Scientific Report for the ESF meeting: Geometry and Analysis of Random Processes Cambridge, April 8-12, 2013

1 Summary

The workshop took place during April 8-12, 2013 in the Centre for Mathematical Sciences, Cambridge. The meeting was well attended, with over 80 registered participants to the conference coming from eight countries. This was well in excess of the 60 anticipated participants. The conference was organised by N. Berestycki, G. Grimmett and J. Norris, who were expertly helped by the secretary of the Statistical Laboratory, Julia Blackwell, and assisted for financial details by Angela Smith. The meeting was jointly funded by ESF and the EPSRC-funded programme grant on Random Geometry, whose investigators are the organisers of the meeting.

The conference's theme was centred on the recent developments at the frontier between probability, geometry and analysis. The choice of this theme corresponds to an ambitious programme of research going on in Cambridge at the moment, which is supported by the EPSRC grant that co-funded the meeting. Beyond the local team (consisting of the three organisers, two postdocs and several PhD students), the meeting was particularly aimed towards young probabilists, with four mini-courses delivered by Omer Angel, Martin Hairer, Grégory Miermont and Ofer Zeitouni. Beside presenting and sharing the new developments of the field within the mathematical community, the aim of the workshop was to provide a stimulating environment where participants could learn new ideas and techniques, and have the opportunity to interact with some of the experts of the field. Indeed the format, with three hours of talks in the morning and two in the afternoon, allowed ample time for discussions between participants.

2 Scientific summary

The website: `http://www.statslab.cam.ac.uk/GARP/index.html` contains all the details of the meetings including a detailed schedule. The subject of the meeting, the new mathematical challenges arising from geometric and analytic points of view in probability, is one where spectacular progress has taken place over the last few years. Let us mention critical phenomena in two dimensions and the KPZ universality class, or the Gaussian Free Field and and random planar maps.

The meeting revolved around the four mini-courses by Omer Angel, Martin Hairer, Grégory Miermont and Ofer Zeitouni, mentioned above. The subject of their courses were as follows.

- Omer Angel (two hours.) *Half-Planar Random Maps.* In the first lecture, Omer Angel described his joint work with Gourab Ray, a graduate student, on the classification of half-planar random maps. These are infinite random maps in the upper-half plane, which arise as local limits of planar maps with a large boundary (linear in the number of faces). The main result is that there is only a one-parameter family of maps which satisfy a domain Markov property. This is the analogue of Schramm's principle that there is only a one-parameter family (SLE) of domain Markov, conformally invariant, random curves.The second lecture was devoted to an exposition of a recent result, joint with Nicolas Curien, on an impressive rigorous evaluation of many critical exponents for percolation on random planar maps, confirming predictions made years ago by physicists in the context of Liouville Quantum Gravity.

- Martin Hairer (three hours). *Renormalisation of Stochastic PDEs.* The course attempted to give an overview of Martin Hairer's groundbreaking recent theory on a unified approach to solving SPDEs including some notoriously ill-posed cases such as the KPZ equation. The approach relies on a complete rethinking of the notion of Taylor expansions, where polynomials are replaced with purpose-built rougher functions. A by-product of his approach seems to be a rigorous version of the renormalisation group theory from statistical physics.

- Grégory Miermont (two hours). *Random planar maps.* The mini-course was centred on his 2011 proof that uniformly chosen quandrangulations with a large number of faces, converge as metric spaces to the Brownian map when rescaled by $n^{-1/4}$. There was also a discussion of his ongoing work with J. Bettinelli on the higher-genus case.

- Ofer Zeitouni (three hours): *Branching random walks and the Gaussian free field.* The course was an exposition of the techniques leading to his recent proof, with M. Bramson and J. Ding, that if M_n is the maximum of the Gaussian Free Field on the two-dimensional $n \times n$ grid, then $M_n - \mathbb{E}(M_n)$ converges in distribution to a limiting random variable. The course started with the analogous result for branching random walk, which is slightly simpler because there is more independence.

These mini-courses were complemented by lectures from the following people:

1. Alison Etheridge (Oxford), on *Modelling Natural Selection*,
2. Peter Friz (Berlin), on *Some aspects of stochastic area*,

3. Christina Goldschmidt (Oxford), on *The scaling limit of the minimum spanning tree of the complete graph*,

4. Wilfrid Kendall (Warwick), on *Google maps and improper Poisson line processes*,

5. Andreas Kyprianou (Bath), on *Censored Stable Processes*,

6. Ioan Manolescu (Geneva), on *The endpoint of self-avoiding walk delocalizes*,

7. Jason Miller (MIT), on *SLE and the Gaussian free field*,

8. Oliver Riordan (Oxford), on *Explosive percolation and Achlioptas processes*

9. Perla Sousi (Cambridge), on *Hunter, Cauchy Rabbit and Optimal Kakeya Sets*

10. Balint Toth (Bristol), on *Superdiffusive CLT for periodic Lorentz gas in the Boltzmann-Grad regime.*

The lectures interacted very well with the mini-courses. For instance, Christina Goldschmidt's lecture on the scaling limit of the mean-field minimal spanning trees introduced all the notions of Gromov-Hausdorff convergence, which was useful for Gregory Miermont's course. Jason Miller's talk about SLE and the Gaussian Free Field benefitted from the heuristics coming from Ofer Zeitouni's course on maxima of the GFF in two dimensions (albeit in the discrete case).

In addition, the following PhD students gave short presentations (15 mins. each):

1. Jiarui Cao (Warwick), Condensation in the Totally Asymmetric Inclusion Process

2. Sean Ledger (Oxford), SPDEs from Large Portfolio Credit Modelling

3. Maren Eckhoff (Bath), The strong law of large numbers for superdiffusions

4. Paul Chleboun (Warwick), Time scale separation and dynamic heterogeneity in the low temperature East model

5. Marion Hesse (Bath), Branching Brownian motion in a strip: Survival near criticality

6. Ed Mottram (Cambridge), Percolation with constant freezing

7. Gourab Ray (UBC), Large unicellular maps in high genus

Overall these presentations were remarkably well done. The students all managed to convey essential ideas about their work and its context and some even managed to say a word about the proof. This was found to be a very good format, giving students what was often a first opportunity to give a talk in front of a senior audience.

3 Assessment of the results and impact of the event on the future directions of the field

Of course, it is hard to assess precisely the impact of a single meeting on an entire field, especially one as broad as the interactions between probability, geometry and analysis. However, we were very happy to see that the audience included a very large proportion of junior members, either in PhD or in postdocs. The atmosphere was very stimulating, and people could be seen working in groups in the CMS after the talks in one of the many spaces provided to this effect by the CMS. (We already know of at least one paper initiated at this meeting; see http://arxiv.org/abs/1305.0814.) For instance, the common room of Pavillion D (which hosts the Statistical Laboratory) was often used by groups of students working out some particular details in some of the mini-courses. We are optimistic that a high proportion of these students, postdocs and other junior members will choose to enter the field and hence the meeting will have long-lasting impact.

Another impact on which we can testify first-hand is on the research programme going on in Cambridge in Random Geometry. Indeed the synergies with this programme (which involves the three organisers, two postdocs and six PhD students), were exceptional. In this context we profited from one-month visits by Omer Angel and his student Gourab Ray, and by Jason Miller, by involving them in the meeting.

4 Annexes: Participants, Programme

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PROGRAMME
Geometry and Analysis of Random Processes
UK Probability Easter Meeting 2013 8 - 12 April 2013

	Speaker	**Title**
Monday 8th April		
10.45-11.45	Omer Angel (mini course)	*Domain Markov half planar maps and percolation*
11.45-12.45	Balint Toth	*Superdiffusive CLT for periodic Lorentz gas in the Boltzmann-Grad regime*
2.30-3.30	Ioan Manolescu	*The endpoint of self-avoiding walk delocalizes*
3.45-4.45	Ofer Zeitouni (mini course)	*Branching random walks and the Gaussian free field*
5.15	**Drinks Reception**	**CMS Central Core**
Tuesday 9th April		
9.15-10.15	Ofer Zeitouni (mini course)	*Branching random walks and the Gaussian free field*
10.45-11.45	Wilfrid Kendall	*Google maps and improper Poisson line processes*
11.45-12.45	Omer Angel (mini course)	*Domain Markov half planar maps and percolation*
2.30-3.30	Andreas Kyprianou	*Censored Stable Processes*
3.45-4.45	Martin Hairer (mini course)	*Renormalisation of stochastic PDEs*
Wednesday 10th April		
9.15-10.15	Ofer Zeitouni (mini course)	*Branching random walks and the Gaussian free field*
10.45-11.45	Perla Sousi	*Hunter, Cauchy Rabbit and Optimal Kakeya Sets*
11.45-12.45	Martin Hairer (mini course)	*Renormalisation of stochastic PDEs*
2.30-3.30	Christina Goldschmidt	*The scaling limit of the minimum spanning tree of the complete graph*
3.45-4.45	Oliver Riordan	*Local limit theorems for giant components*
Thursday 11th April		
9.15-10.15	Martin Hairer (mini course)	*Renormalisation of stochastic PDEs*
10.45-11.00	Jiarui Cao*	Condensation in the Totally Asymmetric Inclusion Process
11.00-11.15	Sean Ledger*	SPDEs from Large Portfolio Credit Modelling
11.15-11.30	Maren Eckhoff*	The strong law of large numbers for superdiffusions
11.45-12.45	Gregory Miermont (mini course)	*Random planar maps*
2.30-3.30	Peter Friz	*Some aspects of stochastic area*
3.45-4.45	Jason Miller	*SLE and the Gaussian free field*
7.30	**Conference Dinner**	**King's College**
Friday 12th April		
9.15-10.15	Alison Etheridge	*Modelling Natural Selection*
10.45-11.00	Paul Chleboun*	*Time scale separation and dynamic heterogeneity in the low temperature East model*
11.00-11.15	Marion Hesse*	*Branching Brownian motion in a strip: Survival near criticality*
11.15-11.30	Ed Mottram*	*Percolation with constant freezing*
11.30-11.45	Gourab Ray*	*Large unicellular maps in high genus*
11.45-12.45	Gregory Miermont (mini course)	*Random planar maps*

*PhD Student