Spring school: Random geometric graphs

March 28 – April 1, 2022

TU Darmstadt

Short Courses:
Peter Mörters
Mathew Penrose

Invited Speakers:
Steffen Dereich
Benedikt Jahnel
Christian Hirsch

Organization:
Frank Aurzada
Volker Betz
Matthias Meiners

March 23, 2022

Contents

1 General Information

1.1 Accommodation

The participants are recommended to stay in one of the following hotels, located in walking distance (15 minutes) to the lecture venue.

BEST WESTERN Darmstadt Mitte
Grafenstraße 31, 64283 Darmstadt
Tel: +49-6151-28100 info@hotel-darmstadt.bestwestern.de

HOTEL WELCOME
Karolinenplatz 4, 64289 Darmstadt
Tel: +49-6151-3914-0 info.dar@welcome-hotels.com

HOTEL ATLANTA
Kasinostraße 129, 64293 Darmstadt
Tel: +49-6151-1789-0 info@hotel-atlanta-darmstadt.de

For directions please see the map on the back cover.

1.2 Registration

On Monday morning, starting from 8:00, registration is possible in the lobby of the lecture hall.

1.3 Lecture Hall

Location: Technische Universität Darmstadt. The registration and all lectures will take place in building S2|08, Hochschulstraße 4, 64289 Darmstadt in lecture hall S2|08/171. In the lecture hall, there are 2 large blackboards and a projector.

1.4 Map & Points of Interest

The map can be found on the back cover.

1.5 Public Transportation

The closest bus and tram stops to the venue of the workshop are **Schloss** (trams: S2, S3, S9) and **Willy-Brandt-Platz** (trams: S4, S5, S6, S7, S8). Both stops are within 10 minutes walking distance to the lecture hall.

1.6 Food & Beverage

Cheap and plain food can be purchased at the TU Darmstadt Refectory-Canteen ("Mensa"), Alexanderstr. 4, building S1|11, Monday to Friday 11:15 to 14:15. Additionally there are lots of good restaurants and bistros near TU Darmstadt. Please dial +49 6151 preceding the number given below.

Name	**Address**	**Phone**	**Cuisine**	**Opening**
Ratskeller	Marktplatz 8	26444	German	10:00 - 01:00
Pizzeria da Nino	Alexanderstr. 29	24220	Italian	18:00 - 23:00
Haroun's	Friedensplatz 6	23487	Oriental	11:00 - 22:30
Wellnitz	Lauteschlägerstr. 4	6699255	Bistro	12:00 - 24:00
Cafe Extrablatt	Marktplatz 11	5998820	Bistro	08:30 - 23:30
Ristorante Sardegna	Kahlertstraße 1	23029	Italian	11:30 - 14:45

1.7 Conference Dinner

On Tuesday, March 29, 2022, there will be a conference dinner at the Restaurant Oberwaldhaus, Dieburger Str. 257, 64287 Darmstadt, Phone: +49-6151-712266

1.8 Free Afternoon

On Wednesday, March 30, 2022, there will be a free afternoon.

1.9 Contact Information

If you have any questions concerning the workshop, please feel free to contact one of the local organizers or the technical support:

- Prof. Dr. Frank Aurzada
  Office: S2-15, Room 341
  Phone: +49 6151 - 16 23375
- Prof. Dr. Volker Betz
  Office: S2-15, Room 340
  Phone: +49 6151 - 16 23370
- Office Department
  Office: S2-15, Room 339
  Phone:+49 6151 - 16 23380
- springschool@mathematik.tu-darmstadt.de

Acknowledgements

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TECHNISCHE UNIVERSITÄT DARMSTADT

Fachbereich **Mathematik**

SPP2265 Random Geometric Systems

Time	Monday	Tuesday	Wednesday	Thursday	Friday
08:00	Registration				
09:00	Penrose	Penrose	Mörters	Penrose	Mörters Session 2: Mörters
10:30	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
11:00	Penrose	Penrose Session 2: Penrose	Mörters Coffee break Invited talk Jahnel	Mörters	Mörters
12:30	*Lunch*	*Lunch*	13:30 *Lunch*	*Lunch*	*Lunch*
14:00	Invited talk Dereich	Invited talk Hirsch	*Free* *Afternoon* *Excursion*	Session 1: Mörters	*End of* *Workshop*
15:00	*Coffee break*	*Coffee break*		Coffee break	
15:30	Session 1: Penrose Short talks: Düsterbeck Tóbiás Sönmez Schroeder Trapp Prévost Bermann Igelbrink	Short talks: Kerriou Kupper Ziegenbalg Malhotra Ravelomanana Maitra Bet Dickson		Short talks: Alban Schickentanz Lees Yang Ray Lehnen Hafer Coffee break Lienau Kumar Jhawar Quitmann Vu Andreis Iyer Lodewijks	
	Reception	Dinner			

Monday, 28 March 2022

Time	Speaker	*Title of Talk*
09:00-09:05	Welcome	
09:05-10:35	Mathew Penrose	*Mini course* *Connectivity and components of random Euclidean graphs*
10:35-11:00		–Coffee break–
11:00-12:30	Mathew Penrose	*Mini course* *Connectivity and components of random Euclidean graphs*
12:30-14:00		–Lunch break–
14:00-15:00	Steffen Dereich	*Invited talk: Traces left by random walk in the neighbourhood of a vertex*
15:00-15:30		–Coffee break–
15:30-16:15	Problem session 1: Penrose	
16:30-16:40	Short talk	Marilyn Düsterbeck
16:40-16:50	Short talk	András Tóbiás
16:50-17:00	Short talk	Ercan Sönmez
17:00-17:10	Short talk	Lars Schroeder
17:10-17:20	Short talk	Vanessa Trapp
17:20-17:30	Short talk	Alexis Prévost
17:30-17:40	Short talk	Sebastian Bergmann
17:40-17:50	Short talk	Jan Lukas Igelbrink
18:00-23:00	Reception	–Cheese & Wine–

Tuesday, 29 March 2022

Time	Speaker	*Title of Talk*
09:00-10:30	Mathew Penrose	*Mini course* *Connectivity and components of random Euclidean graphs*
10:30-11:00		–Coffee break–
11:00-11:45	Mathew Penrose	*Mini course* *Connectivity and components of random Euclidean graphs*
11:45-12:30	*Problem session 2: Penrose*	
12:30-14:00		–Lunch break–
14:00-15:00	Christian Hirsch	*Invited talk: Large deviations of the k-nearest neighbor graph*
15:00-15:30		–Coffee break–
15:30-15:40	Short talk	Céline Kerriou
15:40-15:50	Short talk	Niclas Kupper
15:50-16:00	Short talk	Max Ziegenbalg
16:00-16:10	Short talk	Nandan Malhotra
16:10-16:20	Short talk	Jean Bernoulli Ravelomanana
16:20-16:30	Short talk	Neelardi Maitra
16:30-16:40	Short talk	Gianmarco Bet
16:40-16:50	Short talk	Matthew Dickson
18:30-22:00	Conference Dinner	–Restaurant Oberwaldhaus–

Wednesday, 30 March 2022

Time	Speaker	*Title of Talk*
09:00-10:30	Peter Mörters	*Mini course* *Chapter 1. Scale-free random graphs*
10:30-10:45		–Coffee break–
10:45-12:15	Peter Mörters	*Mini course* *Chapter 2. Spatial preferential attachment*
12:15-12:30		–Coffee break–
12:30-13:30	Benedikt Jahnel	*Invited talk: First-passage percolation and chase-escape dynamics on random geometric graphs*
13:30-14:30		–Lunch break–
		–Free afternoon – Excursion–

Thursday, 31 March 2022

Time	Speaker	*Title of Talk*
09:00-10:30	Mathew Penrose	*Mini course* *Connectivity and components of random Euclidean graphs*
10:30-11:00		–Coffee break–
11:00-12:30	Peter Mörters	*Mini course* *Chapter 3. Scale-free geometric random graphs*
12:30-14:00		–Lunch break–
14:00-14:45	*Problem session 1: Mörters*	
14:45-15:15		–Coffee break–
15:15-15:25	Short talk	Alexander Alban
15:25-15:35	Short talk	Dominic T. Schickentanz
15:35-15:45	Short talk	Benjamin Lees
15:45-15:55	Short talk	Xiaochuan Yang
15:55-16:05	Short talk	Rounak Ray
16:05-16:15	Short talk	Michéle Lehnen
16:15-16:25	Short talk	Bernhard Hafer
16:35-16:50		–Coffee break–
16:50-17:00	Short talk	Matthias Lienau
17:00-17:10	Short talk	Sanjoy Kumar Jhawar
17:10-17:20	Short talk	Alexandra Quitmann
17:20-17:30	Short talk	Anh Duc Vu
17:30-17:40	Short talk	Luisa Andreis
17:40-17:50	Short talk	Tejas Iyer
17:50-18:00	Short talk	Bas Lodewijks

Friday, 1 April 2022

Time	Speaker	*Title of Talk*
09:00-09:45	Peter Mörters	*Mini course* *Chapter 4. Existence of sub- and supercritical phases*
09:45-10:30	Problem session 2: Mörters	
10:30-11:00		–Coffee break–
11:00-12:30	Peter Mörters	*Mini course* *Chapter 5. Shortest paths*
12:30-14:30		–Lunch, end of the Spring School–

2 List of Talks

2.1 Short Courses

Peter Mörters
Universität zu Köln, Germany
Mini course Scale-free random geometric graphs

Chapter 1. Scale-free random graphs
We discuss the simplest models for scale-free random graphs. These models are locally tree-like and we show how the local structure can be used to determine global connectivity properties of these graphs.

Chapter 2. Spatial preferential attachment
Real networks typically have local clustering and this means that they are not locally tree-like. Spatially embedded networks address this weakness, but are harder to analyse. In this chapter we therefore look at a spatial preferential attachment network and investigate its local structure.

Chapter 3. Scale-free geometric random graphs
The local structure of spatial preferential attachment networks naturally leads us to the investigation of a class of spatially embedded scale-free random graphs, which we call weight-dependent random connection models. We give examples, old and new, of graphs in this class.

Chapter 4. Existence of sub- and supercritical phases
We investigate the presence of phase transitions for the connectivity of weight-dependent random connection models. We give sharp conditions for the existence of a subcritical phase and, in $d = 1$, for the existence of a supercritical phase. This chapter is based on recent work of Gracar, Lüchtrath, Mönch and the speaker.

Chapter 5. Shortest paths
We investigate the phenomenon of ultrasmallness in weight-dependent random connection models, i.e. when the shortest path between two vertices behaves like the iterated logarithm of their Euclidean distance. We give sharp conditions for ultrasmallness and verify a limit theorem for the length of the shortest path. This chapter is based on recent work of Gracar, Grauer and the speaker.

Mathew Penrose
University of Bath, United Kingdom
Mini course: Connectivity and components of random Euclidean graphs

The random Euclidean graph $G(n,r)$ has n vertices uniformly distributed in the unit square, with edges between any two vertices distant less than r from each other. This course is concerned with the asymptotic behaviour of the graph $G(n,r(n))$ (or the Poissonized version thereof) in the large-n limit with a given sequence $r(n)$. We shall prove two types of phase transition:

If $nr(n)^2/\log n$ tends to a constant c, then the graph is disconnected with high probability for $c < 1/\pi$, but connected w.h.p. for $c > 1/\pi$.

If instead $nr(n)^2$ tends to a constant b, then the graph enjoys a unique 'giant component' containing a positive proportion of the vertices, asymptotically in probability, if and only if b exceeds a certain critical value.

On the way we shall explain a number of key results and ideas in the theory of point processes and continuum percolation, which are needed to derive the above two results.

Steffen Dereich
Traces left by random walk in the neighbourhood of a vertex
WWU Münster, Germany

We analyse the visits of a random walk to the neighbourhood of a fixed root vertex. One typically sees the following behaviour in large graphs. When a random walk visits a fixed root vertex it may have further visits on a time scale of order one. Once it leaves the root "significantly" the return time will be of the order of the number of vertices of the graph. In that case we will call the return to the root vertex a new *macroscopic visit*. In the limit one can distinguish between macroscopic and microscopic visits and we will provide convergence results for a point process that keeps track of the indicidual macroscopic visits including information on each visit on the natural time scale. A standard tool for the analysis of random graphs is local convergence in the sense of Benjamini and Schramm. We show how this concept has to be adapted in order to derive results in our context. Roughly speaking, our results may be applied whenever the mixing time of the random walk is smaller than the number of steps that we can run an exploration algorithm without finding differences to a limitting graph model, with high probability. We mention that our results may be applied for general sparse random graph models. As an example we consider the random graph with fixed degree sequence. Moreover, we discuss related work, in particular, on vacant set percolation.

Christian Hirsch
Large deviations of the k-nearest neighbor graph
Aarhus University, Denmark

In this talk, I will describe the large deviation asymptotic of the sum of power-weighted edge lengths $\sum_{e\in E} |e|^\alpha$ in the Poisson k-nearest neighbor graph in $\mathbb{R}^d$. While the case $\alpha < d$ can be treated through classical methods from large deviations theory, an interesting dichotomy occurs if $\alpha > d$. Rare events in the lower tail can still be explained by subtle changes of the Poisson process throughout the sampling window. However, the most likely cause for rare events in the upper tail is a condensation phenomenon: the excess edge weight is caused by a negligible portion of Poisson points whose configuration can be described through a concrete geometric optimization problem. After presenting the general proof strategy, I will also elucidate on the prospects and limits of generalzing our approach to other spatial networks. Based on joint work with D. Willhalm.

Benedikt Jahnel

First-passage percolation and chase-escape dynamics on random geometric graphs

WIAS Berlin, Germany

In this talk I will first present recent results on the shape of the infected region of first-passage percolation on supercritical random geometric graphs. Inspired by applications in device-to- device communication networks, in the second part, I will then exhibit statements on the local and global survival and extinction in a two-species model on the same graph. For this, a second type of nodes will be introduced, which start to spread only on the set of previously infected nodes according to the same mechanism, with a potentially different rate, giving rise to a competition of chase and escape. Joint work with Alexander Hinsen, Elie Cali, Jean-Philipp Wary, Lucas de Lima, Daniel Valesin and Cristian Coletti.

Alexander Alban
The extremal process of variable speed Branching Brownian Motion: The boundary case
JGU Mainz, Germany

The order of the maximum of Branching Brownian Motion (BBM) differs in a logarithmic correction term from the one in corresponding independent setting. In this talk we zoom into this transition. We study "variable speed BBM" where the "speed functions", that describe the time-inhomogeneous variance, approach the one of BBM from below. We show that the logarithmic correction only depends on the initial and final diffusion parameters. We will see that the key to the above result is a precise understanding of the entropic repulsion experienced by an extremal particle. Based on joint work in progress with Lisa Hartung.

Luisa Andreis
Phase transitions in random graphs and coagulation processes
University of Florence, Italy

In this talk we present a model where particles interact via a coagulation mechanism and we focus our attention on some particular coagulation kernels, for which the existence of a phase transition is known, it depends on time and it is called gelation. We draw connections with inhomogeneous random graphs, which are a natural generalization of the well-known *Erdős–Rényi* random graph, where vertices are characterized by a type and edges are present independently according to the type of the vertices that they are connecting. In the sparse regime, these graphs undergo a phase transition in terms of the emergence of a giant component exactly as the classical *Erdős–Rényi* model. We will present an alternative approach, via large deviations, to prove this phase transition. This allows a comparison with the gelation phase transition and with phase transitions of condensation type emerging in several systems of interacting components.
This is based on ongoing joint works with Wolfgang König (WIAS and TU Berlin), Tejas Iyer (WIAS), Heide Langhammer (WIAS), Elena Magnanini (WIAS) and Robert Patterson (WIAS).

Sebastian Bergmann

Time-evolved Gibbs measures on trees

Ruhr Universität Bochum, Germany

In my short talk I would like to introduce the concept of Gibbs-non-Gibbs transitions of time-evolved Gibbs measures on trees and introduce a fixed point criterion for proving the existence of these transitions.

Gianmarco Bet

Detecting anomalies in geometric networks

Università degli Studi di Firenze, Italy

Recently there has been an increasing interest in the development of statistical techniques and algorithms that exploit the structure of large complex-network data to analyze networks more efficiently. For this talk, I will focus on detection problems. In this context, the goal is to detect the presence of some sort of anomaly in the network, and possibly even identify the nodes/edges responsible. Our work is inspired by the problem of detecting so-called botnets. Examples are fake user profiles in a social network or servers infected by a computer virus on the internet. Typically a botnet represents a potentially malicious anomaly in the network, and thus it is of great practical interest to detect its presence and, when detected, to identify the corresponding vertices. Accordingly, numerous empirical studies have analyzed botnet detection problems and techniques. However, theoretical models and algorithmic guarantees are missing so far. We introduce a simplified model for a botnet, and approach the detection problem from a statistical perspective. More precisely, under the null hypothesis we model the network as a sample from a geometric random graph, whereas under the alternative hypothesis there are a few botnet vertices that ignore the underlying geometry and simply connect to other vertices in an independent fashion. We present two statistical tests to detect the presence of these botnets, and we show that they are asymptotically powerful, i.e., they correctly distinguish the null and the alternative with probability tending to one as the number of vertices increases. We also propose a method to identify the botnet vertices. We will argue, using numerical simulations, that our tests perform well for finite networks, even when the underlying graph model is slightly perturbed. Our work is not limited in scope to botnet detection, and in fact is relevant whenever the nature of the anomaly to be detected is a change in the underlying connection criteria. Based on joint work with Kay Bogerd (TU/e), Rui Pires da Silva Castro (TU/e) and Remco van der Hofstad (TU/e).

Matthew Dickson
Triangle Condition and the Marked Random Connection Model
LMU München, Germany

For the usual (non-marked) Random Connection Model, the Triangle Condition is known to prove the existence of mean-field critical exponents. I will introduce a marked version of the Random Connection Model, and give a theorem that proves that the Triangle Condition holds for this marked model in sufficiently high dimensions

Marilyn Düsterbeck
Ellipses percolation
Universität zu Köln, Germany

We consider a Poisson point process on $\mathbb{R}^2$ in which the points are centers of ellipses. To begin the ellipses have a uniformly random orientation, a minor axis of the length one and the major axis h_{max} with a tail distribution satisfying $\mathbb{P}(h_{max} \geq r) = ar^{-\alpha}$ for $r \geq 1, \alpha \in (1,2), a > 0$. In this model we say two points are connected by an edge if the corresponding ellipses intersect. We prove a limit theorem for the chemical distance of two vertices in the ultrasmall regime, refining a result of Hilário and Ungaretti (2021). We generalise the model so that the minor axis is also random and not necessarily independent of the major axis. Interesting questions that arise are for example: Under which circumstances is the expected degree of a point finite? Does the chemical distance behave as before?

Bernhard Hafer
Expected sizes of Delaunay complexes
Universität Osnabrück, Germany

Motivated by surface reconstruction we analyse Delaunay complexes based on a Poisson point process. In the literature there is already an expression for the expected number of simplices in the Delaunay complex, but the occurring constants are only known in dimensions 2, 3 and 4. We want to obtain results for higher dimensions and/or informations about the asymptotic behavior of the constants. The difficulty of the calculation comes especially from the dependence on the number of visible simplex facets from the origin. This seems to be hard to manage with integral geometry.

Jan Lukas Igelbrink
A fresh look on the Hammond and Sheffield urn
JGU Mainz, Germany

In the power-law Pólya's urn of Hammond and Sheffield [HS], every integer is populated by one individual. Each individual samples its parent independently from *its past* according to a heavy tailed measure μ, i.e. $\mu(>n) = n^{-\alpha}$ for $0 < \alpha < 1$. This gives rise to a random partition of $\mathbb{Z}$.

In the case of $0 < \alpha < \frac{1}{2}$ the random partition has almost surely infintely many components. If one now colours every component independently with ± 1 the sum over the renormalised sum of these colouring converges to fractional Brownian motion. In joint work with Anton Wakolbinger [IW] we prooved this based on Stein's method.

For $\frac{1}{2} < \alpha < 1$ the random partition has almost surely exactly one component. One obvious question is how deep the most recent common ancestor of $0, 1, 2, \ldots, n$ lies.

[HS] Hammond, A. and Sheffield, S. Power law Pólya's urn and fractional Brownian motion. *Probability Theory and Related Fields*, **157** (3), 691–719 (2013).

[IW] Igelbrink, J.L. and Wakolbinger, A. Asymptotic Gaussianity via coalescence probabilites in the Hammond-Sheffield urn, 2021. URL `https://arxiv.org/abs/2201.06576`

Tejas Iyer
Evolving Inhomogeneous Random Structures I
WIAS Berlin, Germany

Motivated, in part, by the evolution of complex networks, we consider models of recursive random structures with inhomogeneities, so that the evolution of a node may depend not only on its degree, but on a random weight. These weights lead to a richer structure on the dynamics of the networks as it potentially allows newer nodes to compete for influence in the network with older ones. We show that the limiting degree distribution of such networks has a universal form, whereas, depending on the distribution of the weights, phase transitions can occur. These include "condensation", where a positive proportion of edges in the network accumulate around weights conferring maximal reinforcement; a phase transition in the locations and sizes of the maximal degree, where the location transitions from an early arriving node to nodes of index growing with the size of the network; and, based on ongoing work, phase transitions in the infinite limiting structure. Based on joint works with a number of authors, including Laura Eslava, Nikolaos Fountoulakis, Cécile Mailler, Marcel Ortgiese and Henning Sulzbach.

Céline Kerriou
The several-big-jumps principle and an application to random graphs
Universität zu Köln, Germany

We prove a large deviation principle for the sum of n independent heavy-tailed random variables, which are subject to a moving cut-off boundary at a location around n. Conditional on the sum being large at scale n, we show that a finite number of summands take values near the cut-off boundary, while the remaining variables still obey the law of large numbers. This generalises the well-known single-big-jump principle for random variables without cut-off to a situation where just the minimal necessary number of jumps occur. As an application, we consider a random graph with vertex set given by the lattice points of a torus with sidelength $2N$. Every vertex is the centre of a ball with a random radius sampled from a heavy-tailed distribution. Oriented edges are drawn from the central vertex to all other vertices in this ball. When this graph is conditioned on having an exceptionally large number of edges we use our main result to show that, as N tends to infinity, the excess outdegrees condense in a fixed, finite number of randomly scattered vertices of macroscopic outdegree. By contrast, no condensation occurs for the indegrees of the vertices, which all remain microscopic in size.

Sanjoy Kumar Jhawar
Poisson approximation and connectivity in a scale-free network
WIAS Berlin, Germany

In this talk I will present results about connectivity and Poisson approximation in a scale-free network using Stein's method. The vertex set of the graph is a homogeneous Poisson point process $\mathscr{P}_s$ of intensity $s > 0$ on the unit cube $S = \left(-\frac{1}{2}, \frac{1}{2}\right]^d$, $d \geq 2$. Each vertex is endowed with an independent random weight distributed as W, where $P(W > w) = w^{-\beta} 1_{[1,\infty)}(w)$, $\beta > 0$. Given the vertex set and the weights an edge exists between $x, y \in \mathscr{P}_s$ with probability

$$1 - \exp\left(-\frac{\eta W_x W_y}{(d(x,y)/r)^\alpha}\right),$$

independent of everything else, where $\eta, \alpha > 0$, $d(\cdot,\cdot)$ is the toroidal metric on S and $r > 0$ is a scaling parameter. We derive conditions on α, β such that under the scaling

$$r_s(\xi)^d = \frac{1}{c_0 s}\left(\log s + (k-1)\log\log s + \xi + \log\left(\frac{\alpha\beta}{k!d}\right)\right),$$

$\xi \in \mathbb{R}$, the number of vertices of degree k converges in total variation distance to a Poisson random variable with mean $e^{-\xi}$ as $s \to \infty$, where c_0 is an explicitly specified constant that depends on α, β, d and η but not on k. In particular, for $k = 0$ we obtain the regime in which the number of isolated nodes stabilizes, a precursor to establishing a threshold for connectivity. If time permits I will also derive a sufficient condition for the graph to be connected with high probability for large s.

Niclas Kupper
Largest Components in Soft Random Geometric Graphs
University of Bath, United Kingdom

The Soft Random Geometric Graph (SRGG) generalizes the Random Geometric Graph (RGG) by making pairs of points connect randomly according to a connection function. We consider a simple family of connection functions governed by a single parameter p given by $p1_{d(x,y)\leq 1}$. A standard result for the RGG is that the behaviour of the largest component is governed by the percolation probability. We try to extend this result to the SRGG using new methods that were developed for the discrete case by Dumil-Copin and Tassion, and have been applied to the RGG model by Ziesche. We use a discretization to allow us to deal with the doubly stochastic nature of the model.

Benjamin Lees
The Random Path Model
University of Bristol, United Kingdom

Many models in statistical mechanics can be written in terms of a collection of (random) geometric objects. This may consist of a “soup” of random walks/loops, random currents, or random transpositions. I will introduce a model of random paths that includes several interesting models when its parameters are chosen appropriately. One such example is the spin O (N) model. Unlike similar representations of this model, the random path model is defined in terms of a product of local terms which allows many nice techniques, such as reflection positivity, to be used.

Michéle Lehnen
Maximum of BBM among obstacles
JGU Mainz, Germany

We study the height of the maximum at time t of a one dimensional branching Brownian motion with a space-dependent branching rate. The branching rate is set to zero in finitely many intervals (obstacles) of order t. We obtain almost sure asymptotic of the first order of the maximum, describe the optimal strategy of a particle reaching this height and describe its dependence on the size and location of the obstacles.

Matthias Lienau
Component sizes of scale-free inhomogeneous random graphs
TU Hamburg, Germany

The Norros-Reittu model is an inhomogeneous random multigraph that exhibits the so-called scale-free or power-law behaviour, which is observed in real-world complex networks. We study the component sizes of the Norros-Reittu model in the subcritical regime, i.e. in the abscence of a giant component, and show convergence of the point process of the component sizes to a Poisson process. It is planned to derive similar results for other models such as the random connection model.

Bas Lodewijks
Evolving Inhomogeneous Random Structures II
Institut Camille Jordan in Saint-Etienne, France

Motivated, in part, by the evolution of complex networks, we consider models of recursive random structures with inhomogeneities, so that the evolution of a node may depend not only on its degree, but on a random weight. These weights lead to a richer structure on the dynamics of the networks as it potentially allows newer nodes to compete for influence in the network with older ones. We show that the limiting degree distribution of such networks has a universal form, whereas, depending on the distribution of the weights, phase transitions can occur. These include “condensation”, where a positive proportion of edges in the network accumulate around weights conferring maximal reinforcement; a phase transition in the locations and sizes of the maximal degree, where the location transitions from an early arriving node to nodes of index growing with the size of the network; and, based on ongoing work, phase transitions in the infinite limiting structure. Based on joint works with a number of authors, including Laura Eslava, Nikolaos Fountoulakis, Cécile Mailler, Marcel Ortgiese and Henning Sulzbach.

Neeladri Maitra
Spatial Inhomogeneous Random Graphs: local structure, clustering, and other questions.
TU Eindhoven, Netherlands

In this presentation I will present some recent joint results with Remco van der Hofstad and Pim van der Hoorn on the local structure and the clustering function of Spatial Inhomogeneous Random Graphs, which is a random graph model with underlying geometry. I will conclude by leaving open some questions and further research directions.

Nandan Malhotra
Spectra of Random Graphs
Leiden University, Netherlands

My PhD aims to study spectra of the adjacency matrices of random graphs. We will briefly see existing results in this area. In particular, we review the combinatorial and analytical techniques from random matrix theory that help us study the spectra of the *Erdős–Rényi* Random Graph. Further, we see how one can use similar techniques to analyse the inhomogeneous *Erdős–Rényi* random graph in the sparse setting, which is my current object of interest.

Alexis Prévost
Percolation for two-dimensional excursions clouds and the Gaussian free field
University of Cambridge, United Kingdom

We consider the excursion process, a random soup of Markov chains which can be interpreted as a two-dimensional version of random interlacements, both in the discrete and continuous setting. Using SLE theory, the critical parameters associated to the percolation of the corresponding vacant sets can be identified. We also provide bounds on the critical parameter associated to the percolation of the level sets of the two-dimensional discrete Gaussian free field with Dirichlet boundary conditions. This leads to a set of inequalities between these critical parameters in dimension two, which are either known or conjectured only in higher dimension. I will also investigate some extensions of this problem.

Alexandra Quitmann
Macroscopic loops in a random walk loop soup
WIAS Berlin, Germany

We consider a general system of interacting random loops which includes several models of interest, such as the Spin O(N) model, the double dimer model, random lattice permutations, and is related to the interacting Bose gas in discrete space. We discuss the system in $\mathbb{Z}^d, d > 2$, and present some recent results about the occurrence of macroscopic loops whose length is proportional to the volume of the system as the inverse temperature is large enough.

Jean Bernoulli Ravelomanana
Warning Propagation: stability and subcriticality
TU Dortmund, Germany

Warning Propagation is a combinatorial message passing algorithm that unifies and generalises a wide variety of recursive combinatorial procedures. Special cases include the Unit Clause Propagation and Pure Literal algorithms for satisfiability, as well as the peeling process for identifying the k-core of a random graph. Here we analyse Warning Propagation in full generality on a very general class of multi-type random graphs. We prove that under mild assumptions on the random graph model and the stability of the message limit, Warning Propagation converges rapidly. In effect, the analysis of the fixed point of the message passing process on a random graph reduces to analysing the process on a multi-type Galton-Watson tree. Moreover, it would be interesting to see if the techniques that we developed also apply for Random Geometric Graphs, for example, in the search for the k-core.

Rounak Ray
Local convergence of preferential attachment models
TU Eindhoven, Netherlands

We study preferential attachment models where vertices enter the network with an i.i.d. random number of edges. We identify their local limit, substantially extending the work of Berger et al. The degree distribution of this limiting random graph, which we call the random Pólya point tree, has a surprising size-biasing phenomenon. Many of the existing preferential attachment models can be viewed as a special case of our preferential model with i.i.d. random out-degrees. Additionally, our model incorporates negative values of the preferential attachment fitness parameter, which allows us to consider preferential attachment models with infinite-variance degrees. We assume some moment conditions of the out-degree distribution. Our proof of local convergence consists of two main steps: a Pólya urn description of our graphs, and explicit identification of the neighbourhoods in them. We provide novel and explicit proof to establish a coupling between the PAMs and the Pólya urn graph.

Dominic T. Schickentanz
Brownian Motion Conditioned to Spend Limited Time Below a Barrier
TU Darmstadt, Germany

We condition a Brownian motion with arbitrary starting point $y \in \mathbb{R}$ on spending at most 1 time unit below 0 and provide an explicit description of the resulting process. In particular, we provide explicit formulas for the distributions of its last zero $g = g^y$ and of its occupation time $\Gamma = \Gamma^y$ below 0 as functions of y. This generalizes a result of Benjamini and Berestycki from 2011, which covers the special case $y = 0$. Additionally, we study the behavior of the distributions of g^y and Γ^y, respectively, for $y \to \pm\infty$. This is joint work with Frank Aurzada (Darmstadt).

Lars Schroeder
Donsker's theorem on continuum percolation graphs
TU Dortmund, Germany

On the real axis, Donsker's theorem shows the convergence of a rescaled random walk to the Brownian motion. We will discuss the generalization of this theorem to continuum percolation graphs.

Ercan Sönmez
The longest edge in discrete and continuous long-range percolation
Universtität Klagenfurt, Austria

We consider both a discrete and continuous variant of long-range percolation on $\mathbb{R}^d$ in which an edge between two points at distance r is present with probability $\bar{g}(r)$. We elucidate yet unrevealed properties these models exhibit, namely by investigating the longest edge with at least one endpoint within some finite observation window, as the volume of this window tends to infinity. We show that the length of the latter in the continuous model, after normalizing by some appropriate centering and scaling sequences, asymptotically behaves like one of each of the three extreme value distributions, depending on choices of the probability $\bar{g}(r)$. In the discrete variant the results are more intriguing and we encounter subtle differences to the continuous model, in which we prove convergence in distribution for all of the cases considered. Parts of the proof employ the Chen-Stein method, a general result on Poisson approximation related to Stein's method and Palm calculus. The talk is based on a joint work with Arnaud Rousselle.

András Tóbiás
Absence of percolation in graphs based on stationary processes with degrees bounded by two
TU Berlin, Germany

We consider undirected graphs that arise as deterministic functions of stationary point processes such that each point has degree bounded by two. For a large class of point processes and edge-drawing rules, we show that the arising graph has no infinite connected component, almost surely. In particular, this extends our previous result for SINR graphs based on stabilizing Cox point processes and verifies the conjecture of Balister and Bollobás that the bidirectional k-nearest neighbor graph of a two-dimensional homogeneous Poisson point process does not percolate for $k = 2$. The subject of this talk is joint work with Benedikt Jahnel (WIAS Berlin).

Vanessa Trapp
Lower bounds for variances of Poisson functionals
TU Hamburg, Germany

To obtain central limit theorems for Poisson functionals, one often needs lower bounds for variances. In this talk, a specific lower bound is introduced that uses the difference operator of the Malliavin calculus. For example, this bound can be applied to several statistics of spatial random graphs, such as degree and component counts.

Anh Duc Vu
An Application for Percolation Theory in Analysis
WIAS Berlin, Germany

Percolation theory deals with the emergence of infinite structures (or lack thereof) in stochastic models, e.g. connected components in random graphs. In this talk, we will explore one use case of said theory outside of pure stochastics, namely in the modelling of compound materials.

Xiaochuan Yang
Limit theory for the coverage threshold
Brunel University London, United Kingdom

I will present a weak limit result for coverage threshold of spherical Poisson Boolean models with explicit error bounds. This quantifies a theorem of Janson/Hall in 1986.

Max Ziegenbalg

Multivariate Regular Variation of Random Networks

OVGU Magdeburg, Germany

Links between websites on the internet or scientific papers and the references between them are two of many real life examples of random networks which exhibit heavy-tail behaviour. A popular model for the growth of such networks are preferential attachment random graphs. After a brief introduction to regular variation, we will inspect the multivariate tail behaviour of preferential attachment models in random time by means of the regular variation framework.

3 Participants

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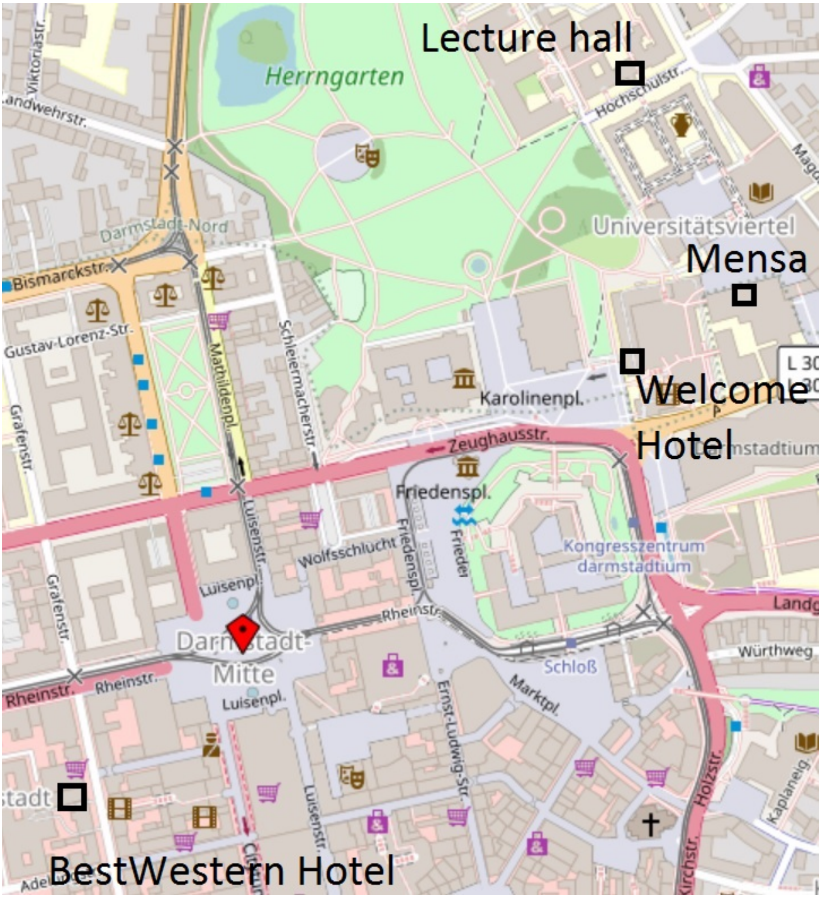
Lecture hall
Mensa
Welcome
Hotel
BestWestern Hotel
Herrngarten
Universitätsviertel
Darmstadt-Nord
Bismarckstr.
Gustav-Lorenz-Str.
Mathildenpl.
Schleiermacherstr.
Karolinenpl.
Zeughausstr.
Friedenspl.
Kongresszentrum
darmstadtium
Wolfsschlucht
Luisenpl.
Luisenstr.
Rheinstr.
Darmstadt-
Mitte
Schloß
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Ernst-Ludwig-Str.
Holzstr.
Kirchstr.
Würthweg
Kaplaneig.
Grafenstr.
Landwehrstr.
Viktoriastr.
Hochschulstr.