reuter Platz, plus approximately 5 minutes of walking.
- Buses M45, X9 and 245, at the stop U Ernst-Reuter Platz or Marchstraße, plus approximately between 5 and 10 minutes of walking.
- S-Bahn lines S3, S5, S7, and S9 at the stop S Tiergarten, plus approximately 10 minutes of walking.
- U-Bahn line U9, at the stop S+U Zoologischer Garten, plus approximately 20 minutes of walking.

For more information, please check `fahrinfo.bvg.de`.

Where to eat

There are several places to eat near the conference venue. The first three in the list below offer special prices for students. In order to pay for your meal there, you need a Mensa card. You can obtain a Mensa card from the machines in front of the Mensa; for that, you need to pay a deposit of 1,55€, which will be refunded to you if you return your card before leaving Berlin. You will need to present a valid student ID to receive a discount on the Mensa prices. In the following list, the prices pertain to a simple menu excluding drinks. Student prices are used where applicable.

- TU Mensa (3 – 5€, Mensa card only), Hardenbergstraße 34.
- TU Cafeteria Ernst-Reuter-Platz/Architekturgebäude (4 – 5€, Mensa card only), Straße des 17. Juni 152.
- TU Cafeteria Skyline (4 – 5.50€, cash and Mensa card), Ernst-Reuter-Platz 7.

[1] Please keep in mind that, due to construction work, there is no train service on the U2 between U Zoologischer Garten and U Gleisdreieck. Please check the available alternatives online if you plan to use the U2 to reach TU Berlin.

- TU Math Canteen (2.50 – 4.50€, cash only), 9th floor of the conference venue.
- TU Math Cafeteria (2.70 – 5€, cash only), ground floor of the conference venue.
- cafénero Volkswagenbibliothek (4 – 7€, cash only), Fasanenstraße 88.

Campus map [2]

[2]Image adapted from www.tu-berlin.de/menue/service/standortuebersicht/campusplan/.

Social events

Visit to the Tränenpalast (Palace of Tears)

In the time of the Berlin Wall, the Tränenpalast (Palace of Tears) at the Berlin Friedrichstraße station was a border crossing point between West and East Berlin. Now it is an interactive museum with an exhibition about the Cold War and the German reunification. This historical site, where many Germans had to say goodbye to their loved ones, offers a moving exhibition allowing visitors to learn about life in divided Germany and experience some of the border crossing procedures. For more information, visit `www.hdg.de/en/traenenpalast/permanent-exhibition/`.

On Wednesday, February 20, there will be a group visit to the Tränenpalast. The guided tour will start at 17:30. All conference participants interested in joining the event should let the organizers know by noon that day. This can be done via email or during registration on Wednesday morning. Please note that the tour is limited to 25 participants. Registration is on a first-come, first-served basis.

To get to the Tränenpalast, we will meet on the ground floor of TU Berlin near the main entrance after the last talk on Wednesday and will leave TU at 16:45. If you prefer, you can meet us at the entrance of the Tränenpalast at 17:20.

Wine & Cheese

Our traditional Wine & Cheese evening is one of the highlights of the BMS year and is an opportunity to enjoy trying different kinds of wine and cheese in the company of many current and prospective members of the BMS. You don't drink alcohol or don't like cheese? No problem! You can socialize just as well over a non-alcoholic drink or other snacks.

This event will take place on Thursday, February 21, starting at 19:00 in the TU BMS Lounge (Straße des 17. Juni 136, 10623 Berlin, room MA209).

Invited speakers

Martina Juhnke-Kubitzke

Martina Juhnke-Kubitzke is a Professor of Discrete Mathematics at the University of Osnabrück. She obtained her PhD from the Philipps-Universität Marburg/Lahn in 2009 under the supervision of Volkmar Welker. Before joining the University of Osnabrück, she has held positions as a postdoctoral researcher in Reykjavík (Háskólin í Reykjavík), Vienna (University of Vienna), and Frankfurt am Main (Goethe-Universität). Her research interests include algebraic and topological combinatorics, discrete and convex geometry, and real algebraic geometry.

For more information, visit her webpage: https://tina.juhnix.net.

Olga Holtz

Olga Holtz is a Professor of Mathematics at the University of California-Berkeley, a Professor of Applied Mathematics at the Technical University Berlin, and a member of the BMS faculty. She obtained her PhD in mathematics from the University of Wisconsin-Madison in 2000. Her advisor was Hans Schneider. In the past, she has been a postdoctoral researcher at the Computer Science Department at the University of Wisconsin-Madison, Humboldt fellow at the Institute of Mathematics of the Technical University Berlin, and assistant and associate professor at the University of California-Berkeley. Her research interests include classical and numerical analysis, matrix and operator theory, approximation theory, commutative algebra, analysis of algorithms and computational complexity. She is a recipient of the Sofja Kovalevskaja Award and the European Mathematical Society Prize, among others.

For more information, visit her webpage: https://people.eecs.berkeley.edu/~oholtz/ or http://page.math.tu-berlin.de/~holtz/holtz_en.html.

Abstracts - Invited speakers

Thursday 12:00, 21/02/2019

Balanced manifolds or how to color a donut

Martina Juhnke-Kubitzke (University of Osnabrück)

The enumeration of faces of various types of simplicial complexes is a prominent topic in algebraic, topological and geometric combinatorics. In this talk, I will first provide a short survey on what is known for general simplicial complexes, simplicial polytopes and triangulations of manifolds. In the second part, the focus lies on balanced simplicial complexes, i.e., simplicial complexes whose underlying graph permits a minimal proper coloring in the graph-theoretic sense.

Thursday 14:30, 21/02/2019

Zeros of polynomials, from Descartes' Rule to P vs. NP

Olga Holtz (TU Berlin & UC Berkeley)

First algebraic methods for zero localization of polynomials go back to Descartes and Newton. But the story does not end there. Instead, it continues till today, leading to a number of recent advances such as the construction of Ramanujan graphs of every degree. I will review its humble beginnings and its rich connections to problems as varied — and as notorious — as the Riemann Hypothesis and P vs. NP.

Abstracts - Contributed talks

Wednesday, 20/02/2019

10:30 The dimensionality of point clouds

Johannes von Lindheim (TU Berlin)

Manifold learning or nonlinear dimensionality reduction is concerned with the task of finding a d-dimensional parametrization of a D-dimensional data set (or point cloud) that is supported on a d-dimensional manifold, where typically $d \ll D$. Almost all existing techniques, however, require the a priori unknown hyperparameter d called "intrinsic dimension" (ID). Intrinsic dimension estimation is therefore concerned with finding this number of degrees of freedom in such a data set. We will see why that problem is difficult and consider a list of desiderata. I will present some relevant work in this field — however, to this day, there is no algorithm achieving all requirements of an "ideal" intrinsic dimension estimator. Moreover, I will briefly touch upon an own ID estimator based on a novel approach using ideas from importance sampling.

11:00 Port-Hamiltonian systems

Candan Güdücü (TU Berlin)

The framework of port-Hamiltonian systems (PH systems) combines both the Hamiltonian approach and the network approach, by associating with the interconnection structure of the network model a geometric structure given by a Dirac structure. Furthermore, port-Hamiltonian systems theory is ideally suited for a systematic mathematical treatment of multi-physics systems by using energy and power as the lingua franca between different physical domains. A numerical method that exploits the structure of PH systems by using additive splitting methods has been derived. The results from a series of parametrized numerical experiments are presented to show the numerical stability and behavior of the solution depending on the parameters.

12:00 An experimental classification of maximal mediated sets and their relation to nonnegativity

Oguzhan Yürük (TU Berlin)

In various real-world applications polynomial optimization plays an important role, and nonnegativity is an essential tool in polynomial optimization.

Maximal mediated sets (MMS), first introduced by Bruce Reznick, arise as a natural structure in the study of nonnegative polynomials supported on circuits. Due to Reznick's, de Wolff's, and Iliman's results, given a nonnegative polynomial f supported on a circuit C with vertex set Δ, f is a sum of squares if and only if the non-vertex element of C is in the MMS of Δ. In this talk, we will first discuss the relation between MMS and nonnegative polynomials, and then present the results of the joint project with Olivia Röhrig and Timo de Wolff.

12:30 Grids of quadrilaterals with touching inscribed conics

Alexander Fairley (TU Berlin)

Conics are classical mathematical objects that have engendered many theorems. I will talk about a few theorems on the projective geometry of inscribed conics. In particular, I will present a theorem about grids of quadrilaterals with touching inscribed conics. Throughout the talk, there will be many illustrative computer graphics. At the end of the talk, I will mention current research about nets of planar quadrilaterals with touching inscribed conics.

14:30 Hamiltonian systems, symplectomorphisms and generalised diffeomorphisms

Lars T. Kreutzer (Albert Einstein Institute, Max Planck Society)

The study of Hamiltonian systems is central to much of modern physics. We will explore what physicists mean when they talk about a 'theory', how Hamiltonian systems are analysed and how this is related to generalised notions of diffeomorphisms.

15:00 Signal-to-interference ratio percolation for Cox point processes

András Tóbiás (TU Berlin)

One of the main questions in wireless communications is long-range connectivity in large networks. In the field of continuum percolation, long-range connectivity is identified with *percolation*, i.e., the existence of infinite connected components in random graphs in $\mathbb{R}^d$, $d \geq 2$. This field was introduced by Gilbert in 1961, who assumed that users of the network form a homogeneous Poisson point process, and that two users are connected if and only if their distance is less than a given constant $r > 0$. This model can be made more realistic in various ways. First, the locations of users should follow a street system, instead of a homogeneous spatial distribution. This setting was recently investigated by Hirsch, Jahnel and Cali, who studied Gilbert's graph model for Cox point processes, i.e., Poisson point processes with a random intensity measure. Second, connections should not only depend on the distance between transmitter and receiver, but also on the interference coming from all other users. Signal-to-interference plus noise ratio (SINR) percolation is a variant of continuum percolation having this property, which was studied by Dousse et al. in case of users given by a Poisson point process for $d = 2$. They showed that if the spatial density of users is high enough, then the SINR graph has an infinite connected component if interferences are sufficiently reduced (without vanishing).

In my talk, I will sketch these preliminary results, and afterwards I will tell about my research on SINR percolation for Cox point processes for $d \geq 2$. I will show that under certain conditions on the intensity measure of the Cox point process and on the path-loss function, the SINR graph percolates if the user density is large and interferences are sufficiently cancelled. In particular, I will explain the case of the two-dimensional Poisson-Voronoi tessellation, which is one of the most realistic models for random street systems.

16:00 Parameterizing families of curves

Carlos Maestro Pérez (HU Berlin)

In geometry, a parameterization of a given object is a way of expressing its coordinate functions in terms of a series of parameters. For example, the sphere $S^2 = \{x^2 + y^2 + z^2 = 1\}$ can be described by the rational equations

$$x(t) = \tfrac{2a}{a^2+b^2+1}\,, \quad y(t) = \tfrac{2b}{a^2+b^2+1}\,, \quad z(t) = \tfrac{a^2+b^2-1}{a^2+b^2+1}\,,$$

which depend on the parameter $t = a + ib \in \mathbb{C} \cup \{\infty\} = \mathbb{P}^1_{\mathbb{C}}$. Equivalently, this fact can be expressed as the existence of a dominant rational map

$$\mathbb{P}^1_{\mathbb{C}} \to S^2\,, \quad t \mapsto (x(t), y(t), z(t))\,,$$

that is, a map defined almost everywhere whose image covers almost all of the target space. Building on this idea, rational parameterizations in algebraic geometry are defined as dominant rational maps $\mathbb{P}^n_{\mathbb{C}} \dashrightarrow X$ from some projective space to the object X we want to study. The case where X is a family of algebraic varieties — say, genus g curves — is particularly interesting: indeed, finding a parameterization of such a family would mean that almost every curve of genus g could be completely determined by just

n complex numbers. Trying to assume as little background in algebraic geometry as possible, we will explore some of these constructions in low genera, as well as the beautiful geometry that is hidden behind them.

Thursday, 21/02/2019

10:30 A recap on the history of point-based graphics

Martin Skrodzki (FU Berlin)

Point sets arise naturally in many kinds of 3D laser-based acquisition processes, like 3D scanning. As early as 1985, they have been recognized as fundamental shape representations in computer graphics. They have diverse applications, e.g. in face recognition, traffic accident analysis, or archeology.

Point set surfaces have a more than 15 years long history in geometry processing and computer graphics as they naturally arise in 3D acquisition processes. A guiding principle of these algorithms is the direct processing of raw scanning data without prior meshing — a principle that has a long-established history in classical numerical computations. However, their usage mostly restricts to full dimensional domains embedded in $\mathbb{R}^2$ or $\mathbb{R}^3$ and a thorough investigation of a differential geometric representation of point set surfaces and their properties is not available.

In this talk, I will give a brief overview on the central structures and algorithms of point-based graphics.

11:00 Counting projective planes

Simona Boyadzhiyska (FU Berlin)

A finite *projective plane* is a pair $(\mathcal{P}, \mathcal{L})$, where $\mathcal{P}$ is a finite set of elements, called *points*, and $\mathcal{L}$ is a set of subsets of $\mathcal{P}$, called *lines*, satisfying the following axioms:

(i) For any distinct $p_1, p_2 \in \mathcal{P}$, there is a unique $\ell \in \mathcal{L}$ such that $p_1, p_2 \in \ell$.

(ii) For any distinct $\ell_1, \ell_2 \in \mathcal{L}$, we have $|\ell_1 \cap \ell_2| = 1$.

(iii) There exists a set of four points, no three of which belong to the same line.

It can be shown that if $(\mathcal{P}, \mathcal{L})$ is a finite projective plane, then there exists a number $n \in \mathbb{Z}_{\geq 2}$, called the *order* of the projective plane, such that any point is contained in exactly $n+1$ lines, $|\ell| = n+1$ for any $\ell \in \mathcal{L}$, and $|\mathcal{P}| = |\mathcal{L}| = n^2 + n + 1$.

Finite projective planes have been studied extensively, and yet some of the simplest and most natural questions related to them remain open or only partially answered. The first example of such a question is, given an integer n, does there exist a projective plane of order n? Perhaps surprisingly, for many values of n the answer is still unknown.

Another interesting question we could ask is, what is the number of pairwise non-isomorphic projective planes of order n? In this talk, we will discuss some of the known results in this direction; in particular, we will see asymptotic lower and upper bounds on this number.

16:00 Tropical linear algebra

Jorge Alberto Olarte (FU Berlin)

Tropical geometry is a relatively recent field that studies 'polyhedral shadows' of algebraic varieties. In the tropical world there are many objects and theorems which are analogous to those in algebraic geometry. In this talk we will look specifically at tropical linear spaces and compare them with classical linear spaces. The main objective of the talk is to provide the audience with an understanding of what tropical linear spaces are, how do they look like and how do they relate to matroid polytopes. At the end I will briefly mention some results from the research that I have carried out with Alex Fink and with Marta Panizzut and Benjamin Schröter.

16:30 Simulating hurricanes on bunnies, point vortex dynamics on closed surfaces

Marcel Padilla (TU Berlin)

If we get lazy and track fluid motion just as a set of points representing the whirls of the fluid we end up with point vortex dynamics. The main question now becomes: "how do these point vortices move by the whirls they induce?" In my talk I will explain this for planar, spherical and bunny shaped planets. This M.S. thesis will also be a gentle introduction into fluid dynamics.

Friday, 22/02/2019

10:30 The Fiber Theorem and the Nerve Theorem

Evgeniya Lagoda (FU Berlin)

In this talk we will look at the poset Fiber Theorem and the Nerve Theorem for simplicial complexes, which establish isomorphisms of homotopy groups of simplicial complexes under certain conditions and are important tools in topological combinatorics. We will also consider some applications of these theorems. This talk will mostly follow the article “Nerves, fibres and homotopy groups” by Anders Björner.

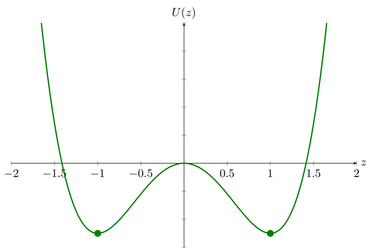
11:00 Exponential loss of memory for the stochastic Allen-Cahn equation with small noise

Tom Klose (TU Berlin)

We study the stochastic ordinary differential equation (SODE)

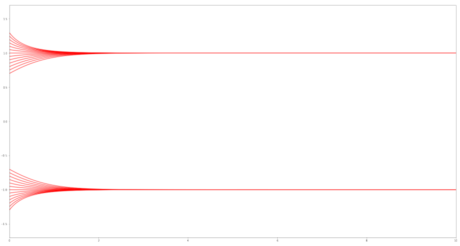
$$\dot{u}_\varepsilon(t) = -\nabla U(u_\varepsilon(t)) + \varepsilon \dot{w}(t), \quad u_\varepsilon(0) \in B(\pm 1, \delta), \tag{AC}$$

which is started in a small δ-ball around $+1$ or -1, the stable equilibria of the *double-well potential* $U(z) = \frac{1}{4}z^4 - \frac{1}{2}z^2$:

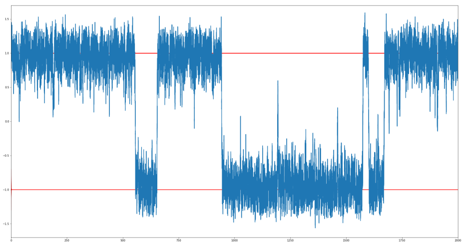


Under the presence of a temporal white noise $\dot{w}$ with small intensity $\varepsilon > 0$, solutions to (AC) exhibit *metastable* behaviour: they “jump” between neighbourhoods of $+1$ and -1 (Figure b), a phenomenon completely different from deterministic dynamics (Figure a).
Started from two different initial conditions $u_{\varepsilon,1}(0), u_{\varepsilon,2}(0) \in B(\pm 1, \delta)$, however, solutions to (AC) (in case $\varepsilon > 0$) couple asymptotically with high probability: under the same random evolution, the equation “loses memory” of its initial condition exponentially fast.

I will make the preceding statement precise and outline the strategy of proof. Time permitting, I will discuss how the recent breakthrough in the



(a) $\varepsilon = 0$: the ODE case.



(b) $0 < \varepsilon \ll 1$: the SODE case.

study of singular stochastic *partial* differential equations (SPDE) allows to "tame infinities" (Martin Hairer, Fields Medal 2014) using renormalisation techniques. We are then able to tackle the exponential loss of memory for the dynamic Φ^4_3 model *formally* given by the non-linear SPDE

$$(\partial_t - \Delta)\Phi_\varepsilon(t,x) = -\nabla U(\Phi_\varepsilon(t,x)) + \varepsilon\xi(t,x), \quad (t,x) \in \mathbb{R}_+ \times \mathbb{T}^3, \qquad (\Phi^4_3)$$

which describes phase separation phenomena in statistical physics and serves as a toy model for Euclidean quantum field theory.

The latter is joint work in progress with Pavlos Tsatsoulis (MPI Leipzig).

12:00 Hollow polytopes of large width

Giulia Codenotti (FU Berlin)

The aim of this talk is to present the construction of lattice polytopes of width larger than their dimension. After introducing lattice polytopes and some of their properties, such as width and hollowness, I will show how taking a direct sum of certain polytopes yields a hollow lattice polytope (resp. a hollow lattice simplex) of dimension 14 (resp. 404) and of width 15 (resp. 408). They are the first known hollow lattice polytopes of width larger than dimension. Asymptotic results can also be proved with this method, and will be touched upon if time allows. All terms introduced here (and more!) will be defined during the talk.

12:30 How many zeros does a random fewnomial system have?

Josué Tonelli-Cueto (TU Berlin)

A *fewnomial system* in n variables with t terms is a polynomial system $f_1(x) = 0, \dots, f_n(x) = 0$ of equations where each polynomial f_i in the system has a prescribed set of monomials described by a set $A \subseteq \mathbb{N}^n$ of cardinality t.

In 1980, Khovanskii proved that such a system with real coefficients has at most

$$2^{\binom{t-1}{2}}(n+1)^{t-1}$$

nondegenerate positive real solutions. It is important to note that this bound does not depend on the degrees of the polynomials. It is conjectured that this bound can be improved to be polynomial in t. However, all existing improvements are still exponential in t.

In this talk, we consider a probabilistic version of this conjecture. We show that the expected number of nondegenerate positive real solutions of a random fewnomial system in n variables with t terms is bounded by

$$2\binom{t}{n},$$

which is polynomial in t.

This is joint work with Peter Bürgisser and Alperen A. Ergür.