Workshop on Disordered Media
Erdős Center
Budapest, Hungary, 27 January - 31 January 2025

ZEITOUNI, Ofer (Weizmann Institute and New York University)
Directed polymers, log correlated fields and varying variance branching random walks
Monday, 27 January, 9:30-10:20

Abstract: I will discuss the directed polymer in Gaussian environment in dimension 2, with subcritical scaling that leads to weak disorder. It is known since the work of Caravenna, Sun and Zygouras that the logarithm of the partition function, properly scaled, converges to a logarithmically correlated field. The study of extremes of this field leads to some surprises and helps in elucidating the nature of the field, which relates to branching random walks with (slowly) varying variance profile. (Work in progress with Clement Cosco and Shuta Nakajima).

CENATIEMPO, Serena (Gran Sasso Science Institute)
Bose-Einstein Condensation and low temperature phases of Dilute Bose Gases
Monday, 27 January, 10:50-11:40

Abstract: Dilute Bose gases are unique quantum systems that exhibit a fascinating low-temperature phase known as the Bose-Einstein condensate. In this talk, we will discuss the challenge of developing rigorous mathematical models that describe how this macroscopic phase emerges from the system's microscopic description, focusing on recent advances in this field over the past two decades. We will also touch on the stability of this phase in the presence of disorder.

OLLA, Stefano (Université Paris Dauphine – PSL)
Diffusive behaviour in extended completely integrable dynamics
Monday, 27 January, 11:50-12:40

Abstract: On a diffusive space-time scaling, density fluctuations behave very differently in extended completely integrable systems with respect to chaotic systems. I will expose some recent results concerning the one dimensional hard rods infinite dynamics and the box-ball cellular automata (an ultradiscretization of the KdV equation). Joint works with Pablo Ferrari, Makiko Sasada, Hayate Suda.

MORFE, Peter (Max Planck Institute, Leipzig)
Intermittent Behavior of the Averaged Lagrangian Coordinate in a Critical 2D Diffusion Process
Monday, 27 January, 15:00-15:50

Abstract: I will discuss recent results on a certain 2D diffusion process with critically correlated random drift, namely, the so-called diffusion in the curl of the GFF. Significant progress has been made recently on the asymptotic behavior of this process,

confirming physicists' prediction that the mean-square displacement has a certain logarithmic, superdiffusive growth. In my talk, I will begin by reviewing one approach to proving this, based on concepts from homogenization theory. The remainder of my talk will be devoted to a connection with a certain diffusion on the special linear group SL(2). By exploiting this connection, we are able to prove intermittent/non-Gaussian behavior at the level of the averaged Lagrangian coordinates. This is joint work with Chatzigeorgiou, Otto, Wagner, and Wang.

PROCACCIA, Eviatar (Technion)
Multi-particle aggregation models
Monday, 28 January, 16:20-17:10

Abstract: In this talk I will discuss some statistical physics models generated by many diffusing clusters. For a simplification of MDLA, modeling aggregating droplets, we show that a phase transition for the growth rate occurs at any dimension. I will introduce the Cluster-cluster model, defined by Meaking in 1984, and discuss some physics conjectures. My talk will serve as an introduction to Berger's talk.

BERGER, Noam (Technical University of Munich)
Some results on the cluster-cluster model
Monday, 28 January, 17:20-18:10

Abstract: In continuation of Procaccia's talk, we discuss the behavior pf the cluster-cluster model in various regimes. In particular we show that the model does not condensate in the slow regime in dimension greater than one, and show some (more or less) precise calculations in dimension 1. Based on joint work with G. Amir, E. Procaccia, D. Sharon and D. Schmid.

ZYGOURAS, Nikolaos (The University of Warwick)
The Critical $2d$ Stochastic Heat Flow and some first properties
Tuesday, 28 January, 9:30-10:20

Abstract: The Critical $2d$ Stochastic Heat Flow arises as a high-temperature scaling limit of the solution of the Stochastic Heat Equation (SHE) at the critical dimension 2 and at a phase transition point. It is a log-correlated field which is neither Gaussian nor a Gaussian Multiplicative Chaos. We will review the phase transition of the $2d$ SHE, describe the main points of the construction of the Critical $2d$ SHF and outline some of its features and related questions. Based on joint works with Francesco Caravenna and Rongfeng Sun.

DEMBIN, Barbara (ETH Zürich)
Minimal Surfaces in a Random Environment
Tuesday, 28 January, 10:50-11:40

Abstract: We consider surfaces of $Z^d \to R$ and a random environment η in $Z^d \times R$. We focus on surfaces φ that minimize the sum of their elastic energy (the ℓ_2-norm of

the gradient of the surface in Z^d) and the noise on the surface $\sum_v \eta_{v,\varphi_v}$. We show, under assumptions on the noise, results on localization and delocalization depending on the dimension, as well as relations between the surface energy and the typical height of the surface (scaling relations).

Joint work with Dor Elboim, Daniel Hadas, and Ron Peled.

DREWITZ, Alex (Universität zu Köln)
Random Walk among Moving Traps
Tuesday, 28 January, 11:50-12:40

Abstract: Random walk and Brownian motion among static obstacles have been the subject of extensive research during the last couple of decades. Of particular interest have been the survival probability as well as the path behavior of the motion conditioned on survival. However, comparatively less attention has been given to scenarios involving moving traps. We survey some of the results obtained in the setting of a Poisson cloud of moving traps during the last decade and discuss a recently established functional central limit theorem in dimensions 6 and higher.

BELLA, Peter (TU Dortmund)
From regularity theory for elliptic equations to invariance principle for random walks
Tuesday, 28 January, 15:00-15:50

Abstract: I will discuss local regularity properties of solutions of linear non-uniformly elliptic equations with non-constant degenerate coefficients. Assuming certain integrability conditions on the ellipticity of the coefficient field, we obtain local boundedness of weak solutions. The assumed integrability assumptions are sharp and improve via a cute cut-off optimization upon classical work [Trudinger, ARMA 1971]. The probabilistic motivation for the regularity theory is quenched invariance principle for random walks among random degenerate conductances, which I will discuss together with its local form.

SAPOZHNIKOV, Artem (Universität Leipzig)
Visibility through the vacant set of Boolean models, Poisson cylinders and Brownian interlacements
Wednesday, 29 January, 9:30-10:20

Abstract: Let $\mathcal{C}$ be a random closed subset of $\mathbb{R}^d$ with a rotationally invariant law, thought of as a field of obstacles. A point x is visible if the line segment $[0, x]$ is not intersected by $\mathcal{C}$. We are interested in the probability of visibility to distance r, that is when some point at distance r from 0 is visible. While the probability of visibility of a single point is often explicit, the probability of visibility to distance r is generally not. We discuss sharp bounds on the probability of visibility to distance r in terms of the probability that a given point at distance r from 0 is visible for the three choices of Poissonian obstacles $\mathcal{C}$: Boolean models, Poisson cylinders and Brownian interlacements. We show that the ratio of the two probabilities scales as

$(r/\delta(r))^{d-1}$, where $\delta(r)$ is explicit and can be understood as the size of a correlation window. Generally, $\delta(r) = 1/r$ for all the three models; exceptions are the Brownian interlacements in three dimensions ($\delta(r) = (\log r)^2/r$) and the Poisson cylinders in the plane ($\delta(r) = 1$). Based on a joint work with Yingxin Mu (Leipzig).

HELMUTH, Tyler (Durham University)
Pirogov–Sinai Theory Beyond Lattices
Wednesday, 29 January, 10:50-11:40

Abstract: Independent sets are of interest in both statistical physics and computer science; in the former as a discrete model of crystallization, and in the latter as a constraint satisfaction problem. This common interest has lead to some fruitful interactions between the two fields, and it motivates the study of random independent sets (aka: the hard-core lattice gas) on rather general bipartite graphs. I'll explain this motivation, which lead Sarah Cannon, Will Perkins, and myself to develop Pirogov–Sinai theory beyond it's traditional setting. Using this tool we are able to discuss phase coexistence (and more) for the hard-core lattice gas in some generality.

SABOT, Christophe (Institut Camille Jordan, Univ. Lyon)
A new supersymmetric space associated with the *VRJP
Wednesday, 29 January, 11:50-12:40

Abstract: The Vertex reinforced Jump Process (VRJP) is a continuous time self-interacting process with reinforcement on the vertices. It is closely related to a supersymmetric spin system with hyperbolic symmetries, called the $H^{2|2}$ model. The $H^{2|2}$ model encodes the limiting distribution of the local times of the VRJP, and is also related to the VRJP at finite time via isomorphism theorems. In this talk we will introduce a generalization of the $H^{2|2}$ model and show that it is related to a non-reversible generalization of the VRJP, the *VRJP. We will explain what works the same or differently compared to the VRJP. Based on joint work with Andrew Swan and Pierre Tarrès.

TURNER, Amanda (University of Leeds)
Local fluctuations for planar aggregation
Thursday, 29 January, 9:30-10:20

Abstract: Planar random growth processes occur widely in the physical world. Examples include diffusion-limited aggregation (DLA) for mineral deposition and the Eden model for biological cell growth. One approach to mathematically modelling such processes is to represent the randomly growing clusters as compositions of conformal mappings. In 1998, Hastings and Levitov proposed one such family of models, which includes versions of the physical processes described above. An intriguing property of their model is a conjectured phase transition between models that converge to growing disks, and 'turbulent' non-disk like models. In previous work with Norris and Silvestri, we have shown that the global fluctuations present in these models exhibit behaviour that can be interpreted as the beginnings of a macroscopic phase transition from disks to non-disks. In this talk I will discuss work in progress with Larissa

Richards in which we explore how the correlation structure of local fluctuations near the cluster boundary changes at the point of phase transition.

TONINELLI, Fabio (Technical University of Vienna) and
CANNIZZARO, Giuseppe (University of Warwick)
Superdiffusive Central Limit Theorem for the Stochastic Burgers Equation at the critical dimension
Thursday, 29 January, 10:50-11:40 and Thursday, 29 January, 11:50-12:40

Abstract: The Stochastic Burgers Equation (SBE) was introduced in the eighties by van Beijren, Kutner and Spohn as a mesoscopic model for driven diffusive systems with one conserved quantity. In the subcritical dimension d=1, it coincides with the derivative of the KPZ equation whose large-scale behaviour is polynomially superdiffusive and given by the KPZ Fixed Point, and in the super-critical dimensions d>2, it was recently shown to be diffusive and rescale to an anisotropic Stochastic Heat equation. At the critical dimension d=2, the SBE was conjectured to be logarithmically superdiffusive with a precise exponent but this has only been shown up to lower order corrections. This two-part talk is based on the work joint with Quentin Moulard under the same name https://arxiv.org/abs/2501.00344, where we pin down the logarithmic superdiffusivity by identifying exactly the large-time asymptotic behaviour of the so-called diffusion matrix and show that, once the logarithmic corrections to the scaling are taken into account, the solution of the SBE satisfies a central limit theorem. This is the first superdiffisive scaling limit result for a critical SPDE, beyond the weak coupling regime.

COJA-OGHLAN, Amin (TU Dortmund)
Random 2-SAT revisited
Thursday, 29 January, 15:00-15:50

Abstract: The random 2-SAT problem is a classical example of a random constraint satisfaction problem. Its satisfiability phase transition was already determined in the 1990s. However, finding the number of solutions in the satisfiable regime remained an open problem. A conjecture was put forward by Monasson and Zecchnia in the 1990s based on statistical physics methods. This talk deals with a proof of this conjecture and a related central limit theorem.

POWELL, Ellen (Durham University)
Thick points of the GFF and CLE nesting fields
Thursday, 29 January, 16:20-17:10

Abstract: "Thick points" of the GFF are points where, roughly speaking, the field is atypically high. They provide insight into the geometric properties of the field, and are the basis for the construction of so-called Liouville (quantum gravity) measures. The set of thick points with thickness level a is a fractal set with Hausdorff dimension $2 - a^2/2$. In this talk I will discuss another fundamental property, namely, that the set is almost surely disconnected for all non-zero a. This is based on joint work with

Juhan Aru and Léonie Papon, and uses a remarkable relationship between the GFF and the conformal loop ensemble of parameter 4.

BENCS, Ferenc (University of Amsterdam)
Free-energy of the Random Cluster Model along large girth graphs
Thursday, 29 January, 17:20-18:10

Abstract: For a given graph $G = (V, E)$ the with $v(G)$ vertices the partition function of the random cluster model is given by

$$Z_G(q, w) = \sum_{A \subseteq E} w^{|A|} q^{k(A)},$$

where $k(A)$ is the number of connected components of (V, A). In the talk, we will consider d-regular large girth graph sequences $(G_n)_n$ and present some results on the free-energy per site along this sequence, i.e.

$$\lim_{n\to\infty} \frac{1}{|V(G_n)|} \log Z_{G_n}(q, w) = \log \Phi_{d,q,w}$$

exists and is independent of the particular large girth sequence.

In particular, when $q \geq 2$ and $w > 0$, we see that $\Phi_{d,q,w}$ has a nice description that extends the result of Dembo, Montanari, Sly and Sun. Moreover, we confirm a conjecture of Helmuth, Jenssen and Perkins, namely that the order-disorder phase transition is at

$$w_c = \frac{q-2}{(q-1)^{1-2/d} - 1} - 1.$$

JOHNSON, Tobias (College of Staten Island, CUNY)
Self-organized criticality in activated random walk
Friday, 30 January, 9:30-10:20

Abstract: Physicists Bak, Tang, and Wiesenfeld in the 1980s proposed "self-organized criticality" as an explanation for why systems in nature with no obvious phase transition can exhibit self-similarity and power-law tails reminiscent of statistical mechanics systems at criticality. Based on simulations, they and others proposed that simple mathematical models of sandpiles drive themselves to criticality, in various senses. These predictions have been quite difficult to confirm mathematically. We consider activated random walk (ARW), one of the sandpile models that seems to follow physicists' predictions. In dimension one, we prove the density conjecture: ARW on a finite interval with particles added in the middle and destroyed at the edges naturally drives itself to the critical density of ARW on the infinite line. This is the first rigorous proof of any sandpile model driving itself to a critical state. Joint work with Chris Hoffman and Matt Junge.

BAEUMLER, Johannes (University of California, Los Angeles)
The truncation problem for long-range percolation

Friday, 30 January, 10:50-11:40

Abstract: In long-range percolation on the integer lattice, for each pair of points $\{x, y\}$, there is an open edge between these points with probability depending on the Euclidean distance between the points, independent of all other edges. When are the long edges necessary for the existence of an infinite cluster? The truncation problem asks whether one can remove all long enough edges while still retaining an infinite open cluster. We discuss this question in the non-summable regime in dimensions $d \geq 3$. Here we show that the truncation problem has an affirmative answer.

ARMSTRONG, Scott (Courant Institute of Mathematical Sciences, NYU)
Coarse-graining elliptic operators
Friday, 30 January, 11:50-12:40

Abstract: I will discuss a quantitative theory of coarse-graining for elliptic PDEs developed recently with Tuomo Kuusi. This grew out of our theory of quantitative homogenization (developed about ten years ago jointly with Jean-Christophe Mourrat) but is now more flexible and has much broader possible applications. The goal of the talk is to explain how this coarse-graining actually works at an intuitive level, with some analytic details. I will also discuss several such applications, including our recent quenched superdiffusive CLT for a diffusion in the curl of a log-correlated field (with Ahmed Bou-Rabee), and upper bound estimates for the correlation lengths in the random conductance model.

DARIO, Paul (Université Paris Est Créteil)
Delocalisation for the low temperature long-range Gaussian chain
Friday, 30 January, 15:00-15:50

Abstract: In this talk, we will discuss the discrete long-range Gaussian chain with $1/r^\alpha$ interactions. I will introduce the model, its history and phase diagram. In this direction, a first notable result is the existence of a roughening phase transition for $\alpha = 2$ established by Kjaer-Hilhorst and FrĂśhlich-Zegarlinski. For $\alpha > 2$, the model is not expected to undergo a phase transition and a few important results have been recently obtained: Garban characterized the fluctuations of the chain at high temperature (and in fact fully identified its scaling limit) and Coquille–van Enter–Le Ny–Ruszel showed the (qualitative) delocalisation of the chain at every inverse temperature. After discussing these results in more details, I will present some quantitative estimates in the low temperature regime with range exponent $\alpha > 2$ obtained in an joint work with L. Coquille and A. Le Ny.

GUREL-GUREVICH, Ori (Einstein Institute of Mathematics, Hebrew University of Jerusalem)
Asymptotic resistance of the critical series-parallel graph
Friday, 30 January, 16:20-17:10

Abstract: Consider a sequence of random graphs: G_0 consists of two vertices connected by a single edge. Given G_n we construct G_{n+1} by replacing each edge in G_n by

either two edges in parallel (with probability p) or two edges in series (with probability $1-p$). This model was introduced and studied by Hambly and Jordan. They proved that in the non-critical case the resistance across the graph almost surely tends to 0 (for $p > 1/2$) or to infinity (for $p < 1/2$). They conjectured that in the critical case, the resistance converges to 0 or infinity with probability 1/2 each. We partially resolve this conjecture, proving the result for a subsequential limit. Based on joint work with my student Nadav Jacobs.

MATHIEU, Pierre (Centre de Mathématiques et d'Informatique, Université d'Aix-Marseille)

Merging properties for time-inhomogeneous Markov chains

Friday, 30 January, 17:20-18:10

Abstract: We consider time-inhomogeneous Markov chains taking values in an infinite countable discrete set. The classification of time-homogeneous Markov chains into transient, null recurrent and positive-recurrent chains does not quite apply to time-inhomogeneous chains. In particular the question of the convergence to stationarity should be rephrased using the "merging property" discussed in a series of papers by L. Saloff-Coste and J. Zuniga. Roughly, merging means loss of memory of the initial state.

In this talk, we shall discuss new conditions that ensure a Markov chain has the merging property. The proofs are based on an alternative expression of the law of the chain based on what we called "accompanying sets". (joint work with A.N. Moumeni)