Science Meeting – Scientific Report

The scientific report (WORD or PDF file - maximum of seven A4 pages) should be submitted online <u>within two months of the event</u>. It will be published on the ESF website.

<u>*Proposal Title*</u>*: Random Geometry of Large Interacting Systems and Statistical Physics*

<u>*Application Reference N°*</u>*: 5200*

1)   **Summary (up to one page)**

In January 2014, Eurandom was the venue for the Stochastic Activity Month (SAM) on "Probability and Combinatorics". The SAM is a recurring event at Eurandom since 2011. The SAM "Probability and Combinatorics" had three main components:

1. A major week-long workshop on "Probability and Graphs", which was opened by Joel Spencer, one of the founding fathers of probabilistic combinatorics, and brought together over 70 participants.

2. A week of three mini-courses within the same theme, for a deeper look at current advances in the area, accessible to graduate students.

3. A smaller three-day workshop on "Networks with community structure", a multidisciplinary event that brought together computer scientists, statisticians, probabilists and physicists.

2)   **Description of the scientific content of and discussions at the event (up to four pages)**

The main objectives of the event were as follows:

1. To showcase cutting-edge developments at the interface between probability theory and combinatorics, specifically in the areas of graph limits, the probabilistic method in combinatorics, and random graph theory.

2. To provide a stimulating forum for the discussion of techniques, ideas, questions among the world's leading researchers in the area.

3. To nurture an environment where Dutch researchers, especially those early in their career, can interact and exchange ideas with some of the most important researchers in probability and combinatorics.

4. To provide opportunities for undergraduate and graduate students to learn from the experts on recent trends, and to spark their interest in a research career.

5. To promote probability and combinatorics to the broader mathematical community.

The connection between probability and combinatorics is long-established and deep. One of the most famous examples is the 1947 work of Erdos which provided an early demonstration of the striking power of the probabilistic method, by using a random graph construction for existential lower bounds on Ramsey numbers. This remains essentially the best-known construction in this exceptionally difficult area of mathematics. This lay groundwork not only for probabilistic and extremal combinatorics, but also for random graph theory (later developed far more thoroughly in 1959/60 by Erdos and Renyi), both of which are active and mature areas of contemporary mathematics.

In more recent years, both of these research areas have been experiencing exciting changes as a result of contrasting influences. From one side, there is the steadily growing importance of networks, which demands from a practical viewpoint the fast and accurate analysis/modelling of massive real networks (which come from areas as diverse as sociology, biology and engineering). From another direction, theoretical researchers have been discovering and developing powerful algebraic and analytic tools — e.g. the flag algebra method of Razborov, the graph limits paradigm of Lovasz and Szegedy, and Friedgut's sharp threshold criterion — to mount major attacks on several of the critical and most difficult challenges in the field.

In our planned events, we gathered several of the most influential researchers to discuss the impact of recent advances, to share ideas and perspective on new directions of research, and to pass on intuition and knowledge to the next generation of researchers.

3)   Assessment of the results and impact of the event on the future directions of the field (up to two pages)

During the SAM, Eurandom provided an exciting environment for interaction among important figures in the area. The showpiece event was the opening workshop "Probability and Graphs", 6-10 January, which featured the following ten plenary lectures (listed in chronological order). These lectures spanned a wide spectrum of topics of probability and combinatorics, including aspects of random graphs, random graph process, Ramsey theory, extremal graph theory, graph limits, algebraic/geometric combinatorics, and randomised algorithms.

Joel Spencer (NYU) "Finding Needles in Exponential Haystacks"

Peter Cameron (QMUL/St Andrews) "Acyclic orientations"

Miklos Simonovits (Renyi Institute) "Embedding trees into graphs"

Mihyun Kang (TU Graz) "Phase transitions in random graphs"

Tom Bohman (CMU) "Dynamic Concentration in random greedy processes"

Gabor Lugosi (Pompeu Fabra) "Connectivity properties of random geometric irrigation graphs"

Anusch Taraz (TU Hamburg) "On the tree-packing conjecture of Gyarfas and Lehel"

Bruce Reed (McGill) "The structure of a typical H-free Graph"

Christian Borgs (Microsoft) "Convergence of sparse graphs as a problem at the intersection of graph theory, statistical physics and probability"

Colin McDiarmid (Oxford) "Random graphs from a minor-closed class"

There were also twenty five invited shorter talks: Andrew Beveridge (Macalaster), Graham Brightwell (LSE), Guillaume Chapuy (Paris 7), Steffen Dereich   (Westfalische Wilhelms), Josep Diaz (UPC Barcelona), Benjamin Doerr (Polytechnique), Andrzej Dudek (Western Michigan), Martin Dyer (Leeds), Asaf Ferber (ETH Zurich), Stefanie Gerke (Royal Holloway London), Simon Griffiths (Oxford), Danny Hefetz (Birmingham), Cecilia Holmgren (Stockholm), Linyuan Lu (South Carolina), Malwina Luczak (QMUL), Viresh Patel (QMUL), Oleg Pikhurko (Warwick), Pawel Pralat (Ryerson), Daniel Reichman (Weizmann), Jozef Skokan (LSE), Greg Sorkin (LSE), Miloš Stojaković (Novi Sad), Danny Vilenchik (Weizmann), Lutz Warnke (Cambridge).

Mini-courses

The following week, 13-16 January, we organised three mini-courses, accessible to graduate students or researchers who are new to the area. Our mini-courses were based on prominent recent scientific developments in three areas related to the theme "Probability and Combinatorics":

1. Graph limits. On Monday, January 13, Christian Borgs (Microsoft) and Yufei Zhao (MIT) gave a six-hour mini-course on graph limits. Graph limits provides a powerful tool to describe convergence of graphs of increasing size. It has strong connections to the analysis of large networks, algebraic combinatorics, extremal graph theory, and probabilistic methods. Borgs was intimately involved in the early work in the area, jointly with a.o. Lazlo Lovasz. Zhao is an exciting young researcher who (with Borgs, Chayes and Cohn) has done important recent work on sparse graph limits. We were privileged to witness an account of some of the latest progress in this rapidly evolving area.

2. Probabilistic aspects of Minimal Spanning Trees. In the past years, a full insight into the scaling limit of the Minimal Spanning Tree (MST) on the Complete Graph was developed in work of Louigi Addario-Berry (McGill), Nicolas Broutin (INRIA), Christina Goldschmidt (Oxford) and Gregory Miermont (Paris 11). Interestingly, it turns out that the scaling limit of the MST is closely

related to the critical Erdos-Renyi random graph, a result that suggests that the MST on a graph is closely related to critical percolation on that graph. Their recent work describes the scaling limit of the MST as a graph, which is a phenomenal achievement. In a series of four 1.5-hour lectures by each of the four co-authors, we were given a deep treatment of this breakthrough.

3. Analysis of Boolean functions. The past decade or so has seen major advances in several areas of theoretical computer science and combinatorics due to the application of tools from harmonic analysis. This has led to interesting results in several areas, including computational approximation and complexity theory, sharp thresholds in random structures, additive number theory, coding theory, machine learning, and more. The analysis of Boolean functions is a rapidly developing area at the interface of computer science, analysis, probability and combinatorics. Guy Kindler (Hebrew University of Jerusalem), delivered a 9-hour mini-course that thoroughly and intuitively covered many important aspects of this field.

Communities workshop

In the third week, 22-24 January, Eurandom hosted a smaller, informal workshop concerned with a current topic in complex networks: the study, detection, structure of communities in such networks. This is a broad area, with interdisciplinary perspectives. The workshop had several interesting talks with contributions from probability/statistics, operations research, physics and computer science, as evidenced for instance by the following talks:

Marc Lelarge (INRIA) "Optimal clustering for the edge-labeled stochastic block model"

Konstantin Avratchenkov (INRIA) "Semi-supervised Learning Methods for Community Detection"

Janos Kertesz (CEU) "Communities in large communication networks: Static and dynamic aspects"

Alessandro Panconesi (Sapienza) "Random walks and sybil attacks"

Other invited participants included Nina Balcan (Georgia Tech), Sharmodeep Bhattacharyya (Berkeley), Emilie Coupecoux (Nice), Nelly Litvak(TU Twente), Giacomo Livan (Abdus Salam), Konstantin Makarychev (Microsoft), Gergely Palla (MTA-ELTE), Alexandre Proutiere (KTH), Yun Seyoung (KTH), Nees Jan van Eck (Leiden), Ludo Waltman (Leiden). There was undoubtedly much valuable interaction between communities.

Participation

The SAM was very well attended, featuring invited participation mainly from North America and Europe (and also the Middle East), from 15 countries. The opening workshop was one of the largest events held at Eurandom, with close to 75 participants each day. The mini-course and communities workshop had attendance estimated at between 35 and 45 people. The SAM had 20 registered students (though there were several local, unregistered students in attendance also). Several graduate students were supported to travel from abroad (Canada, Hungary, Poland, Spain, UK, USA), or from further away in the Netherlands, thanks to the support of WONDER and other sponsorship.

4) **Annexes 4a) and 4b): Programme of the meeting and full list of speakers and participants**

Annex 4a: Programme of the meeting

Programme Workshop "Probability and Graphs"

MONDAY JANUARY 6

09.00 - 09.10	Opening	Remco van der Hofstad	
09.10 - 10.00		Joel Spencer	Finding Needles in Exponential Haystacks
10.00 - 10.30	Break		
10.30 - 11.00		Guillaume Chapuy	On the diameter of random planar graphs
11.00 - 11.30		Asaf Ferber	Universality of random graphs and rainbow embedding
11.30 - 12.00		Danny Hefetz	Random directed graphs are robustly Hamiltonian
12.00 - 13.30	Lunch		
13.30 - 14.20		Peter Cameron	Acyclic orientations
14.20 - 14.50	Break		
14.50 - 15.20		Graham Brightwell	Extinction Times in the Stochastic Logistic Epidemic
15.20 - 15.50		Cecilia Holmgren	Stein Couplings for the Study of Fringe Trees
15.50 - 16.20		Benjamin Doerr	Tight Analysis of Randomized Rumor Spreading in Complete Graphs

TUESDAY JANUARY 7

09.10 - 10.00		Martin Dyer	The chromatic number of a random hypergraph
10.00 - 10.30	Break		
10.30 - 11.30		Miklos Simonovits	Embedding trees into graphs
11.30 - 12.00		Greg Sorkin	The Satisfiability Threshold for k-XORSAT
12.00 - 13.30	Lunch		
13.30 - 14.20		Mihyun Kang	Phase transitions in random graphs
14.20 - 14.50	Break		
14.50 - 15.20		Viresh Patel	A domination algorithm for $\{0,1\}$-instances of the travelling salesman problem
15.20 - 16.20		talks by PhD students (20 min each)	Tamas Hubai: Matchings in Benjamini-Schramm convergent graph sequences
			Laura Florescu: The range of rotor walk and recurrence of directed lattices

			Marcin Witkowsky: Hamilton cycles in random lifts of graphs
18.30 -	*Conference Dinner*		

WEDNESDAY JANUARY 8

09.10 - 10.00		Tom Bohman	Dynamic Concentration in random greedy processes
10.00 - 10.30	*Break*		
10.30 - 11.00		Simon Griffiths	
11.00 - 11.30		Pawel Pralat	A few random open problems, some of them for random graphs
11.30 - 12.00		Daniel Reichman	The layers model with applications
12.00 - 13.30	*Lunch*		
13.30 - 14.20		Gábor Lugosi	Connectivity properties of random geometric irrigation graphs
14.20 - 14.50	*Break*		
14.50 - 15.20		Andrew Beveridge	Maker-Breaker Games on Random Geometric Graphs
15.20 - 15.50		Andrzej Dudek	On Hamiltonicity of Random Hypergraphs
15.50 - 16.20		Jozef Skokan	Improved counting relative to pseudorandom graphs

THURSDAY JANUARY 9

09.10 - 10.00		Anusch Taraz	On the tree-packing conjecture of Gyarfas and Lehel
10.00 - 10.30	*Break*		
10.30 - 11.00		Stefanie Gerke	Maximum matchings in random bipartite graphs with degree constraints
11.00 - 11.30		Danny Vilenchik	Chasing the k-colorability threshold
11.30 - 12.00		Linyuan Lu	High Order Phase Transition in Random Hypergraphs
12.00 - 13.30	*Lunch*		
13.30 - 14.20		Bruce Reed / Yuditsky	The structure of a typical H-free Graph
14.20 - 14.50	*Break*		
14.50 - 16.30		5 talks by PhD students (20 min each)	Anne Hildebrand: Edge-Coloured Degree Sequences of Forests and Unicyclic Graphs
			Guillem Perarnau: Large H-free subgraphs
			Liana Yepremyen: Lagrangian of r-intersecting families
			Joonkyung Lee: Two Approached to Sidorenko's Conjecture

			Robert Fitzner: Nearest-neighbour percolation shows mean-field behaviour in d>14.

FRIDAY JANUARY 10

09.10 - 10.00		Christian Borgs	Convergence of sparse graphs as a problem at the intersection of graph theory, statistical physics and probability
10.00 - 10.30	*Break*		
10.30 - 11.00		Josep Diaz	Recent results on infections and mutations
11.00 - 11.30		Steffen Dereich	Condensation in Preferential Attachment Models with Fitness
11.30 - 12.00		Lutz Warnke	Phase transitions in random graphs with dependencies
12.00 - 13.30	*Lunch*		
13.30 - 14.20		Colin McDiarmid	Random graphs from a minor-closed class
14.20 - 14.50	*Break*		
14.50 - 15.20		Malwina Luczak	SIR epidemics on random graphs with a given degree sequence
15.20 - 15.50		Miloš Stojaković	Threshold for Maker-Breaker H-game
15.50 - 16.20		Oleg Pikhurko	Measurable edge-colourings of graphings

Programme Mini courses

MONDAY JANUARY 13

09.00 - 10.00		Christian Borgs/Yufei Zhao	
10.00 - 10.30	*BREAK*		
10.30 - 12.30		Christian Borgs/Yufei Zhao	
12.30 - 14.00	*LUNCH*		*Graph limits*
14.00 - 16.00		Christian Borgs/Yufei Zhao	
16.00 - 16.30	*BREAK*		
16.30 - 17.30		Christian Borgs/Yufei Zhao	

TUESDAY JANUARY 14

13.30 - 15.30		Guy Kindler	
15.30 - 16.00	*BREAK*		*Analysis of Boolean functions*
16.00 - 17.00		Guy Kindler	

WEDNESDAY JANUARY 15

09.00 - 10.30		Louigi Addario-Berry, Nicolas Broutin, Christina Goldschmidt, Grégory Miermont	*Probabilistic aspects of Minimal Spanning Trees*
10.30 - 11.00	*BREAK*		
11.00 - 12.30		Louigi Addario-Berry, Nicolas Broutin, Christina Goldschmidt, Grégory Miermont	*(link to the notes)*
12.30 - 14.00	*LUNCH*		
14.00 - 16.00		Guy Kindler	
16.00 - 16.30	*BREAK*		*Analysis of Boolean functions*
16.30 - 17.30		Guy Kindler	

THURSDAY JANUARY 16

09.00 - 10.30		Louigi Addario-Berry, Nicolas Broutin, Christina Goldschmidt, Grégory Miermont	*Probabilistic aspects of Minimal Spanning Trees*
10.30 - 11.00	*BREAK*		
11.00 - 12.30		Louigi Addario-Berry, Nicolas Broutin, Christina Goldschmidt, Grégory Miermont	
12.30 - 14.00	*LUNCH*		
14.00 - 16.00		Guy Kindler	
16.00 - 16.30	*BREAK*		*Analysis of Boolean functions*
16.30 - 17.30		Guy Kindler	

Programme Workshop "Networks with community structure"

WEDNESDAY JAN 22

08.30 - 09.00	Registration		
09.00 - 09.10	Opening		
09.10 - 10.00		Marc Lelarge	Optimal clustering for the edge-labeled stochastic block model
10.00 - 10.30	*BREAK*		
10.30 - 11.15		Giacomo Livan	Social networks: A perspective from Statistical Physics
11.15 - 12.00		Nina Balcan	Finding Endogenously Formed Communities
12.00 - 14.00	*LUNCH*		
14.00 - 14.45		Nelly Litvak	Detecting trends and popular

			entities in social media
14.50 - 15.35		Konstantin Avratchenkov	Semi-supervised Learning Methods for Community Detection
15.35 - 16.00	*BREAK*		
16.00 - 16.45		Konstantin Makarychev	Constant Factor Approximation for Balanced Cut in the PIE Model
18.30 -	*CONFERENCE DINNER*		

THURSDAY JAN 23

09-00 - 09.45		Janos Kertesz	Communities in large communication networks: Static and dynamic aspects
09.50 - 10.35		Nicolas Verzelen	Detecting a community in Random Networks
10.35 - 11.00	*BREAK*		
11.00 - 11.45		Gergely Palla	Finding overlapping communities with k-clique percolation
12.00 - 14.00	*LUNCH*		
14.00 - 14.45		Alessandro Panconesi	Random walks and sybil attacks
14.50 - 15.35		Emilie Coupechoux	Diffusion of innovations in random clustered networks with overlapping communities
15.35 - 16.00	*BREAK*		
16.00 - 16.45		Sharmodeep Battacharyya	Community Detection in Networks Using Graph Distance

FRIDAY JAN 24

09.00 - 09.45		Ludo Waltman	Two challenges in community detection: Large networks and overlapping communities
09.50 - 10.35		Nees Jan van Eck	Applications of community detection in bibliometric network analysis
10.35 - 11.00	*BREAK*		
11.00 - 11.45		Alexandre Proutiere/Yun Seyoung	Community Detection via Random and Adaptive Sampling
11.50 - 12.00	*CLOSING*		
12.00 - 13.00	*LUNCH*		

Annex 4b: Full list of speakers and participants

Name	Firstname	Affiliation
Abiad	Aida	Tilburg University
Addario-Berry	Louigi	McGill University
Albenque	Marie	CNRS
Avratchenkov	Konstantin	Inria Sophia Antipolis
Backhausz	Agnes	MTA Renyi Institute
Balcan	Maria Florina	Georgia Tech
Bartha	Zsolt	Budapest University of Technology and Economics
Bet	Gianmarco	TU/e
Beveridge	Andrew	Macalester College
Bhattacharyya	Sharmodeep	University of California, Berkeley
Bhattacharyya	Sharmodeep	UC Berkeley
Bohman	Tom	Carnegie Mellon University
Borgs	Christian	Microsoft Research
Brightwell	Graham	LSE
Broutin	Nicolas	Inria Paris-Rocquencourt
Cameron	Peter	University of London
Castro	Rui	TU/e
Chapuy	Guillaume	CNRS and Université Paris Diderot
Coupechoux	Emilie	Université Nice Sophia Antipolis
Deák	Attila	ELTE University
DeCorte	Evan	TU Delft
Dereich	Steffen	WWU Münster
Diaz	Josep	Univer. Politecnica Catalunya
Doerr	Benjamin	Ecole Polytechnique
Dommers	Sander	Università di Bologna
Dudek	Andrzej	Western Michigan University
Dyer	Martin	University of Leeds
Eslava	Laura	McGill University
Ferber	Asaf	ETH, Zurich
Fitzner	Robert	Stockholm University
Florescu	Laura	NYU-Courant
Fokkink	Robbert	TU Delft
Gerke	Stefanie	RHUL
Giberti	Claudio	DISMI - Universita' di Modena e Reggio E.
Goldschmidt	Christina	Department of Statistics, University of Oxford

Gottschau	Marinus	TU München
Griffiths	Simon	University of Oxford
Hefetz	Dan	University of Birmingham, UK.
Henard	Olivier	Queen Mary University
Hetterich	Samuel	Goethe Universität Frankfurt
Holmgren	Cecilia	Stockholm University
Horobet	Emil	TU Eindhoven
Howe	Sei	Imperial College London
Huang	Jia-Ping	VU University Amsterdam
Jahnel	Benedikt	Ruhr University Bochum
Kang	Ross	Utrecht University
Kang	Mihyun	TU Graz
Kertesz	Janos	CEU
Kolossvary	Istvan	Budapest University of Technology and Economics
Krohmer	Anton	University of Jena
Kuelske	Christof	Ruhr University Bochum
Lee	Joonkyung	University of Oxford
Lelarge	Marc	INRIA-ENS
Li	Anshui	Utrecht University
Li		University of Cambridge
Litvak	Nelly	TU Twente
Livan	Giacomo	Abdus Salam International Centre for Theoretical Physics
Louis	Pierre-Yves	University of Poitiers
Lu	Linyuan	University of South Carolina
Luczak	Malwina	Queen Mary University of London
Lugosi	Gabor	ICREA & UPF
Makarychev	Konstantin	Microsoft Research
Matzke	Kilian	TU Eindhoven
McDiarmid	Colin	University of Oxford
Miermont	Grégory	ENS de Lyon
Molontay	Roland	Budapest University of Technology and Economics
Moscatelli	Mirko	University of Roma Tre
Muller	Tobias	Utrecht University
Nardi	Francesca	TU Eindhoven
Oosterwijk	Tim	Maastricht University
Palla	Gergely	MTA-ELTE Statistical and Biological Physics Research Group
Panconesi	Alessandro	Sapienza, University of Rome
Patel	Viresh	Queen Mary, University of London
Pikhurko	Oleg	University of Warwick
Pralat	Pawel	Ryerson University

Prioriello	Maria Luisa	Università degli studi di Modena e Reggio Emilia
Proutiere	Alexandre	KTH
Reed	Bruce	McGill University
Regts	Guus	Universiteit van Amsterdam
Reichman	Daniel	Weizmann Institute
Seyoung	Yun	KTH
Simonovits	Miklos	Renyi Math Institute, Budapest
Skokan	Jozef	LSE and UIUC
Sorkin	Gregory	London School of Economics
Spencer	Joel	Courant Institute
Spencer	Joel	New York University
Stojakovic	Milos	University of Novi Sad
Stougie	Leen	VU & CWI, Amsterdam
Taraz	Anusch	TU Hamburg-Harburg
ten Thij	Marijn	Vrije Universiteit Amsterdam
Tolkacheva	Anna	Twente University
Vágó	Lajos	Department of Stochastics, Institute of Mathematics, Technical University of Budapest, 1521 Budapest, P.O.Box 91, Hungary
van der Hofstad	Remco	TU Eindhovne/Eurandom
van der Hoorn	Pim	University Twente
Van der Pol	Jorn	TU/e
van Eck	Nees Jan	Leiden University, Centre for Science and Technology Studies (CWTS)
van Enter	Aernout	RU Groningen
van Zwam	Stefan	Princeton University
Vera	Juan C	Tilburg University
Verzelen	Nicolas	INRA
Vilenchik	Dan	The Weizmann Institute
Waltman	Ludo	Centre for Science and Technology Studies (CWTS), Leiden University
Warnke	Lutz	University of Cambridge
Windridge	Peter	Queen Mary University of London
Witkowski	Marcin	Adam Mickiewicz University
Yepremyan	Liana	McGill University
Yuditsky	Lena	McGill
Zhao	Yufei	Massachusetts Institute of Technology