8th BMS Student Conference

February 19-21, 2020

Location:
MA 042
Mathematics Building
Str. des. 17. Juni 136
Technische Universität, Berlin

Berlin Mathematical School
BMS

https://tinyurl.com/bms-conf-2020

Welcome!

It is our pleasure to welcome you to Berlin and the 8th 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 Stefano Luzzatto and Professor Peter Bürgisser 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.

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

Organizers:

María Fernanda Delfín Ares de Parga	(HU Berlin)
Sophia Elia	(FU Berlin)
Benjamin Gardiner	(TU Berlin)
Abhinav Jha	(FU Berlin)
Evgeniya Lagoda	(FU Berlin)
Riccardo Morandin	(TU Berlin)

Website:

https://bmsstudconf.github.io/2020/

E-Mail:

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Schedule

	Wednesday	Thursday	Friday
09 : 30 – 09 : 55	**Registration**	**Registration**	
10 : 00 – 10 : 25	Boyadzhiyska	Levinson	Stephan
10 : 30 – 10 : 55	Lopez Nieto	Chaudhuri	Merino
11 : 00 – 11 : 25	Wei	Rothgang	Milbradt
11 : 30 – 11 : 55	**Coffee Break**	**Coffee Break**	**Coffee Break**
12 : 00 – 12 : 25	Prof. Bürgisser	Padilla	Prof. Luzzatto
12 : 30 – 12 : 55	(Invited Speaker)	Hegab	(Invited Speaker)
13 : 00 – 13 : 25			
13 : 30 – 13 : 55	**Lunch**	**Lunch**	**Lunch**
14 : 00 – 14 : 25			**&**
14 : 30 – 14 : 55	Fairley	Grabs	**Closing**
15 : 00 – 15 : 25	Rehfeldt	Müyesser	
15 : 30 – 15 : 55	**Coffee Break**	**Coffee Break**	
16 : 00 – 16 : 25		Comăneci	
16 : 30 – 16 : 55	**Social Event**	Schröder	
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 MA 042.

How to get to TU Berlin

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

- U-Bahn line U2, at the stop U Ernst-Reuter Platz, 5 minute walk.
- Buses M45, X9 and 245, at the stop U Ernst-Reuter Platz or Marchstraße, 5-7 Minute Walk.
- S-Bahn lines S3, S5, S7, and S9 at the stop S Tiergarten, 10 Minute Walk.
- U-Bahn line U9 and Regional Trains, at the stop S+U Zoologischer Garten, 20 Minute Walk.

For more information, please check `fahrinfo.bvg.de` or Google maps.

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.
- 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.
- Café Nero Volkswagenbibliothek (4 – 7€, cash only), Fasanenstraße 88.

Campus map [1]

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

Social Events

Visit to Urban Nation (Street Art Museum)

The Urban Nation Museum for Urban Contemporary ART is set in a Wilhelminian-era building at Bülowstrasse 7 in Schöneberg. An existing building has been converted into a museum from the innovative plans of the architecture bureau GRAFT. In contrast to a conventional museum, the architecture and exterior surfaces are also canvasses themselves, turning the building into an artwork in its own right. The mobile facade elements are kept and preserved along with the more conventional collection of paintings. A catwalk stretches across the entire two-storey interior that allows the exhibited works to be observed both from a distance and close up.

For more information, visit www.https://urban-nation.com/museum/.

On Wednesday, 19 February, there will be a group visit to Urban Nation. 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 **16:15**.

Urban Nation is located very close to U-Bahnhof Nollendorfplatz at Bülowstraße 7

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.

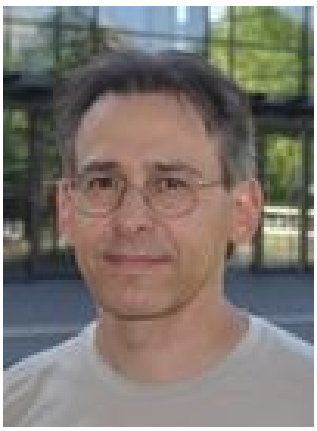
This event will take place on Thursday the 20th of February , starting at 19:00 in the TU BMS Lounge (Straße des 17. Juni 136, 10623 Berlin, room MA 209).

Invited Speakers

Stefano Luzzatto

Stefano Luzzatto coordinates the activities in Dynamical Systems and Ergodic Theory within the Mathematics Section of the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste. He received his PhD in Dynamical Systems from the International School for Advanced Studies (SISSA) in Trieste and the Instituto de Matematica Pura e Aplicada (IMPA) in Rio de Janeiro, under the supervision of Marcelo Viana an Jacob Palis in 1995. He was a postdoc at the Mathematics Institute at Warwick University from 1995 to 1999 and a lecturer, senior lecturer and reader from 2000 at Imperial College London where he co-founded the Dynamical Systems group DynamIC. In 2009 he moved to his current position in at the ICTP.

Peter Bürgisser



Peter Bürgisser received his doctorate in 1990 from the University of Konstanz under the supervision of Volker Strassen. He was a postdoc at the University of Bonn from 1991 to 1993 and then at the University of Zürich. He was a professor at the University of Paderborn and has been a professor at the Technical University of Berlin (TU Berlin) since 2013. He has been a a visiting scholar at the Simons Institute for the Theory of Computing in Berkeley and was also a visiting scholar at ETH Zurich.

His research deals with efficient algorithms for the solution of algebraic problems and lower bounds in the complexity of algebraic problems, as well as with symbolic and numerical algorithms and the probabilistic analysis of numerical algorithms. He has notably contributed to the solution of Smale's Problem No. 17 with Felipe Cucker in 2011.

Websites for the invited speakers are linked from the conference web page (see the cover).

Abstracts - Invited speakers

Friday 12:00, 21/02/2020

Physical Measures for Dynamical Systems

Stefano Luzzatto (International Centre for Theoretical Physics, Trieste Italy)

Since the 1970's it has become well understood that many apparently simple deterministic dynamical systems have unpredictable and chaotic behaviour. This has led to a huge amount of research and very deep results about the structure of dynamical systems. Amongst the many and varied approaches to the topic, a very effective one has been the application of ideas from ergodic theory and statistical mechanics to study deterministic systems with the language and tools of probability theory.

In this talk I will give an elementary introduction to some of these ideas and outline some of the main open problems and conjectures in the field. In particular I will introduce and motivate the notion of a "physical measure" as a very powerful way to study complicated dynamics, and formulate some conjectures and results on the existence of physical measures.

Wednesday 12:00, 19/02/2020

Optimization, Complexity and Invariant Theory

Peter Bürgisser (TU Berlin)

I will give a gentle introduction to recent research for finding efficient algorithms for natural problems in geometric invariant theory. While the original motivation for this research came from algebraic complexity theory, surprising connections to a diverse set of problems in different areas of mathematics, computer science, and physics popped up.

Abstracts - Student Contributed talks

Wednesday, 19/02/2020

10:00 Minimum Degrees of Minimal Ramsey Graphs

Simona Boyadzhiyska (FU Berlin)

A graph G is *Ramsey* for another graph H if any red/blue-coloring of the edges of G contains a monochromatic copy of H. A classical result due to Ramsey shows that Ramsey graphs exist for any choice of H. Once we know that Ramsey graphs for H exist, it is natural to ask what such graphs look like and what properties they must satisfy. For instance, if you have taken a basic course in combinatorics, you might be familiar with the problem of determining the *Ramsey number* of a graph H, which in this language can be defined as the minimum number of vertices in a graph that is Ramsey for H.

In this talk, we will give a short introduction to the study of (minimal) Ramsey graphs, focusing on questions related to minimum degrees. We will mainly discuss classical results, aiming to illustrate some of the ideas and methods used in this field.

10:30 The Poincaré-Bendixson theorem in delay differential equations

Alejandro López Nieto (FU Berlin)

The Poincaré-Bendixson theorem for ordinary differential equations on the plane is one of the most iconic results in dynamical systems theory. The core idea is that the long term behavior of the solution curves is heavily constrained by the 2-dimensional phase space.

Surprisingly, Mallet-Paret and Sell [3] have drawn analogous conclusions for delay differential equations with monotone feedback, for which the phase space is infinite-dimensional.

In the talk I will comment on the results in [3]. As an application, we characterize the, genuinely infinite-dimensional, periodic solutions of a particular delay differential equation in terms of a planar ordinary differential equation [1, 2].

References

[1] J. Kaplan, J. Yorke, *Ordinary differential equations which yield periodic solutions of differential delay equations*, J. Math. An. and App. (1974).
[2] A. López Nieto, *A converse to a theorem of Kaplan and Yorke: Characterization of periodic solutions in delay equations*, preprint (2019).

[3] J. Mallet-Paret, G. R. Sell, *The Poincaré-Bendixson theorem for monotone cyclic feedback systems*, J. Diff. Eq. (1996).

11:00 Geometry of QRT map

Kangning Wei(TU Berlin)

QRT map appears in various contexts in mathematical physics and discretizations. Geometrically, one obtains a QRT map by composing two involutions defined on a pencil of biquadratic curves on the plane. The QRT map is then a planar birational map with singularities at the base points of the pencil. One can resolve these singularities by blowing up and lifting the QRT map to a surface automorphism. Some dynamical properties can be derived using the help of elliptic surface theory.

14:30 Koenigs nets in discrete differential geometry

Alexander Y. Fairley (TU Berlin)

At the end of the nineteenth century, Gabriel Kœnigs (1858-1931) proved some interesting theorems about conjugate nets with equal Laplace invariants. Nowadays, discrete conjugate nets with equal Laplace invariants are pervasive in discrete differential geometry. In recognition of Gabriel Kœnigs' work, they are usually called Koenigs nets. Via the projective geometry of inscribed conics, I will introduce Koenigs nets and I will explain why they can be regarded as a discretisation of conjugate nets with equal Laplace invariants.

15:00 Parallel interior-point methods for large-scale linear energy system models

Daniel Rehfeldt (TU Berlin)

Energy system models are a crucial component of energy system design and operations, as well as energy policy consulting. If detailed enough, such models lead to large-scale linear optimization problems (linear programs, or short LPs) that are intractable even for the best state-of-the-art solvers. This talk describes a new interior-point solver that exploits common structures of energy system LPs to efficiently solve them in parallel on distributed-memory systems. In particular, we will describe a preconditioned Schur complement based decomposition approach for solving the linear systems arising within the interior-point algorithm. As a result, energy system LPs with more than one billion variables and constraints can now be solved within two hours.

Thursday, 20/02/2020

10:00 Characteristic classes - Who are they?

Tatiana Levinson (FU Berlin)

Characteristic classes is a name for a group of cohomological invariants which satisfy certain axioms. In a sense, they measure how much twisted a vector (or, more generally, a principle) bundle is. This is a very powerful tool of Algebraic Topology. For instance, you can use them to prove Hairly ball theorem, which states that you can't draw a continuous non vanishing vector field on a 2-dimensional sphere. You will find characteristic classes in Atiyah–Singer index theorem, one of the most powerful theorems I know, which has application all over the math, from Algebraic Geometry to Mathematical Physics. They are also one of the key tools in modern condensed matter physics.

The goal of my talk is to give you a feeling of what they are and why do we care. Don't be scared if you don't understand words in a first two sentences of this abstract - I will give an intuitive explanation, as well as formal definition for those who do.

10:30 Singular Limits of the Compressible Fluid Models

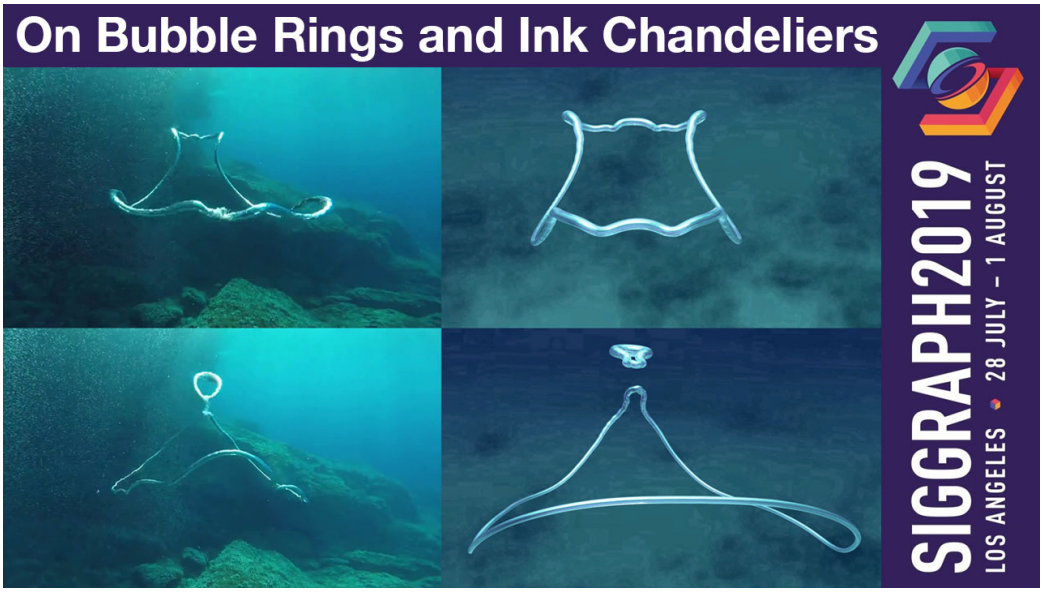
Nilasis Chaudhuri (TU Berlin)

Compressible fluid models describe a large spectrum of possible models in meteorology, geophysics and astrophysics. The models are given by systems of partial differential equations. Writing these systems in dimensionless form involve characteristic numbers (i.e Mach number, Rossby number, Froude number, Reynolds number etc.). If these numbers are small or large we observe some interesting phenomena. In this talk my aim is to give an idea about this limit behavior.

11:00 Form follows function's flow: what does pouring honey on a lifebuoy have to do with planetary motion?

Michael Rothgang (HU Berlin)

I will explain what pouring e.g. honey on a lifebuoy tells you about its topology. It turns out that similar ideas can be applied in a rather different setting, which provides insight into planetary motion. Along the way, we will learn about Morse and Hamiltonian Floer homology and catch a glimpse at how working in symplectic topology can be like.



12:00 On Bubble Rings and Ink Chandeliers

Marcel Padilla (TU Berlin)

Rising air bubbles can roll up into bubble rings with mesmerizing dynamics. A drop of ink in water can create a beautiful chandelier like patterns. What causes these fluid phenomena and how can you simulate their behavior? In this talk a novel model using viscous vortex filaments with buoyancy is presented that accurately recreates real life footage of bubble rings and ink chandeliers.

See videos and more on `http://page.math.tu-berlin.de/~padilla/`.

12:30 The secret of 27: Lines on Cubic Smooth Surfaces

Fawzy Hegab (TU Berlin)

In this talk, we present a classical result on algebraic geometry namely, that every smooth cubic surface has exactly 27 lines. Our aim is to introduce the terminologies behind this result to non-algebraic geometers and to sketch its proof. The proof of this theorem is interesting not only because it presents a justification for a nice result but also because it combines important ideas in algebraic geometry like parameter spaces, which will appear naturally in the course of the proof. Moreover, for fun, we will give evidence for this fact computationally by running a code enumerating them for various "randomly chosen" surfaces.

14:30 Minimal Elastic Energy Surfaces

Claudia Grabs (Potsdam University)

We use differential geometric methods to deal with the following problem coming from continuum mechanics: Consider an elastic membrane, fixed to a boundary. By deforming, bending and stretching that boundary, the elastic membrane will take shape such a way that the resulting elastic strain energy is minimal and the external and internal elastic forces balance out. What do these elastic surfaces look like? We look at numerical simulations of rotationally symmetric equilibrium shapes as well as compare these to experiments. To model different elastic materials, stiff materials or stretchy materials, we employ different material laws. Like for minimal surfaces, questions about existence, regularity and stability of the elastic surfaces pop up.

15:00 Soldiers and Potentials

Alp Müyesser (FU Berlin)

It is well-known that in a battlefield, soldiers are placed on $\mathbb{Z}^2$ and advance by jumping over one another, causing the jumped-over soldier to perish. We introduce the technique of potential functions, and use it to show many soldiers are needed to advance more than a couple of coordinates in a battlefield. This shows that wars should be best left as a thought-exercise.

16:00 Sums of Squares

Andrei Comăneci (HU Berlin)

The relation between sums of squares and non-negativity of polynomials was firstly studied by Hilbert at the end of the 19^{th} century and led to the formulation of the 17^{th} problem from his celebrated list of problems. This drove to significant developments in real algebraic geometry and, more recently, sums of squares were found to be useful in optimization. In this talk, I will present general facts about sums of squares and how they are related to semi-definite programming. In the end, we will see a few applications.

16:30 Centered Colorings for Various Graph Classes

Felix Schröder (TU Berlin)

A p-centered coloring is a vertex-coloring of a graph G such that for every connected subgraph H of G either H receives more than p colors or there

is a color that appears exactly once in H. The concept was introduced by Nešetřil and Ossona de Mendez to provide a local condition suitable to measure sparsity of graphs.

We develop first non-trivial lower bounds on the p-centered coloring numbers. For outerplanar graphs, we prove that their maximum p-centered coloring number is in $\Theta(p \log p)$. For planar graphs, we show that some require $\Omega(p^2 \log(p))$ colors, while all of them admit a p-centered coloring with $\mathcal{O}(p^3 \log(p))$ colors. This improves an $\mathcal{O}(p^{19})$ bound by Pilipczuk and Siebertz. For graphs of degree at most Δ, we give a coloring with $\mathcal{O}(\Delta^2 p)$ colors which is in strong contrast to the result for the related weak coloring numbers.

This is joint work with Michał Deþski, Stefan Felsner and Piotr Micek.

Friday, 21/02/2020

10:00 On Mathematical Coarse-Graining for Linear Reaction Systems

Artur Stephan (HU Berlin)

In my talk, we consider linear reaction systems (which can also be interpreted as master equations or Kolmogorov forward equations for Markov processes on a finite state space). Modeling real-world processes, one often assumes that some reactions are slow and others are fast.

We investigate the limit behavior of the reaction system if the fast reaction rates tend to infinity. As we will see, this leads to a coarse-grained model on a smaller state space, where the fast reactions create microscopically equilibrated clusters, while the exchange mass between the clusters occurs on the slow time scale. Interestingly, the whole evolution equation can be reconstructed from the coarse-grained system without loosing any information.

Moreover, one can also show that the coarse-graining and reconstruction procedure does even work on the level of the underlying physical principle (namely the energy-dissipation-principle) and not only for the evolution equation itself. In particular, this justifies the coarse-graining procedure from the physical point of view.

10:30 How to pack objects into a Knapsack?

Arturo Merino (TU Berlin)

When trying to fly on an airplane one is given the daunting task of selecting which items to bring along. To make this task easier, for each object i in your possession, you do the following:

1. you assign to it a happiness-score h_i and
2. you put it on a scale obtaining it's weight w_i.

Your plan is to select a subset of items that satisfy the weight restriction of the airline while maximizing happiness. Sadly, even though the problem seems very simple, it is not possible to solve it optimally and efficiently (unless $\mathtt{P} = \mathtt{NP}$). This last observation motivates the search for "good-enough" or approximate solutions that can be found efficiently.

In this talk we will first discuss the traditional Knapsack problem and the methods used to deal with it. Afterwards, we will consider a two-dimensional

generalization of the problem. This time the Knapsack is a square of fixed size, and the objects to pack are now polygons. Our understanding of this problem highly depends on the input polygons. For example, if all polygons are axis-parallel squares you can find arbitrarily-good solutions efficiently.

Our main result is an approximation algorithm that is quasi-efficient (i.e. that runs in quasi-polynomial time) and allows for convex polygons. To the best of our knowledge, these are the first results for two-dimensional Knapsack in which the input objects are not limited to axis-parallel rectangles or circles and in which you can rotate by arbitrary angles.

This is joint work with Andreas Wiese.

11:00 Approximations for Limit Order Books with Large Price Changes

Cassandra Milbradt (HU Berlin)

A limit order book (LOB) is an electronical tool used in economics to store and display unexecuted orders. One research objective is to describe realistic discrete dynamics of a LOB which can be approximated by a continuous time model. In order to apply such a model for intraday electricity markets, we aim to extend existing mathematical analysis of LOB models for purely nancial markets. In contrast to traditional stock markets, electricity markets are not as liquid, exhibit large spreads and unforeseen power outages can lead to extreme spikes in the prices, including possibly negative prices. Hence, one starting point in extending existing convergence results for nancial markets is to allow larger sizes of price changes which do not become small in the limit. Ensuring that these large price changes only appear with a small probability that scales in the right way, a convergence to a diusion approximation can still be proven. How can we extend these results to an approximation by a diusion with jumps?

List of Speakers

(Alphabetical by last name)

- Simona Boyadzhiyska – Wednesday 10:00 – Minimum degrees of minimal Ramsey graphs
- Nilasis Chaudhuri – Thursday 10:30 – Singular limits of the compressible fluid models
- Andrei Comăneci – Thursday 16:00 – Sums of Squares
- Alexander Fairley – Wednesday 14:30 – Koenigs nets in discrete differential geometry
- Claudia Grabs – Thursday 14:30 – Minimal elastic energy surfaces
- Fawzy Hegab – Thursday 12:30 – The secret of 27: lines on cubic smooth surfaces
- Tatiana Levinson – Thursday 10:00 – Characteristic classes - who are they?
- Alejandro Lopez Nieto – Wednesday 10:30 – The Poincaré-Bendixson theorem in delay differential equations
- Arturo Merino – Friday 10:30 – How to pack objects into a Knapsack?
- Cassandra Milbradt – Friday 11:00 – Approximations for limit order books with large price changes
- Alp Müyesser – Thursday 15:00 – Soldiers and Potentials
- Marcel Padilla – Thursday 12:00 – On Bubble Rings and Ink Chandeliers
- Daniel Rehfeldt – Wednesday 15:00 – Parallel interior-point methods for large-scale linear energy system models
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- Felix Schröder – Thursday 16:30 – Centered colorings for various graph classes

- Artur Stephan – Friday 10:00 – On mathematical coarse-graining for linear reaction systems
- Kangning Wei – Wednesday 11:00 – Geometry of QRT map