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# Winter School Spatial Models in Statistical Mechanics

February 24-28, 2014

TU Darmstadt

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## Organization

V. Betz

M. Meiners

## Short Courses

V. Beffara

V. Sidoravicius

## Invited Speakers

A. Fribergh

M. Heydenreich

G. Pete

S. Müller

D. Ueltschi



February 20, 2014

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## 1 General Information

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### 1.1 Accommodation

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The participants are recommended to stay in one of the following hotels, located in walking distance (5 - 15 minutes) to the lecture venue.

- WELCOME HOTEL DARMSTADT  
Karolinenplatz 4  
64289 Darmstadt  
Tel: +49-6151-3914-0  
Fax: +49-6151-3914-444
- HOTEL Atlanta  
Kasinostraße 129  
64293 Darmstadt  
Tel: +49-6151-1789-0  
Fax: +49-6151-1789-66

For directions please see the map in section 1.4.

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### 1.2 Registration

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

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### 1.3 Lecture Hall

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Location: Technische Universität Darmstadt. The registration and all lectures will take place in building S2|04, Hochschulstraße 8 | 64289 Darmstadt in lecture hall S2|04/213. In the lecture hall, there are 2 large and 4 small blackboards, an overhead projector and a beamer.

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### 1.4 Map & Points of Interest

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The map can be found on the last page.

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### 1.5 Public Transportation

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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.

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## 1.6 Food & Beverage

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Cheap and plain food can be purchased at the TU Darmstadt Refectory-Canteen, building S1|11 (see map), Monday to Friday 11:15 to 14:00. Additionally there are lots of good restaurants and bistros near TU Darmstadt. Please dial 0049 6151 preceding the number given below.

| Name                | Address          | Phone   | Cuisine  | Opening Hours |
|---------------------|------------------|---------|----------|---------------|
| Ratskeller          | Marktplatz 8     | 26444   | German   | 10:00 - 24:00 |
| Pizzeria da Nino    | Alexanderstr. 29 | 24220   | Italian  | 12:00 - 23:00 |
| Haroun's            | Friedensplatz 6  | 23487   | Oriental | 11:00 - 01:00 |
| Vis à Vis           | Furhmannstr. 2   | 9670806 | Bistro   | 10:00 - 15:30 |
| Central Station     | Carree           | 809460  | Bistro   | 12:00 - 14:30 |
| Ristorante Sardegna | Kahlertstraße 1  | 23029   | Italian  | 11:30 - 15:00 |

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## 1.7 Conference Dinner

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On Tuesday, February 25<sup>th</sup> there will be a conference dinner at the Welcome Hotel (see map) at 19:00.

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## 1.8 Free Afternoon

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On Wednesday, February 26<sup>th</sup> there will be a free afternoon.

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## 1.9 Contact Information

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

- Prof. Dr. Volker Betz  
Office: S2-15, Room 340  
Phone: +49 (0) 6151 - 16 2288
- Jun.-Prof. Dr. Matthias Meiners  
Office: S2-15, Room 351  
Phone: +49 (0) 6151 - 16 76199
- Office Department  
Office: S2-15, Room 339  
Phone: +49 (0) 6151 - 16 5343 / or 3638

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## Acknowledgements

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Financial support by the ESF activity entitled ‘Random Geometry of Large Interacting Systems and Statistical Physics’ (RGLIS), the Department of Mathematics at Technische Universität Darmstadt, and the University of Münster (via the dissertation prize 2009) is gratefully acknowledged.

## 2 Programme

| Monday                                                                  | Tuesday                                                            | Wednesday           | Thursday                                                                      | Friday              |
|-------------------------------------------------------------------------|--------------------------------------------------------------------|---------------------|-------------------------------------------------------------------------------|---------------------|
| Registration and Welcome                                                |                                                                    |                     |                                                                               |                     |
| V. Befarra                                                              | V. Befarra                                                         | V. Befarra          | V. Befarra                                                                    | V. Befarra          |
| <i>Coffee break</i>                                                     | <i>Coffee break</i>                                                | <i>Coffee break</i> | <i>Coffee break</i>                                                           | <i>Coffee break</i> |
| V. Sidoravicius                                                         | V. Sidoravicius                                                    | V. Sidoravicius     | V. Sidoravicius                                                               | V. Sidoravicius     |
| <i>Lunch</i>                                                            | <i>Lunch</i>                                                       | <i>Coffee break</i> | <i>Lunch</i>                                                                  | <i>Lunch</i>        |
| D. Ueltschi                                                             | M. Heydenreich                                                     | A. Fribergh         | G. Pete                                                                       | S. Müller           |
| Contributed talks:<br>Aumann<br>Fitzner<br>Erhard                       | Contributed talks:<br>Sulzbach<br>Marynych<br>Graf                 | <i>Lunch</i>        | Contributed talks:<br>Poisat<br>Cortines Peixoto Neto<br>Bauernschubert       | <i>Coffee break</i> |
| <i>Coffee break</i>                                                     | <i>Coffee break</i>                                                | Free Afternoon      | <i>Coffee break</i>                                                           | End of Workshop     |
| Short talks:<br>Duhart, Jahnel,<br>Lees, Matetski ,<br>Pulvirenti, Tate | Short talks:<br>Bethuelssen, Orenshrein,<br>Pham, Taggi,<br>Walter |                     | Short talks:<br>Döbler, Duraj,<br>Höfelsauer/Weidner,<br>Miller, Mönch, Coijn |                     |
|                                                                         | Conference dinner                                                  |                     |                                                                               |                     |

## Monday, 24. February 2014

| Time        | Speaker             | Title of Talk                                                                                                                  |
|-------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------|
| 09:05-10:50 | Vincent Beffara     | <i>Mini course on Schramm-Loewner evolution</i>                                                                                |
| 10:50-11:15 |                     | –Coffee Break–                                                                                                                 |
| 11:15-12:45 | Vladas Sidoravicius | <i>Mini course on random walk in random environment</i>                                                                        |
| 12:45-14:00 |                     | –Lunch Break–                                                                                                                  |
| 14:00-15:00 | Daniel Ueltschi     | <i>Random loop representations for quantum spin systems</i>                                                                    |
| 15:00-15:20 | Simon Aumann        | <i>Singularity of nearcritical percolation scaling limits</i>                                                                  |
| 15:20-15:40 | Robert Jörg Fitzner | <i>Nearest-neighbor percolation shows mean-field behavior in <math>d &gt; 14</math></i>                                        |
| 15:40-16:00 | Dirk Erhard         | <i>Brownian paths homogeneously distributed in space: percolation phase transition and uniqueness of the unbounded cluster</i> |
| 16:00-16:30 |                     | –Coffee Break–                                                                                                                 |
| 16:30-17:30 | Short talks         | Duhart, Jahnelt, Lees, Matetski, Pulvirenti, Tate                                                                              |
| 17:30-19:00 | Cheese & Wine       |                                                                                                                                |

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## Tuesday, 25. February 2014

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| Time        | Speaker             | Title of Talk                                                                                    |
|-------------|---------------------|--------------------------------------------------------------------------------------------------|
| 09:00-10:30 | Vincent Beffara     | <i>Mini course on Schramm-Loewner evolution</i>                                                  |
| 10:30-11:00 |                     | –Coffee Break–                                                                                   |
| 11:00-12:30 | Vladas Sidoravicius | <i>Mini course on random walk in random environment</i>                                          |
| 12:30-14:00 |                     | –Lunch Break–                                                                                    |
| 14:00-15:00 | Markus Heydenreich  | <i>Sharp percolation transition of contact processes</i>                                         |
| 15:00-15:20 | Henning Sulzbach    | <i>The dual tree of a recursive triangulation of the disk: convergence and fractal dimension</i> |
| 15:20-15:40 | Alexander Marynych  | <i>The Bernoulli sieve: allocation scheme in a random environment</i>                            |
| 15:40-16:00 | Robert Graf         | <i>A forest-fire model on the upper half-plane</i>                                               |
| 16:00-16:30 |                     | –Coffee Break–                                                                                   |
| 16:30-17:30 | Short talks         | Bethuelsen, Orenshtein, Pham, Taggi, Walter                                                      |
| 19:00-22:00 | Conference dinner   |                                                                                                  |

Wednesday, 26. February 2014

| Time        | Speaker             | Title of Talk                                                                                     |
|-------------|---------------------|---------------------------------------------------------------------------------------------------|
| 09:00-10:30 | Vincent Beffara     | Mini course on Schramm-Loewner evolution                                                          |
| 10:30-10:45 |                     | -Coffee Break-                                                                                    |
| 10:45-12:15 | Vladas Sidoravicius | Mini course on random walk in random environment                                                  |
| 12:15-12:30 |                     | -Coffee Break-                                                                                    |
| 12:30-13:30 | Alexander Fribergh  | Phase transition for the speed of the biased random walk on the supercritical percolation cluster |
| 13:30-15:00 |                     | -Lunch Break-                                                                                     |
| 15:00-18:00 |                     | -Free Afternoon-                                                                                  |

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## Thursday, 27. February 2014

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| Time        | Speaker                    | Title of Talk                                                                          |
|-------------|----------------------------|----------------------------------------------------------------------------------------|
| 09:00-10:30 | Vincent Beffara            | <i>Mini course on Schramm-Loewner evolution</i>                                        |
| 10:30-11:00 |                            | –Coffee Break–                                                                         |
| 11:00-12:30 | Vladas Sidoravicius        | <i>Mini course on random walk in random environment</i>                                |
| 12:30-14:00 |                            | –Lunch Break–                                                                          |
| 14:00-15:00 | Gabor Pete                 | <i>Near-critical percolation versus near-critical FK-Ising</i>                         |
| 15:00-15:20 | Julien Poisat              | <i>Quenched functional central limit theorem for random walks in random sceneries</i>  |
| 15:20-15:40 | Aser Cortines Peixoto Neto | <i>Front velocity and polymers in random medium</i>                                    |
| 15:40-16:00 | Elisabeth Bauernschubert   | <i>Perturbing random walk in a random environment with cookies of maximal strength</i> |
| 16:00-16:30 |                            | –Coffee Break–                                                                         |
| 16:30-17:30 | Short talks                | Döbler, Duraj, Höfelsauer/Weidner, Miller, Mönch                                       |

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## Friday, 28. February 2014

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| Time        | Speaker             | Title of Talk                                          |
|-------------|---------------------|--------------------------------------------------------|
| 09:00-10:30 | Vincent Beffara     | Mini course on Schramm-Loewner evolution               |
| 10:30-11:00 |                     | –Coffee Break–                                         |
| 11:00-12:30 | Vladas Sidoravicius | Mini course on random walk in random environment       |
| 12:30-14:00 |                     | –Lunch Break–                                          |
| 14:00-15:00 | Sebastian Müller    | Interacting growth processes and invariant percolation |
| 15:00-15:30 |                     | –Coffee Break, End of Workshop–                        |

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## 3 List of Talks

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### 3.1 Short Courses

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**Vincent Beffara**

*Mini course on Schramm-Loewner evolution*

UMPA - ENS Lyon, France

Abstract: In recent years, there have been tremendous progress in the understanding of critical two-dimensional random models such as percolation, the Ising and random-cluster models, loop-erased walks, uniform spanning trees and the Gaussian free field. What these objects have in common is that they exhibit conformal invariance in the scaling limit, which implies that their interfaces can be described as random, conformally invariant curves (Schramm-Loewner evolutions or its variants).

The aim of the mini-course is to give an overview of SLE, of the proofs of convergence to it for a few models, and of what can then be deduced about the discrete models themselves from their scaling limits. For instance: the probability that a critical percolation cluster has diameter more than  $R$  scales like  $R^{-5/48}$ ; and the probability for  $p > p_c$  that the origin lies on an infinite cluster behaves like  $(p - p_c)^{5/36}$ .

Possible references for the mini-course (further references therein):

- V. Beffara, *SLE and other conformally invariant objects*, Clay math. proc. 15 (2012), pp. 1–48.
- V. Beffara and H. Duminil-Copin, *Planar percolation with a glimpse of SLE*, Prob. Surveys 10 (2013), pp. 1–50.
- G. Lawler, *Conformally invariant processes in the plane*, AMS Mathematical Surveys and Monographs 114 (2005).

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**Vladas Sidoravicius**

*Mini course on random walk in random environment*

IMPA Rio de Janeiro, Brasil

Abstract: In this course, a hybrid topic between percolation and random walk in random environment will be studied.

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### 3.2 Invited Speakers

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**Alexander Friberg**

*Phase transition for the speed of the biased random walk on the supercritical percolation cluster*

Université de Toulouse, France

Abstract: We prove the sharpness of the phase transition for speed in the biased random walk on the supercritical percolation cluster on  $\mathbb{Z}^d$ . That is, for each  $d \geq 2$ , and for any supercritical parameter  $p > p_c$ , we prove the existence of a critical strength for the bias, such that, below this value, the speed is positive, and, above the value, it is zero. We identify the value of the critical bias explicitly, and, in the sub-ballistic regime, we find the polynomial order of the distance moved by the particle. Each of these conclusions is obtained by investigating the geometry of the traps that are most effective at delaying the walk. A key element in proving our results is to understand that, on large scales, the particle trajectory is essentially one-dimensional; we prove such a dynamic renormalization statement in a much stronger form than was previously known.

**Markus Heydenreich**

*Sharp phase transition for contact processes*

Universiteit Leiden, Netherlands

Abstract: We consider the two-dimensional contact process and a variant that arises as model for vegetation patterns in arid landscapes. We focus on percolation under invariant measure of such processes, and prove that the percolation transition is sharp. We discuss implications concerning early warning signals for desertification. Based on joint work with Rob van den Berg and Jakob Björnberg.

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**Sebastian Müller**

*Interacting growth processes and invariant percolation*  
LATP Marseille, France

Abstract: The aim of the talk is to underline the (perhaps surprising) relation between reversible growth processes and invariant percolation. We present several examples where survival of interacting growth processes can be expressed in terms of invariant percolation on trees. In general the study of interacting growth processes or particles systems is challenging and a universal treatment seems to be out of reach (at least at the moment). Moreover, the case-by-case study often involves a high amount of technical effort. The approach given here is more conceptual using "soft proofs" and might be useful in a wider set of problems.

**Gábor Pete**

*Near-critical percolation versus near-critical FK-Ising*  
Technical University of Budapest, Hungary

Abstract: For standard Bernoulli percolation on planar lattices, Kesten's scaling relation (1987) gives the near-critical window and the off-critical exponent in terms of critical exponents. Moreover, in a long project with Christophe Garban and Oded Schramm, we managed to build the scaling limit of the near-critical percolation ensemble from the critical scaling limit. However, the near-critical ensembles of the  $FK(p,q)$  Random Cluster models behave very differently from the  $q=1$  percolation case, and are much more mysterious. Based on joint work with Hugo Duminil-Copin and Christophe Garban on the Ising  $q=2$  case, I will describe some features that are understood and some others that are not.

**Daniel Ueltschi**

*Random loop representations for quantum spin systems*  
University of Warwick, UK

Abstract: I will review the background for quantum spin systems such as the Heisenberg models, that are relevant in condensed matter physics and in quantum information theory. There exist fascinating random loop representations that allow to express the quantum correlations in a probabilistic way. I will describe an extension of the representations of Tóth and Aizenman-Nachtergaele for the ferromagnetic and antiferromagnetic Heisenberg models. Some results about the absence of long-range order in 2D, and its occurrence in 3D, will be explained. Finally, I will describe intriguing conjectures about the joint distribution of the lengths of large loops.

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### 3.3 Further Speakers

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**Simon Aumann**

*Singularity of Nearcritical Percolation Scaling Limits*  
LMU München, Germany

Abstract: In this talk we consider two-dimensional nearcritical percolation. We explain that two nearcritical scaling limits with different parameters are singular with respect to each other. The result is valid for two versions of scaling limits: First, it holds for the limit of exploration paths, generalising a result of Nolin and Werner. Second, it is true for the limit of the full percolation configuration in the Quad-Crossing-Topology introduced by Schramm and Smirnov. The talk is based on arXiv:1110.4203v2 and arXiv:1301.5175v1.

**Elisabeth Bauernschubert**

*Perturbing random walk in a random environment with cookies of maximal strength*  
Eberhard Karls Universität Tübingen, Germany

Abstract: We consider a random walk in a random environment on  $\mathbb{Z}$  (left-transient or recurrent) that will be disturbed by cookies inducing a drift to the right of strength 1. The number of cookies per site is assumed to be i.i.d. Naturally, the question arises whether the drift induced by the cookies finally 'wins' or not. Using the connection to certain branching processes with immigration, criteria for recurrence and transience of the random walk can be established.

**Aser Cortines**

*Front Velocity and Directed Polymers in Random Medium*  
Univ. Paris Diderot - Paris 7, France

Abstract: We consider a stochastic model of  $N$  evolving particles studied by Brunet and Derrida. This model can be seen as a directed polymer medium with  $N$  sites in the transverse direction. Cook and Derrida use heuristic arguments to obtain a formula for the ground state energy of the polymer. We formalize their argument and show that there is an additional term in the formula in the critical case. We also consider a generalization of the model, and show that in the noncritical case the behavior is basically the same, whereas in the critical case a new correction appears.

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**Dirk Erhard**

*Brownian Paths Homogeneously Distributed in Space: Percolation Phase Transition and Uniqueness of the Unbounded Cluster*  
Universiteit Leiden, Netherlands

Abstract: I present a continuum percolation model on  $\mathbb{R}^d$ ,  $d \geq 1$ . For  $t, \lambda \in (0, \infty)$  and  $d \in \{1, 2, 3\}$ , the occupied set is given by the union of independent Brownian paths running up to time  $t$  whose initial points form a Poisson point process with intensity  $\lambda > 0$ . When  $d \geq 4$ , the Brownian paths are replaced by Wiener sausages with radius  $r > 0$ . In this talk, I will discuss properties of the occupied set such as percolation phase transition and uniqueness of the unbounded cluster in the supercritical regime. This is joint work with Julián Martínez and Julien Poisat.

**Robert Fitzner**

*Nearest-neighbor percolation shows mean-field behavior in  $d > 14$*   
Stockholm University, Sweden

Abstract: We will first review the concept of mean-field behavior for percolation. Then, we introduce the non-backtracking lace expansion (NoBLE) for percolation and informally describe how we use this technique to prove mean-field behavior.

**Alexander V. Marynych**

*The Bernoulli sieve: allocation scheme in a random environment*  
T. S. National University of Kiev, Ukraine

Let  $T := (T_k)_{k \in \mathbb{N}_0}$  be a multiplicative random walk defined by

$$T_0 := 1, \quad T_k := \prod_{i=1}^k W_i, \quad k \in \mathbb{N} := \mathbb{N}_0 \setminus \{0\},$$

where  $\mathbb{N}_0 := \{0, 1, 2, \dots\}$ ,  $(W_k)_{k \in \mathbb{N}}$  are independent copies of a random variable  $W$  taking values in the open interval  $(0, 1)$ . Also, let  $(U_k)_{k \in \mathbb{N}}$  be independent random variables which are independent of  $T$  and have the uniform  $[0, 1]$  law. A random allocation scheme in which 'balls'  $U_1, U_2$  etc. are allocated over an infinite array of 'boxes'  $(T_k, T_{k-1}]$ ,  $k \in \mathbb{N}$ , is called the *Bernoulli sieve*. Since a particular ball falls into the box  $(T_k, T_{k-1}]$  with a random probability

$$P_k := T_{k-1} - T_k = W_1 W_2 \cdots W_{k-1} (1 - W_k),$$

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the Bernoulli sieve is also the classical Karlin's allocation scheme with the *random frequencies*  $(P_k)_{k \in \mathbb{N}}$  (or in the random environment  $(P_k)$  or  $(W_k)$ ).

In my talk I will give an overview of the asymptotic results for various functionals on the Bernoulli sieve, with the emphasis placed on the comparison with allocation schemes in non-random environment.

**Julien Poisat**

*The Critical Curve of the Random Pinning and Copolymer Models at Weak Coupling*

Universiteit Leiden, Netherlands

**Abstract:** We study random pinning and copolymer models, when the return distribution of the underlying renewal process has a polynomial tail with finite mean. We compute the asymptotic behavior of the critical curves of the models in the weak coupling regime, showing that it is universal. This proves a conjecture of Bolthausen, den Hollander and Opoku for copolymer models, which we also extend to pinning models. This is joint work with Quentin Berger, Francesco Caravenna, Rongfeng Sun and Nikos Zygouras. We will also discuss an extension of these results to the case of polymers evolving in a correlated disorder (work in progress with Quentin Berger).

**Henning Sulzbach**

*The dual tree of a recursive triangulation of the disk: convergence and fractal dimension*

INRIA Paris-Rocquencourt, France

In the recursive lamination of the disk, one tries to add chords one after another at random; a chord is kept and inserted if it does not intersect any of the previously inserted ones. Curien and Le Gall [2011, in *Ann. Probab.*] have proved that the set of chords converges (in the Hausdorff metric) to a limit triangulation of the disk encoded by a continuous process  $M$ . In this talk, we discuss a functional limit theorem obtained with the help of the contraction method in function spaces. It shows that, when properly rescaled, the planar dual of the discrete lamination converges almost surely in the Gromov–Hausdorff sense to a limit real tree  $T$  encoded by  $M$ . The limit object  $T$  is one of the first random real trees not coming from the excursion of a Brownian Motion or another Lévy process. We also discuss Minkowski and Hausdorff dimension of  $T$  in a more general framework which as well covers Aldous' continuum random tree. The talk is based on joint work with Nicolas Broutin [2013, to appear in *Ann. Prob.*].

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## 4 Participants

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Figure 4.1: Citymap

Points of interest:

1. Hotel Atlanta
2. Lecture Hall
3. Welcome Hotel
4. Canteen
5. Darmstadt City (Carree)
6. Mathildenhöhe
7. Schloss
8. Central Station