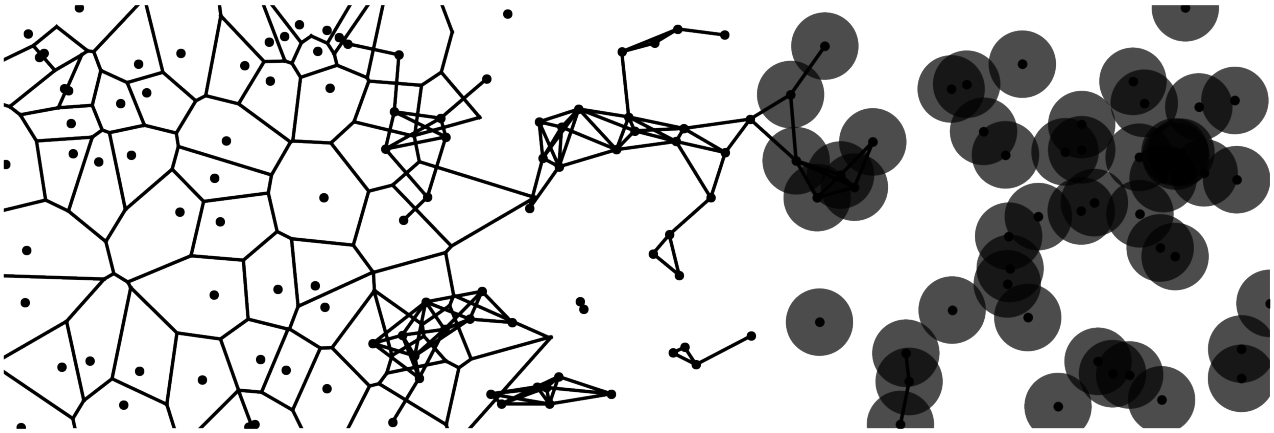
Women in Random Geometric Systems



September 16-18, 2026

Osnabrück, Germany

SPP2265 Random Geometric Systems

Universität Osnabrück

Contents

General information

Conference venue

Osnabrück University, Building 69: Albrechtstaße 28a.
Institute of Mathematics, room E15 on the ground floor.

Talks

Each talk is scheduled for 30 minutes, plus 5 minutes for questions.

Speakers: a laptop and projector will be available for your presentation. To make transitions as smooth as possible, please send your slides to `anna.strotmann@uni-osnabrueck.de` before your talk. You are also welcome to give a blackboard talk.

Lunch and conference dinner

For lunch, the University Cafeteria is a few minutes walk from the institute.

The conference dinner will take place on Wednesday at 6pm, at *Die Laterne* (Krahnstraße 22, in the inner city). The restaurant is reachable from the institute by bus (M2 from Campus Westerberg), or a pleasant 30 minute walk.

The workshop is funded by the DFG Priority Programme SPP 2265 Random Geometric Systems.

Schedule

Wednesday

Registration and coffee break (14:00–14:45)		
14:45–15:20	Anja Sturm	Central limit theorems for functions on weighted sparse inhomogeneous random graphs
15:20–15:55	Bochen Jin	Pareto points in growing dimensions
15:55–16:30	Réka Szabó	Constrained-degree percolation on d-ary trees
Conference Dinner (18:00–)		

Thursday

9:00–09:35	Leoni Carla Wirth	Goodness-of-fit testing for Point processes
9:35–10:10	Cairui Duan	Large-Deviation Analysis of Sparse Many-Body Systems in Motion
Coffee Break (10:10–10:45)		
10:45–11:20	Tara Trauthwein	Localization for Poisson point processes
11:20–11:55	Hajar Miskar	Coverage, Detection, and the Sensing–Communication Trade-off: A Point Process Approach to ISAC Networks
Group photo		
Lunch break (12:00–14:00)		
14:00–14:35	Céline Kerriou	Condensation in geometric inhomogeneous random graphs with excess edges
14:35–15:10	Kinga Nagy	Planarity in general models of random geometric graphs
Coffee Break (15:10–15:45)		
15:45–16:20	Anna Gusakova	Poisson hyperplane tessellation in hyperbolic space

Friday

09:00–09:35	Anne Estrade	Gaussian excursions: an “old” formula for new applications
Coffee Break (09:35–10:20)		
10:20–10:55	Maike de Jongh	Controlled stochastic growth of structures in the zero-temperature Ising model
10:55–11:30	Isabel Lammers	The Block Spin Ising Model

Gaussian excursions: an "old" formula for new applications

Anne Estrade
Université Paris Cité
anne.estrade@u-paris.fr

The presentation will start with an explicit formula giving the value of the mean Euler characteristic for excursions of certain Gaussian fields and it will continue with some extensions and related identities. I will present old and new studies from various authors, illustrating how similar formulas can be used in domains as varied as cosmology, medical imaging, meteorology or topological data analysis.

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Poisson hyperplane tessellation in hyperbolic space

Anna Gusakova
University of Münster
gusakova@uni-muenster.de

In this talk we will consider a random tessellation in hyperbolic space $\mathbb{H}^d$ generated by an invariant Poisson process of hyperplanes (totally geodesic subspaces of dimension $d-1$) of intensity t. These hyperplanes naturally split the space into convex domains (polyhedrons) giving rise to the Poisson hyperplane tessellation. We will consider a few questions related to geometric characteristics of the above tessellation. In particular we will study probability that Poisson hyperplane tessellation contains only bounded cells and will derive some results about cell intensity.

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Condensation in geometric inhomogeneous random graphs with excess edges

Céline Kerriou
Stockholm University
celine.kerriou@mail.mcgill.ca

In this talk, I will introduce and motivate geometric inhomogeneous random graphs (GIRGs), a model in which vertices are distributed according to a Poisson point process $\mathbb{R}^d$, and each vertex carries an independent, heavy-tailed weight representing its "influence". We will address the question of how unlikely it is for the model to have many more edges than expected and reveal that the mechanism that typically realises this rare event is based on a "condensation effect" where a finite number of vertices acquire exceptionally large weights and become hubs connecting to a macroscopic fraction of the network. This talk is based on joint work with Remco van der Hofstad, Pim van der Hoorn, Neeladri Maitra and Peter Mörters.

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Central limit theorems for functions on weighted sparse inhomogeneous random graphs

Anja Sturm
University of Göttingen
asturm@math.uni-goettingen.de

In this talk we consider central limit theorems for certain classes of functions on sparse rank-one inhomogeneous random graphs endowed with additional i.i.d. edge and vertex weights as the number of vertices in the graph tends to infinity. Our proof of the central limit theorem uses a perturbative form of Stein's method and relies on a careful asymptotic analysis of the local structure of the underlying random graphs. These results extend recent work by Cao (2021) for Erdős-Rényi random graphs and additional i.i.d. weights only on the edges.
This is joint work with Moritz Wemheuer from Bielefeld University.

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Constrained-degree percolation on d-ary trees

Réka Szabó

University of Groningen
r.szabo@rug.nl

We investigate the constrained-degree percolation model on d-ary trees. This is a continuous-time percolation model defined by a constraint k and a sequence of i.i.d. uniform random variables in $[0, 1]$ assigned to each edge. Each edge e attempts to open at time U_e, and succeeds if and only if both of its endpoints are incident to at most $k - 1$ open edges at that time. We show that the critical time $t_c(d, k)$ of the model lies strictly between $1/d$ and $1.2/d$ for all k and d, and that $t_c(d, k)$ is monotonically decreasing in both k and d. Joint work with S. Urban.

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Localization for Poisson point processes

Tara Trauthwein
University of Münster
tara.trauthwein@uni-muenster.de

Consider a Poisson point process on a metric space and a function thereof which consist of a sum of 'local' components. Examples of such functions can be the total edge-length or the number of isolated points in a spatial random graph, but they can also include statistics of more complex models like the birth-growth model, which is an interacting particle system. It is known that when those functions exhibit a certain kind of 'local' behaviour, then they satisfy a Central Limit Theorem when the underlying point process grows.
This talk is based on a joint work with Joseph Yukich, where we propose the notion of 'localization', a weak condition on score functions which is sufficient to induce a CLT. We give Berry-Esseen type quantitative convergence rates and illustrate our results on several applications, among them the birth-growth model. The proof is based on new and improved second-order Poincaré inequalities for general functions of Poisson point processes, which are of independent interest.

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Goodness-of-fit testing for Point processes

Leoni Carla Wirth
Imperial College London
wirthleoni@gmail.com

Point processes provide a flexible framework for modeling spatial events, such as disease cases in an epidemiological study or cells in biological tissue. They are especially useful because they can capture how events influence each other's locations, leading to patterns like clustering or repulsion.
A central statistical challenge is the goodness-of-fit assessment for such models. In this talk, I will present ongoing work on such a goodness-of-fit test for spatial point processes based on a kernelized Stein discrepancy (KSD). Unlike many existing approaches, the proposed framework is designed for the relevant setting in which only a single realization of the process is observed, rendering standard i.i.d. based methods inapplicable. The proposed methodology is sensitive to both interaction structure and inhomogeneity, and can therefore identify discrepancies between the fitted model and the observed spatial pattern, including those driven by clustering, repulsion, or incorrect specification of the intensity function.

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Large-Deviation Analysis of Sparse Many-Body Systems in Motion

Cairui Duan
Aarhus University
duan@math.au.dk

We study large deviations for local clusters in a sparse random geometric system of moving particles. The particles form a homogeneous Poisson process of intensity n on the d-dimensional torus, and each particle carries an independent displacement path with law $\mathbb{Q}$. For fixed k, we consider the regime

$$nr_n^d \longrightarrow 0, \qquad \rho_{k,n} = n^k r_n^{d(k-1)} \longrightarrow \infty,$$

and record isolated k-particle clusters together with the rescaled shapes of their trajectories. We prove a large deviation principle for the resulting empirical measure at speed $\rho_{k,n}$. Its rate function is relative entropy with respect to a finite reference measure determined explicitly by the path law $\mathbb{Q}$.

As applications, we derive variational formulas for bounded interactions and hard-core constraints on cluster shapes. Thus, microscopic motion enters the rare-event geometry through the reference measure, whereas energetic tilts select preferred configurations. This extends the large deviation framework for sparse static geometric systems to clusters determined by entire trajectories and provides a basis for studying rare ordered structures such as elongated clusters, chains, and swarms.

Joint work with Paula de Dios Andres (Interdisciplinary Nanoscience Center, Aarhus University), Manish Pandey (Department of Mathematics, Aarhus University), Brigitte Städler (Interdisciplinary Nanoscience Center, Aarhus University), and Christian Hirsch (Department of Mathematics, Aarhus University)

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Pareto points in growing dimensions

Bochen Jin
University of Bern
bochen.jin@unibe.ch

We study Pareto points among n i.i.d. random points uniformly distributed in the unit cube $[0,1]^{d_n}$, where the dimension d_n increases with the sample size n. While the classical fixed-dimensional regime is well understood in [1], allowing the dimension to grow reveals new phenomena.
We identify a sharp phase transition in the number of non-Pareto points. Specifically, if

$$d_n = \frac{2}{\log 2}\log n + c + o(1), \quad c \in \mathbb{R},$$

then this number converges in distribution to a Poisson random variable with mean 2^{-c}. Below this critical regime, the number of non-Pareto points diverges in probability, whereas above it, it converges to zero in probability. Moreover, in the critical regime, asymptotically all non-Pareto points dominate exactly one other point.
We further establish convergence of non-Pareto points at the level of point processes. We prove that the projection of non-Pareto points onto each fixed m-dimensional coordinate subspace converges in distribution (with respect to the vague topology) to an inhomogeneous Poisson point process on $[0,1]^m$ with intensity $2^{m-c}|x|\mathrm{d}x$, where $|x|$ denotes the product of coordinates of $x \in \mathbb{R}^m$.
Finally, we investigate the asymptotic behavior of the moments of the number of points that dominate exactly $r \geq 2$ other points.
Joint work with Andrii Ilienko (University of Bern)

References

[1] Zhi-Dong Bai, Luc Devroye, Hsien-Kuei Hwang, and Tsung-Hsi Tsai. (2005): Maxima in hypercubes. *Random Structures Algorithms* **27**(3), 290–309.

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Controlled stochastic growth of structures in the zero-temperature Ising model

Maike de Jongh
University of Twente
m.c.dejongh@utwente.nl

The optimization of structure growth in spatially stochastic systems poses a compelling challenge in a wide range of applications, including biological pattern formation and solution-based crystallization. In this talk, we investigate control strategies for a two-dimensional zero-temperature Ising model on a finite square lattice evolving under Metropolis dynamics.
We consider a setting in which an external controller aims to drive the system from a configuration containing one or two small droplets of +-spins toward the all-plus configuration by flipping selected spins at prescribed times. To analyze this control problem, we formulate it as a Markov decision process (MDP), a classical framework for sequential decision-making problems under uncertainty.
To compute an optimal policy, we construct a simplified model by reducing the configuration space to the local minima of the Hamiltonian. Leveraging structural properties of this simplified model, we characterize the optimal policy by solving the Bellman equations in a recursive manner. Finally, we present simulation results demonstrating the performance of the optimal policy and illustrating the induced growth mechanism. Moreover, we show that its geometric features persist at low but positive temperatures.

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The Block Spin Ising Model

Isabel Lammers
University of Münster
isabel.lammers@uni-muenster.de

I will talk about recent results on the block spin Ising model with a focus on an infinite version of the model, where N spins get divided into s_N many blocks. While previous models deal with the block magnetization for a fixed number of blocks, we study the the simultaneous limit $N \to \infty$ and $s_N \to \infty$. The model interpolates between the Curie–Weiss model for $s_N = 1$, multi-species mean field for fixed $s_N = s$, and the 1D Ising model for each spin in its own block at $s_N = N$. Under mild growth conditions on s_N, we prove a law of large numbers and a multivariate CLT for the magnetization vector.

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Coverage, Detection, and the Sensing–Communication Trade-off: A Point Process Approach to ISAC Networks

Hajar Miskar

ENSIAS, Mohammed V University in Rabat, Morocco

hajar.miskar@um5.ac.ma

Integrated sensing and communication (ISAC) is emerging as a defining feature of next-generation wireless systems, in which a single network of transceivers simultaneously carries data and probes its environment in a radar-like fashion. Because the performance of such systems is dictated by the random spatial configuration of nodes, scatterers and targets, they are naturally studied within the framework of random geometric systems.

We model an ISAC network as a marked point process Φ on $\mathbb{R}^2$ — Poisson in the baseline case, and Cox (driven by a Poisson line process) or determinantal in regimes with clustering or repulsion — and analyse two coupled performance functionals. Communication reliability is captured by the SINR coverage probability

$$p_c \;=\; \mathbb{P}(\mathrm{SINR} > \theta_c)\,,$$

while sensing reliability is captured by the probability p_s that a target is illuminated with signal-to-clutter-plus-noise ratio exceeding a threshold θ_s. Using Laplace functionals of Φ, Campbell's theorem and Palm calculus, one obtains analytical expressions for both quantities and, going beyond spatial averages, a characterisation of their *meta distributions* through moment sequences and Gil–Pelaez inversion.

The resulting expressions make the underlying geometric trade-off explicit: the same point-process intensity λ that improves detection coverage also raises aggregate interference, so that the region of jointly achievable sensing and communication reliability is bounded by the second-order structure of Φ. The choice of underlying point process reshapes this trade-off region in a quantifiable way, and raises open questions on optimal — possibly repulsive — deployments, where tools from stochastic geometry and geometric probability appear particularly promising.

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Planarity in general models of random geometric graphs

Kinga Nagy
Osnabrück University
kinga.nagy@uni-osnabrueck.de

Consider a random geometric graph with vertices given by a Poisson point process, and whose edges depend on independent marks corresponding to the vertices and pairs of vertices. In this talk, we discuss the planarity of such graphs, that is, whether they can be drawn in the plane without any edge crossings. We focus on models with heavy-tailed mark distributions, in particular with polynomial tails with arbitrary exponents. We show that based on this exponent, the asymptotic behaviour varies significantly within each model, as well as across the models: specifically, the bottlenecks preventing planarity can differ substantially.
Based on joint work with Hanna Döring.

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List of Participants

Cairui Duan (Aarhus University)	duan@math.au.dk
Hanna Döring (Universität Osnabrück)	hanna.doering@uni-osnabrueck.de
Anne Estrade (Université Paris Cité)	anne.estrade@u-paris.fr
Leonhard Gorenflo (Universität Osnabrück)	lgorenflo@uni-osnabrueck.de
Anna Gusakova (University of Münster)	gusakova@uni-muenster.de
Bernhard Hafer (Universität Osnabrück)	bernhard.hafer@uni-osnabrueck.de
Pia Hamelmann (University of Paderborn)	piah@math.uni-paderborn.de
Bochen Jin (University of Bern)	bochen.jin@unibe.ch
Maike de Jongh (University of Twente)	m.c.dejongh@utwente.nl
Céline Kerriou (Stockholm University)	celine.kerriou@mail.mcgill.ca
Isabel Lammers (University of Münster)	isabel.lammers@uni-muenster.de
Tess van Leeuwen (Utrecht University)	t.j.vanleeuwen@uu.nl
Shreya Mandal (University of Münster)	shreyamandal27@gmail.com
Hajar Miskar (ENSIAS, Mohammed V University in Rabat)	hajar_miskar@um5.ac.ma
Vinita Mulay (University of Duisburg-Essen)	vinita.mulay@uni-due.de
Kinga Nagy (Osnabrück University)	kinga.nagy@uni-osnabrueck.de
Max Siemen (University Duisburg-Essen)	max.siemen@stud.uni-due.de
Anna Strotmann (Universität Osnabrück)	anstrotmann@uos.de
Anja Sturm (Universität Göttingen)	asturm@math.uni-goettingen.de
Réka Szabó (University of Groningen)	r.szabo@rug.nl
Benedikt Rednoß (Ruhr University Bochum)	benedikt.rednoss@ruhr-uni-bochum.de
Tara Trauthwein (University of Münster)	tara.trauthwein@uni-muenster.de
Leoni Carla Wirth (Imperial College London)	wirthleoni@gmail.com