Book of abstracts

Mixing times between probability, computer science and statistical physics

ICTP, 5–9 May 2025

Mini-courses

Perla Sousi (Cambridge)

Title: Random walk: cover time and geometry of the uncovered set
Abstract: In this talk we will give a survey of recent progress on fine geometrical properties of random walks. We will focus on the cover time and the structure of the last visited set of points on finite graphs. Along the way we will discuss other related models, such as the Gaussian free field and study its high points.

Alexandre Stauffer (King's College London)

Title: Mixing time of random walks on dynamic graphs
Abstract: In this short series of lectures, we will consider the problem of analyzing the mixing time of a random walk on dynamic graphs. We will first consider a general model of dynamic graphs and then focus on the model of dynamical percolation (not necessarily independent). We will discuss the state-of-the-art and some open problems, and will also present the proof of the mixing time of a random walk on the dynamical percolation obtained from the subcritical random cluster model evolving through Glauber dynamics.

Talks

Monday

Evrydiki Nestoridi (Stony Brooks)

Title: Shuffling via transpositions
Abstract: In their seminal work, Diaconis and Shahshahani proved that shuffling a deck of n cards sufficiently well via random transpositions takes $1/2\, n \log n$ steps. Their argument was algebraic and relied on the combinatorics of the symmetric group. In this talk, I will focus on a generalization of random transpositions and I will discuss the underlying combinatorics for understanding their mixing behavior and indeed proving cutoff. The talk will be based on joint work with S. Arfaee.

Dominik Schmid (University of Augsburg)

Title: Mixing times for the open ASEP
Abstract: In this talk, we consider the asymmetric simple exclusion process with open boundaries (open ASEP). We give an overview on recent results on mixing times for the open ASEP. In particular, we discuss mixing times for the open ASEP at the triple point. This talk is based on joint work with Patrik Ferrari.

Andjela Šarković (Cambridge)

Title: Mixing of a random walk on a randomly twisted hypercube
Abstract: We study the mixing properties of a simple and lazy random walk on a randomly twisted hypercube. In both cases, we establish the order of the mixing time and prove that the model does not exhibit cutoff. Joint work with Zsuzsanna Baran.

Zsuzsanna Baran (Cambridge)

Title: Phase transition for random walks on graphs with an added weighted random matching
Abstract: For a finite graph $G = (V, E)$, we let G^* be the random graph obtained by placing edges of weight ε between pairs of vertices of a random perfect matching. For two families of graphs we establish a phase transition in the occurrence of cutoff of a weighted random walk on G^* in terms of the weight ε. We also give a general condition on ε that is sufficient to ensure cutoff. Joint work with Jonathan Hermon, Andjela Šarković, and Perla Sousi.

Tuesday

Allan Sly (Princeton)

Title: Rapid phase ordering for Ising dynamics on random graphs
Abstract: We consider the Ising Glauber dynamics on random d-regular graphs on n vertices at low temperatures $\beta \geq \frac{C \log d}{d}$. The mixing time is exponential in n due to a bottleneck between the "plus phase" and the "minus phase". We prove that for any $d \geq 7$, from biased initializations with $\epsilon_d n$ more pluses than minuses, the Glauber dynamics rapidly quasi-equilibrates to the plus phase stationary measure in optimal $O(\log n)$ time. Moreover, the requisite bias ϵ_d can be taken to zero as $d \to \infty$. The proof introduces a new approach to control of negative information spread in spacetime despite the model being in low temperature and exhibiting strong local correlations. This step uses a coupled non-Markovian rigid dynamics which is only more minus than the Ising Glauber dynamics, and for which a delicate temporal recursion on probability mass functions of minus spacetime regions establishes their subcriticality. Joint work with Reza Gheissari and Youngtak Sohn.

Shirshendu Ganguly (UC Berkeley)

Title: Critical level set percolation for the GFF in high dimensions: intrinsic geometry and random walk

Abstract: Level set percolation of the GFF in $\mathbb{Z}^d$ is a canonical example of a dependent percolation model exhibiting power law decay of correlations. The intrinsic geometry of the corresponding critical percolation cluster has been the subject of much recent activity admitting certain integrable features. Relying on these, in 2016, Lupu established that the critical percolation cluster has the same law as that in a Poisson loop soup. Studying the geometry of loops, In 2021, Werner presented an insightful semi-rigorous picture for the critical behavior in this context, in particular, predicting that above the upper critical dimension, i.e. $d > 6$, effect of large loops should be negligible and the loop model should behave like the standard independent bond percolation. Consequently the random walk should exhibit mean field exponents in line with the Alexander-Orbach (AO) conjecture. In this talk, we will present recent progress in this direction. We will introduce geometric arguments to tackle the long range nature of the model and as a consequence establish the AO conjecture in high enough dimensions. Other applications include the resolution of a conjecture of Werner which asserts that the deletion of loops with large diameter does not affect the connectivity of the loop soup.

Bastien Dubail (KTH)

Title: Cutoff for mixtures of permuted Markov chains

Abstract: In this talk, I will present results on the mixing time of a Markov chain in random environment defined as a mixture of a deterministic chain and a chain whose state space has been permuted uniformly at random. Under mild assumptions on the base Markov chains, we show the occurrence of a cutoff phenomenon at entropic time: provided the chain is started from a typical state the mixing time will with high probability scale as $\log n/h$ as the number of states n goes to infinity, where h is a constant related to the entropy of the chain. I will show however that in general, the mixing time from an arbitrary starting state can be larger, namely of polylogarithmic order of any degree, while if some reversibility constraints are imposed we recover cutoff uniformly over all starting states. If time allows I will also present a problem I have been working on lately, relating local mixing phenomena with matrix estimation, which finds its motivation in reinforcement learning.

Alessandra Caraceni (Scuola Normale Superiore di Pisa)

Title: Growing random geometries and mixing: from making trees blossom to making quadrangulations flip

Abstract: In this talk we will discuss a way to upper bound the mixing time of certain edge flip Markov chains — especially on planar maps — by constructing canonical paths from “uniform growth schemes”. In particular, we address the problem of coupling a uniform quadrangulation of the sphere with n faces with a uniform quadrangulation of the sphere with $n+1$ faces in such a way that the smaller quadrangulation is always obtained from the larger by collapsing a face. We will explore the connection of this question to the idea of growing trees by the leaves and to the problem of estimating the mixing time of the edge flip chain on quadrangulations of the sphere. Based on joint works with Alexandre Stauffer.

Alessandra Cipriani (University College London)

Title: The spectrum of dense kernel-based random graphs
Abstract: Kernel-based random graphs (KBRGs) are a class of random graph models that account for inhomogeneity among vertices. We consider KBRGs on a discrete d-dimensional torus. Conditionally on an i.i.d. sequence of Pareto weights, we connect any two points independently with a probability that increases in the points' weights and decreases in the distance between the points. We focus on the adjacency matrix of this graph and study its empirical spectral distribution. In the dense regime we show that a limiting distribution with non-trivial second moment exists as the size of the torus goes to infinity, and that the corresponding measure is absolutely continuous with respect to the Lebesgue measure. We also derive a fixed-point equation for its Stieltjes transform in an appropriate Banach space. In the case corresponding to so-called scale-free percolation we can explicitly describe the limiting measure and study its tail. Based on a joint work with R. S. Hazra, N. Malhotra and M. Salvi.

Assaf Shapira (Université Paris Cité)

Title: Topology and time scales in spin $O(N)$ models
Abstract: The effect of topology and topological defects on the $O(N)$ spin model in equilibrium is an active domain of research since the discovery of the Berezinskii-Kosterlitz-Thouless phase transition in the 70's. In this talk we consider the dynamics of this model, when spins move in time. We will discuss the effect of topology on time scales of the system and metastability phenomena. Based on works with Clément Cosco, Pietro Caputo, and Sébastien Ott.

Wednesday

Nina Gantert (TU Munich)

Title: Consensus and disagreement in opinion dynamics
Abstract: We discuss some results and some open questions for two models of opinion dynamics, the averaging process and the compass model. For both models, we investigate convergence of the opinions on infinite graphs. This is based on joint work with Markus Heydenreich and Timo Hirscher/Vilkas.

Dor Elboim (Stanford)

Title: Averaging processes on graphs with random initial opinions

Abstract: In this talk, we will consider two processes of evolving opinions on graphs: the edge-averaging process and the DeGroot dynamics. We will study the typical time it takes for the opinions to reach approximate consensus. In particular, we will show that when the initial opinions of the vertices are random, the convergence is much faster compared to deterministic (worst case) initial opinions. Based on joint works with Yuval Peres and Ron Peretz.

Thursday

Guillem Perarnau (Universitat Politècnica de Catalunya)

Title: Synchronisation in random DFA via random words
Abstract: We study the synchronisation problem on a random deterministic finite automaton with n states (i.e., a random r-out edge-labelled digraph) via random words. Specifically, we compute the probability that a random walk (interpreted as the execution of a random word) of length $k = O(\log n)$ is contracting in the sense that, starting with a particle at each state, after $O(\sqrt{n})$ executions all the walks have coalesced into a single state. Our results imply that, with high probability, there exists a synchronising word of length $O(n^{1/2} \log n)$, which in particular can be found in quasi-quadratic time. This confirms conjectures of several authors based on numerical simulations of the probabilistic version of Černý's conjecture. This is joint work with Guillaume Chapuy.

Sinho Chewi (Yale)

Title: A local error framework for KL divergence via shifted composition
Abstract: Local error analysis is a standard framework for establishing error estimates for the numerical discretization of stochastic systems. However, it is traditionally limited to guarantees in the Wasserstein metric. In this talk, I will describe a strengthening of this framework which yields bounds in the stronger sense of KL divergence or relative entropy. At the heart of this result is a technique to use coupling arguments to control information-theoretic divergences. This technique, which we call "shifted composition", builds on works developed with my co-authors Jason M. Altschuler and Matthew S. Zhang.

Kuikui Liu (MIT)

Title: Strong spatial mixing for colorings on trees and its algorithmic applications
Abstract: Correlation decay is a fundamental and important property of distributions arising in statistical physics and theoretical computer science. A longstanding conjecture is that the uniform distribution over proper q-colorings on any tree of maximum degree Δ exhibits a strong form of correlation decay whenever $q \geq \Delta + 1$. It is surprising that such a basic question is still open, but then again it also highlights how much we still have to learn about random colorings. In this talk, I will discuss a near-resolution of this conjecture, as well

as its algorithmic implications for sampling colorings on bounded-degree graphs via Glauber dynamics. Based on joint work with Zongchen Chen, Nitya Mani, and Ankur Moitra.

Zongchen Chen (Georgia Tech)

Title: New Rapid Mixing Results for Hardcore Model
Abstract: Over the past decades, a fascinating computational phase transition has been identified in sampling from the hardcore model over weighted independent sets. However, the computational complexity at the critical point remains poorly understood, as previous algorithmic and hardness results all required a constant slack from this threshold. In this talk, I will introduce our recent result on resolving this open question at the critical threshold, thus completing the picture of the computational phase transition. Specifically, we show that for the critical hardcore model, the mixing time of Glauber dynamics is always polynomial and in the worst case super-linear in the number of vertices. Furthermore, we establish that on random regular graphs, rapid mixing holds far beyond the uniqueness threshold, showing that the worst-case and average-case complexities of sampling from the hardcore model are fundamentally different. Based on joint work with Xiaoyu Chen, Yitong Yin, and Xinyuan Zhang, and joint work with Xiaoyu Chen, Zejia Chen, Yitong Yin, and Xinyuan Zhang.

Ivailo Hartarsky (Université Claude Bernard Lyon 1)

Title: Cores on lattices
Abstract: Consider activating the n vertices of a discrete square torus one at a time in uniformly random order. For n large, when does an active 3-core (subgraph with minimum degree at least 3 induced by active vertices) appear and what is its size when it does? We answer these questions, revealing a somewhat surprising explosion, stronger than the mean-field phenomenology, covered by the classical work of Łuczak. The tools involved in the proof come from well-established bootstrap percolation theory. Yet, extending the result to other lattices is much more challenging and is the main focus of our work. This talk is based primarily on joint work with Lyuben Lichev available at https://arxiv.org/abs/2501.18976, but also related joint works with Hugo Duminil-Copin and with Augusto Teixeira.

Friday

Weiming Feng (The University of Hong-Kong)

Title: Faster mixing of the Jerrum-Sinclair chain
Abstract: We show that the Jerrum-Sinclair Markov chain on matchings mixes in time $O(\Delta^2 m \operatorname{polylog} n)$ on any graph with n vertices, m edges, and maximum degree Δ, for any constant edge weight $\lambda > 0$. For general graphs with arbitrary, potentially unbounded Δ, this provides the first improvement over the classic $O(n^2 m \operatorname{polylog} n)$ mixing time bound of Jerrum and Sinclair (1989) and

Sinclair (1992). To achieve this, we develop a general framework for analyzing mixing times, combining ideas from the classic canonical path method with the "local-to-global" approaches recently developed in high-dimensional expanders, introducing key innovations to both techniques.