GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Large networks and random graphs

July 9 - July 13, 2018

List of Speakers

Elad Aigner-Horev (Ariel University, Israel)
Petra Berenbrink (University of Hamburg, Germany)
Nils Bertschinger (Frankfurt Institute for Advanced Studies, Germany)
Zongchen Chen (Georgia Institute of Technology, USA)
Artur Czumaj (University of Warwick, UK)
Steffen Dereich (WWU Münster, Germany)
Sander Dommers (University of Hull, UK)
Michael Drmota (Vienna University of Technology, Austria)
Charilaos Efthymiou (Goethe University Frankfurt, Germany)
Nikolaos Fountoulakis (University of Birmingham, UK)
Tobias Friedrich (University of Potsdam, Germany)
Frederik Garbe (Czech Academy of Sciences, Czech Republic)
Martin Hoefer (Goethe University Frankfurt, Germany)
Mihyun Kang (Graz University of Technology, Austria)
Tobias Kapetanopolous (Goethe University Frankfurt, Germany)
Michael Kaufmann (University of Tübingen, Germany)
Daniela Kühn (University of Birmingham, UK)
Eoin Long (University of Oxford, UK)
Dieter Mitsche (Laboratoire J.A.Dieudonné, France)
Richard Montgomery (University of Cambridge, UK)
Noela Müller (Goethe University Frankfurt, Germany)
Tobias Müller (University of Groningen, Netherlands)
Richard Mycroft (University of Birmingham, UK)
Deryk Osthus (University of Birmingham, UK)
Olaf Parczyk (Ilmenau University of Technology, Germany)
Manuel Penschuk (Goethe University Frankfurt, Germany)
Will Perkins (University of Birmingham, UK)
Andrzej Ruciński (Adam Mickiewicz University of Poznan, Poland)
Thomas Sauerwald (University of Cambridge, UK)
Mathias Schacht (University of Hamburg, Germany)
Guilhem Semerjian (ENS Paris, France)
Asaf Shapira (Tel-Aviv University, Israel)
Gregory Sorkin (London School of Economics, UK)
Anand Srivastav (CAU Kiel, Germany)
Anusch Taraz (Hamburg University of Technology, Germany)
Andrew Treglown (University of Birmingham, UK)

Organising Committee

Amin Coja-Oghlan (Goethe University Frankfurt, Germany)
Noela Müller (Goethe University Frankfurt, Germany)
Yury Person (Ilmenau University of Technology, Germany)

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Schedule

Monday, 9th of July (Room 711 groß, Robert-Mayer-Straße 10 at Campus Bockenheim)

12:30-13:30	Welcome and Buffet Lunch
13:30-14:15	Artur Czumaj *Generating Random Permutations Using Switching Networks*
14:15-15:00	Thomas Sauerwald *On coalescence time in graphs – When is coalescing as fast as meeting?*
	- Coffee break -
15:30-16:15	Andrzej Ruciński *Powers of Hamiltonian cycles in randomly augmented graphs*
16:15-17:00	Dieter Mitsche k*-regular subgraphs near the* k*-core threshold of a random graph*
17:00-17:45	Michael Kaufmann *Graph Drawing Beyond Planarity*

Tuesday, 10th of July (Room 1.802, Casino building at Campus Westend)

09:00-09:45	Gregory Sorkin *Extremal Cuts and Isoperimetry in Random Cubic Graphs*
09:45-10:30	Charilaos Efthymiou *Improved bounds for sampling colorings of sparse random graphs*
	- Coffee break -
11:00-11:45	Guilhem Semerjian *Phase transitions in inference problems on sparse random graphs*
11:45-12:30	Sander Dommers *Metastability of the Ising model on random regular graphs at zero temperature*
12:30-13:00	Tobias Kapetanopoulos *Charting the replica symmetric phase*
	Workshop photo in front of the Casino building
	- Lunch break -
15:00-15:45	Petra Berenbrink *Introduction to the Population Model*
15:45-16:30	Nils Bertschinger *Systemic risk in financial networks*
	- Coffee break -
17:00-17:30	Noela Müller

	The satisfiability threshold for random linear equations
17:30-18:30	Tobias Friedrich *Algorithms on and for Hyperbolic Random Graphs*

Wednesday, 11th of July (Room 711 groß, Robert-Mayer-Straße 10 at Campus Bockenheim)

09:00-09:45	Asaf Shapira *Two Erdős-Hajnal-type Theorems in Hypergraphs*
09:45-10:30	Mathias Schacht *Homomorphism threshold for graphs*
	- Coffee break -
11:00-11:45	Anand Srivastav *Derandomizing Martingale inequalities with Applications to Hypergraph Vertex Covering*
11:45-12:30	Martin Hoefer *Graph Algorithms in the Random-Order Model*
12:30-13:00	Manuel Penschuk *Scalable and communication-free generation of hyperbolic graphs*
	- Lunch break -
15:00-15:45	Steffen Dereich *TBA*
15:45-16:30	Mihyun Kang *Random graphs on surfaces*
	- Coffee break -
17:00-17:45	Will Perkins *Sphere packings, codes, and kissing numbers via hard core models*

Thursday, 12th of July (Seminarpavillon SP1.04 at Campus Westend)

09:00-09:45	Michael Drmota *Pattern occurrences in random planar maps*
09:45-10:30	Nikolaos Fountoulakis *Evolving simplicial complexes*
	- Coffee break -
11:00-11:45	Eoin Long *Cycle-complete Ramsey numbers*
11:45-12:30	Richard Montgomery *Resilience in the random graph and digraph processes*
12:30-13:15	Deryk Osthus *A characterization of all testable hypergraph properties*

	- Lunch break -
15:00-15:45	Anusch Taraz *On the size-Ramsey number of the grid*
15:45-16:30	Richard Mycroft *Embedding oriented trees (and other digraphs) in tournaments (and other digraphs)*
	- Coffee break -
17:00-17:30	Frederik Garbe *Contagious sets in degree-proportional bootstrap percolation*
17:30-18:15	Daniela Kühn *On a conjecture of Erdős on locally sparse Steiner triple systems*
19:30	**Workshop dinner**

Friday, 13th of July (Room 711 groß, Robert-Mayer-Straße 10 at Campus Bockenheim)

09:00-09:45	Andrew Treglown *A bandwidth theorem for locally dense graphs*
09:45-10:30	Elad Aigner-Horev *Tight Hamilton cycles in 3-uniform quasirandom hypergraphs*
	- Coffee break -
11:00-11:30	Olaf Parczyk *Randomly perturbed graphs*
11:30-12:00	Zongchen Chen *Swendsen-Wang Dynamics for General Graphs in the Tree Uniqueness Region*
12:00-12:45	Tobias Müller *Logic and random graphs*

Directions

Route from Novum Hotel Imperial to the station Bockenheimer Warte:
`https://goo.gl/maps/5DdZK8AEyo62`

Route from Novum Hotel Imperial to Campus Bockenheim (Monday, Wednesday, Friday):
`https://goo.gl/maps/hm9gSo5KzdA2`

Route from Novum Hotel Imperial to Campus Westend Casino (Tuesday):

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https://www.google.com/maps/dir/Novum+Hotel+Imperial+Frankfurt+Messe,+Sophienstra%C3%9Fe+
40,+60487+Frankfurt+am+Main/Siesmayerstra%C3%9Fe,+60323+Frankfurt+am+Main/Goethe-Universit%
C3%A4t+Campus+Westend+Mensa+Anbau+Casino,+Theodor-W.-Adorno-Platz+2,+60323+Frankfurt+am+Main/
@50.1254267,8.6541091,16z/data=!3m1!4b1!4m20!4m19!1m5!1m1!1s0x47bd0943e8c06047:0xebd497bbef3fa8ba!
2m2!1d8.650254!2d50.123418!1m5!1m1!1s0x47bd094f68e256eb:0x9e2d6f8fd89c5a43!2m2!1d8.6584765!
2d50.1229135!1m5!1m1!1s0x47bd094a10be5e3f:0xb5e56c07689a12c!2m2!1d8.6669234!2d50.1271753!
3e2
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Route from Novum Hotel Imperial to Campus Westend Seminarpavillon (Thursday):

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40,+60487+Frankfurt+am+Main/Siesmayerstra%C3%9Fe,+60323+Frankfurt+am+Main/Stralsunder+Str.
+36,+60323+Frankfurt+am+Main/@50.1268128,8.6555791,16z/data=!3m1!4b1!4m20!4m19!1m5!1m1!1s0x47bd0943
0xebd497bbef3fa8ba!2m2!1d8.650254!2d50.123418!1m5!1m1!1s0x47bd094f68e256eb:0x9e2d6f8fd89c5a43!
2m2!1d8.6584765!2d50.1229135!1m5!1m1!1s0x47bd09344898432b:0x5d7748364a4e2be4!2m2!1d8.66919!
2d50.13111!3e2
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If you prefer to use the bus to Campus Westend, you can use bus 32 towards Ostbahnhof/Sonnemannstraße from Bockenheimer Warte to Miquel-/Hansaallee. The bus station Bockenheimer Warte is situated between the hotel and Campus Bockenheim. From Miquel-/Hansaallee, it is just a short walking distance to Campus Westend.

Abstracts of the talks

Tight Hamilton cycles in 3-uniform quasirandom hypergraphs

Elad Aigner-Horev

Friday, 13th of July, 09:45-10:30

Following a brief overview regarding the current state of the art of quasirandom hypergraphs we shall proceed to outline how to employ the absorbing-path method in order to prove that for any fixed real $\alpha > 0$ the sufficiently large dense members of a certain class of quasirandom 3-uniform hypergraphs having minimum 1-degree at least $\alpha\binom{n-1}{2}$ admit a tight Hamilton cycle.

Introduction to the Population Model

Petra Berenbrink

Tuesday, 10th of July, 15:00-15:45

Population models are used as a theoretical model for a collection of mobile agents that interact with each other and cary out a simple computation. The agents are modelled by finite state machines. Initially every agent is on one fixed state and pairs of agents can exchange state information with other and change their states accordingly. Population models can be used to model mobile ad hoc networks, birds in a flog or collections of molecules undergoing chemical reactions. In this talk I will present some resent results in the area of population models, focusing on majority and leader election.

Systemic risk in financial networks

Nils Bertschinger

Tuesday, 10th of July, 15:45-16:30

The ever increasing complexity of financial interconnections poses new threats to financial stability. Especially the latest financial crisis has revealed the potential of cascading failures that could lead to the break-down of the global financial system. In this talk, I will introduce and discuss several models of financial markets that illustrate different contagion mechanisms, e.g. direct spreading via counter parties defaulting or indirect spreading via fire sales of commonly held financial assets.

Swendsen-Wang Dynamics for General Graphs in the Tree Uniqueness Region

Zongchen Chen

Friday, 13th of July, 11:30-12:00

The Swendsen-Wang dynamics is a popular algorithm for sampling from the Gibbs distribution for the ferromagnetic Ising model on a graph $G = (V, E)$. The dynamics is a "global" Markov chain which is conjectured to converge to equilibrium in $O(|V|^{0.25})$ steps for any graph G at any (inverse) temperature b. It was recently proved by Guo and Jerrum (2017) that the Swendsen-Wang dynamics has polynomial mixing time on any graph at all temperatures, yet there are few results providing $o(|V|)$ upper bounds on its convergence time.

We prove fast convergence of the Swendsen-Wang dynamics on general graphs in the tree uniqueness region of the ferromagnetic Ising model. In particular, when $b < b_c(d)$ where $b_c(d)$ denotes the uniqueness/non-uniqueness threshold on infinite d-regular trees, we prove that the relaxation time (i.e., the inverse spectral gap) of the Swendsen-Wang dynamics is $O(1)$ on any graph of maximum degree $d \geq 3$. Our proof utilizes a monotone version of the Swendsen-Wang dynamics which only updates isolated vertices. We also extend our results to general monotone Markov chains. This class of dynamics includes for example the heat-bath block dynamics, for which we obtain new tight mixing time bounds.

Based on joint work with Antonio Blanca and Eric Vigoda.

Generating Random Permutations Using Switching Networks

Artur Czumaj

Monday, 9th of July, 13:30-14:15

We consider the problem of designing a simple, oblivious scheme to generate (almost) random permutations. We use the concept of switching networks and show that almost every switching network of logarithmic depth can be used to almost randomly permute any set of $(1-\varepsilon)n$ elements with any $\varepsilon > 0$ (that is, gives an almost $(1-\varepsilon)n$-wise independent permutation). Furthermore, we show that the result still holds for every switching network of logarithmic depth that has some special expansion properties, leading to an explicit construction of such networks. Our result can be also extended to an explicit construction of a switching network of depth $O(\log^2 n)$ and with $O(n \log n)$ switches that almost randomly permutes any set of n elements.

Our results are obtained using a non-trivial coupling approach to study mixing times of Markov chains which allows us to reduce the problem to some random walk-like problem on expanders.

TBA

Steffen Dereich

Wednesday, 11th of July, 15:00-15:45

Metastability of the Ising model on random regular graphs at zero temperature

Sander Dommers

Tuesday, 11th of July, 11:45-12:30

We study metastability of the ferromagnetic Ising model on a random regular graph in the zero temperature limit. We prove that in the presence of a small positive external field the time that it takes to go from the all minus state to the all plus state takes an exponential time with the exponent being linear in the inverse temperature, the degree and the size of the graph. For the proof it is necessary to understand the global structure of the random graph, especially bounds on the isoperimetric number of random regular graphs are used. These bounds are combined with the so-called pathwise approach to metastability.

Pattern occurrences in random planar maps

Michael Drmota

Thursday, 12th of July, 09:00-09:45

Random planar maps are a classical topic in the interplay between combinatorics and random graph theory. Several shape parameters have been studied so far. However, there are only very few results on pattern occurences. More precisely, let $X_n^{(P)}$ denote the (random) number of occurences of a pattern P in planar maps with n edges. It is not so difficult to show that $\mathbb{E}X_n^{(P)} \sim c(P)n$ for some positive constant $c(P)$. It is, however, conjectured that $X_n^{(P)}$ obeys a central limit theorem with variance $\mathrm{Var}(X_n^{(P)}) \sim d(P)n$. The purpose of this talk is to give an overview of results and methods into this direction. Actually, a central limit theorem is only known for very few patterns P.

Improved bounds for sampling colorings of sparse random graphs

Charilaos Efthymiou

Tuesday, 10th of July, 09:45-10:30

We study the mixing properties of the single-site Markov chain known as the Glauber dynamics for sampling k-colorings of a sparse random graph $G(n, d/n)$ for constant d. The best known rapid mixing results for general graphs are in terms of the maximum degree Δ of the input graph G and hold when $k > 11\Delta/6$ for all G. Improved results hold when $k > \alpha\Delta$ for graphs with girth ≥ 5 and Δ sufficiently large where $\alpha \approx 1.7632\ldots$ is the root of $\alpha = \exp(1/\alpha)$; further improvements on the constant α hold with stronger girth and maximum degree assumptions.

For sparse random graphs the maximum degree is a function of n and the goal is to obtain results in terms of the expected degree d. The following rapid mixing results for $G(n, d/n)$ hold with high probability over the choice of the random graph for sufficiently large constant d. Mossel and Sly (2009) proved rapid mixing for constant k, and Efthymiou (2014) improved this to k linear in d. The condition was improved to $k > 3d$ by Yin and Zhang (2016) using non-MCMC methods.

Here we prove rapid mixing when $k > \alpha d$ where $\alpha \approx 1.7632\ldots$ is the same constant as above. Moreover we obtain $O(n^3)$ mixing time of the Glauber dynamics, while in previous rapid mixing results the exponent was an increasing function in d. As in previous results for random graphs our proof analyzes an appropriately defined block dynamics to "hide" high-degree vertices. One new aspect in our improved approach is utilizing so-called local uniformity properties for the analysis of block dynamics. To analyze the "burn-in" phase we prove a concentration inequality for the number of disagreements propagating in large blocks.

This is joint work with Tom Hayes, Daniel Stefankovic and Eric Vigoda.

Evolving simplicial complexes

Nikolaos Fountoulakis

Thursday, 12th of July, 09:45-10:30

We will consider a class of dynamic models for random simplicial complexes, which generalise the preferential attachment model. Starting with a simplex of dimension r, vertices arrive one by one and they are equipped with a weight or fitness which is drawn independently each time from a given distribution. Each face of the simplicial complex thus has weight which is a function of the weights of its vertices. A new vertex selects an $(r-1)$-face with probability proportional to its weight and forms an r-simplex, whereas the $(r-1)$-face is removed from the complex. This model is inspired by a model introduced by Bianconi and Rahmede (Nature Scientific Reports, 2015). When the weights are all equal, the above coincides with the class of models known as apollonian networks.

We shall discuss the probabilistic analysis of this model, focusing on the distribution of its degrees.

This is joint work with T. Iyer, C. Mailler and H. Sulzbach.

Algorithms on and for Hyperbolic Random Graphs

Tobias Friedrich

Tuesday, 10th of July, 17:30-18:30

The node degrees of large real-world networks often follow a power-law distribution. Such scale-free networks can be social networks, internet topologies or many other networks. There is, however, no established and simple network model that also has a high clustering of vertices as typically observed in real data. The talk will present several mathematical models of scale-free networks and introduce hyperbolic random graphs as a natural model that fulfills many properties of real world networks. I will also show how to efficiently embed networks in the hyperbolic space and present some algorithms on hyperbolic random graphs.

Contagious sets in degree-proportional bootstrap percolation

Frederik Garbe

Thursday, 12th of July, 17:00-17:30

We study the following bootstrap percolation process: given a connected graph G, we *infect* an initial set $A \subseteq V(G)$, and in each step a vertex v becomes infected if at least a ρ-proportion of its neighbours are infected. Once infected, a vertex remains infected forever. A set A which infects the whole graph is called a *contagious set*. It is natural to ask for the minimal size of a contagious set which we denote by $h_\rho(G)$ and show that for every $\rho \in (0, 1]$, every connected graph G on n vertices has $h_\rho(G) < 2\rho n$ or $h_\rho(G) = 1$. This improves previous results of Chang, Chang and Lyuu, and Gentner and Rautenbach and an easy construction show that this is best-possible. We also provide a stronger bound in the case of graphs of girth at least five and discuss the asymptotic behavior for $\rho \to 0$.

This is joint work with Andrew McDowell and Richard Mycroft.

Graph Algorithms in the Random-Order Model

Martin Hoefer

Wednesday, 11th of July, 11:45-12:30

Many graph-theoretic maximization problems such as matching, independent set, or max-weight forest arise in practice with an online component, where nodes or edges can be thought of arriving sequentially over time. This approach captures prominent applications in the context of e-commerce, wireless networking, scheduling and many more. For these problems, standard adversarial worst-case analysis of algorithms is often overly pessimistic. Over the last decade, the focus has shifted to analyze algorithms wrt. different mixtures of stochastic and adversarial inputs. This allows a more insightful characterization of successful algorithmic strategies. In this talk, I will discuss results in the random-order model, in which an adversary specifies the complete input graph, and then the nodes or edges of the graph arrive in uniform random order. I will discuss recent advances for matching and independent set problems und present some open problems and questions.

Random graphs on surfaces

Mihyun Kang

Wednesday, 11th of July, 15:45-16:30

We shall discuss component structure and properties of random graphs on surfaces. Let $S_g(n, m)$ be a graph chosen uniformly at random from the class of all graphs with vertex set $[n] = \{1, \dots, n\}$ and m edges that are embeddable on the orientable surface $\mathbb{S}_g$ of genus $g \in \mathbb{N} \cup \{0\}$ without crossing edges. We show that $S_g(n, m)$ undergoes two phase transitions as $m = m(n)$ increases from 0 to $3n + O(1)$. The first phase transition mirrors the classical phase transition in the Erdős–Rényi random graph $G(n, m)$. The second phase transition occurs when the giant component covers almost all vertices of the graph – this kind of phenomenon is strikingly different from $G(n, m)$. We also determine for which $g = g(n)$ and $m = m(n)$ two random graph models, $S_g(n, m)$ and $G(n, m)$, are contiguous.

Charting the replica symmetric phase

Tobias Kapetanopoulos

Tuesday, 10th of July, 12:30-13:00

Diluted mean-field models are spin systems whose geometry of interactions is induced by a sparse random graph or hypergraph. They play an important role in combinatorics, computer science and statistical mechanics. A mesmerizing complexity is inherent to these models and they provide challenging benchmark instances for algorithms. In an important contribution [Krzakala et al., PNAS 2007] physicists predicted the existence of a replica symmetry breaking phase transition in such models and sketched a detailed picture of the evolution of the Gibbs measure within the replica symmetric phase. In the course of two recent papers, we were able to rigorise this picture completely for a broad class of models, encompassing the Potts antiferromagnet on the random graph, random (hyper)graph coloring, the k-XORSAT model, the k-NAESAT model and the diluted k-spin model for even k.

Graph Drawing Beyond Planarity

Michael Kaufmann

Monday, 9th of July, 17:00-17:45

Planarity has been established as one of the key structural concepts in graph drawing. Recently, researcher go beyond planarity and focus on graph classes that include graphs that can be drawn with some crossing edges but in locally restricted way. Usually those drawings are characterized by some forbidden configurations. In my presentation, i will provide an overview of such graph classes, give density results and discuss algorithmic and combinatorial questions and variants of this new area.

On a conjecture of Erdős on locally sparse Steiner triple systems

Daniela Kühn

Thursday, 12th of July, 17:30-18:15

Given a set X of size n, a collection S of 3-subsets of X is a Steiner triple system of order n if every 2-subset of X is contained in exactly one of the triples of S (so a Steiner triple system of order n can also be viewed as a decomposition of the n-vertex complete graph into edge-disjoint triangles). A famous theorem of Kirkman says that there exists a Steiner triple system of order n if and only if n equals $1, 3 \mod 6$. In 1976, Erdős conjectured that one can find so-called "sparse" Steiner triple systems. Roughly speaking, the aim is to have at most $j - 3$ triples in S on every set of j points, which would be best possible. (Triple systems with this sparseness property are also referred to as having high girth.)

We prove this conjecture asymptotically by analysing a natural generalization of the random triangle removal process. Our result also solves a problem posed by Lefmann, Phelps and Rodl as well as Ellis and Linial in a strong form. Moreover, we pose a conjecture which would generalize the Erdős conjecture to Steiner systems with arbitrary parameters and provide some evidence for this.

This is joint work with Stefan Glock, Allan Lo and Deryk Osthus.

Cycle-complete Ramsey numbers

Eoin Long

Thursday, 12th of July, 11:00-11:45

The Ramsey number $r(C_\ell, K_n)$ is the smallest natural number N such that every red/blue edge-colouring of a clique of order N contains a red cycle of length ℓ or a blue clique of order n. In 1978, Erdős, Faudree, Rousseau and Schelp conjectured that $r(C_\ell, K_n) = (\ell - 1)(n - 1) + 1$ for $\ell \geq n \geq 3$ provided $(\ell, n) \neq (3, 3)$.

In this talk I will discuss a recent proof of this conjecture for large ℓ, and a strong form of a conjecture due to Nikiforov, showing that $r(C_\ell, K_n) = (\ell-1)(n-1)+1$ provided $\ell \geq \frac{C \log n}{\log \log n}$, for some absolute constant $C > 0$. Up to the value of C this is tight, and answers two further questions of Erdős et al. up to multiplicative constants.

Joint work with Peter Keevash and Jozef Skokan.

k-regular subgraphs near the k-core threshold of a random graph

Dieter Mitsche

Monday, 9th of July, 16:15-17:00

We prove that $G_{n,p}$ whp has a k-regular subgraph if c is at least $e^{-\Theta(k)}$ above the threshold for the appearance of a subgraph with minimum degree at least k; i.e. an non-empty k-core. In particular, this pins down the threshold for the appearance of a k-regular subgraph to a window of size $e^{-\Theta(k)}$.

This is joint work with Mike F. Molloy and Pawel Pralat.

Resilience in the random graph and digraph processes

Richard Montgomery

Thursday, 12th of July, 11:45-12:30

Since the earliest work on random graphs, questions have been asked about which subgraphs are likely to appear. As initiated by Sudakov and Vu around 10 years ago, the limits of our methods here can be explored by studying when a random graph is likely to contain a subgraph resiliently – that is, when it contains a copy of that subgraph despite the removal of many different sets of edges. The goal here is to show that any random graph dense enough to likely contain a copy of a particular subgraph will in fact likely contain a copy of that subgraph resiliently. At its furthest ambition, we wish to show that it is likely that the first graph in the random graph process containing a certain subgraph in fact contains that subgraph resiliently.

I will discuss a resilience version of the hitting-time appearance of Hamilton cycles in the random graph process, as well as a recent analogue for the directed random graph process.

The satisfiability threshold for random linear equations

Noela Müller

Tuesday, 10th of July, 17:00-17:30

Consider a linear equation $Ax = y$ over a finite field, where A is a random matrix and y is a random vector, which are chosen independently of each other. For a specific probabilistic model, we determine the threshold ratio of equations to variables up to which the system admits a solution with high probability. From this, we gain insights on the geometry of the set of solutions. For fields with two to four elements, the problem is well-known and has been studied thoroughly. However, the proof techniques employed in this line of research could not be extended to fields with more elements. Here, we present a different approach which resolves the previous difficulties and allows for a unified treatment of random linear equations over finite fields.

This is joint work with Peter Ayre, Amin Coja-Oghlan and Pu Gao.

Logic and random graphs

Tobias Müller

Friday, 13th of July, 12:00-12:45

We say that a graph property is expressible in the "first order language of graphs" if it can be written as a logic sentence using the universal and existential quantifiers with variables ranging over the nodes of the graph, the usual connectives AND, OR, NOT, parentheses and the relations = and ~, where $x \sim y$ means that x and y share an edge. For example, the property that G contains a triangle can be written as

$\exists\ x, y, z : (x \sim y)$ AND $(x \sim z)$ AND $(y \sim z)$.

A classical result of Glebskii et al. 1969 and indepently Fagin 1976 states that if one samples a graph on n vertices uniformly at random from all such graphs then every first order expressible graph property holds with probability tending to either zero or one (as n tends to infinity). Since then, first order expressible properties have been studied extensively on the most commonly studied model of random graphs, the Erdős-Rényi model. A number of very attractive and surprising results have been obtained, and by now we have a fairly full description of the behaviour of first order expressible properties on this model.

After describing some of these results, time permitting, I will discuss some recent and ongoing work where we try to see what happens both in other models of random graphs (such as random planar graphs, random perfect graphs, random geometric graphs, ...) and when one considers other (i.e. "higher order") logics.

Based on joint works with S. Haber, P. Heinig, M. Noy, A. Taraz.

Embedding oriented trees (and other digraphs) in tournaments (and other digraphs)

Richard Mycroft

Thursday, 12th of July, 15:45-16:30

There are numerous results and conjectures regarding conditions which guarantee that a given oriented tree can be embedded within a digraph. In this talk I will describe recent progress in this area, including the following results.

(i) Almost all oriented trees are unavoidable, meaning that they are contained in every tournament on the same number of vertices (this verifies a conjecture of Bender and Wormald).

(ii) Every oriented tree whose maximum degree is not too large is contained in every directed graph of large minimum semidegree on the same number of vertices.

In fact, the method for (ii) can be applied to digraphs other than trees which are 'sufficiently subdivided'.

This is joint work with Tássio Naia.

A characterization of all testable hypergraph properties

Deryk Osthus

Thursday, 12th of July, 12:30-13:15

We provide a combinatorial characterization of all testable properties of k-graphs (i.e. k-uniform hypergraphs). Here, a k-graph property P is testable if there is a randomized algorithm which makes a bounded number of edge queries and distinguishes with probability $2/3$ between k-graphs that satisfy P and those that are far from satisfying P. For the 2-graph case, such a combinatorial characterization was obtained by Alon, Fischer, Newman and Shapira. Our results for the k-graph setting are in contrast to those of Austin and Tao, who showed that for the somewhat stronger concept of local repairability, the testability results for graphs do not extend to the 3-graph setting.

This is joint work with Felix Joos, Jaehoon Kim and Daniela Kühn.

Randomly perturbed graphs

Olaf Parczyk

Friday, 13th of July, 11:00-11:30

We study the model of randomly perturbed dense graphs, that is, for any constant $\alpha > 0$, the union of some n-vertex graph G_α with minimum degree at least αn and the binomial random graph $G(n, p)$.

We introduce a general approach for studying the appearance of spanning subgraphs in this model. Using this, we can give simpler proofs of several results in the literature concerning the appearance of different spanning subgraphs in this model and obtain new results for bounded degree graphs, powers of Hamilton cycles and universality for bounded degree trees. This addresses two questions of Krivelevich, Kwan, and Sudakov.

This is joint work with Julia Böttcher, Jie Han, Yoshiharu Kohayakawa, Richard Montgomery and Yury Person.

Scalable and communication-free generation of hyperbolic graphs

Manuel Penschuk

Wednesday, 11th of July, 12:30-13:00

Random graph models, originally conceived to study the structure of networks and the emergence of their properties, have become an indispensable tool for experimental algorithmics. Amongst them, hyperbolic random graphs form a well-accepted family, yielding realistic complex networks while being both mathematically and algorithmically tractable. We discuss the recent development of generators for this model and present a novel scalable approach to sample massive hyperbolic graphs in a massive parallel distributed setting. The algorithm performs near-linear work and requires a sub-linear memory footprint. Due to its communication-free design, in practice it scales well to ten-thousands of processors.

Sphere packings, codes, and kissing numbers via hard core models

Will Perkins

Wednesday, 11th of July, 17:00-17:45

We prove a lower bound on the expected size of a spherical code drawn from a “hard cap" model and the expected density of a packing drawn from the hard sphere model in high dimensions. These results allows us to improve the lower bound on the kissing number in high dimensions by a factor d and to prove new lower bounds on the entropy of sphere packings of density $\Theta(d2^{-d})$ in $\mathbb{R}^d$.

Joint work with Matthew Jenssen and Felix Joos.

Powers of Hamiltonian cycles in randomly augmented graphs

Andrzej Ruciński

Monday, 9th of July, 15:30-16:15

In my talk I am going to discuss the existence of powers of Hamilton cycles in graphs with large minimum degree to which additional edges have been added randomly. In particular, for graphs with minimum degree at least $kn/(k+1)$, the addition of just $O(n)$ random edges ensures a creation of the (k+1)-st power of a Hamilton cycle.

This is joint work with Andrzej Dudek, Christian Reiher, and Mathias Schacht.

On coalescence time in graphs – When is coalescing as fast as meeting?

Thomas Sauerwald

Monday, 9th of July, 14:15-15:00

Coalescing random walks is a fundamental stochastic process, where a set of particles perform independent discrete-time random walks on an undirected graph. Whenever two or more particles meet at a given node, they merge and continue as a single random walk. The coalescence time is defined as the expected time until only one particle remains, starting from one particle at every node. The meeting time is defined as the worst-case expected time required for two random walks to arrive at the same node at the same time.

As a general result, we establish that for graphs whose meeting time is only marginally larger than the mixing time (a factor of $\log 2n$), the coalescence time of n random walks equals the meeting time up to constant factors. This upper bound is complemented by the construction of a graph family demonstrating that this result is the best possible up to constant factors.

(joint work with Varun Kanade and Frederik Mallmann-Trenn)

Homomorphism threshold for graphs

Mathias Schacht

Wednesday, 11th of July, 09:45-10:30

The interplay of minimum degree and 'structural properties' of large graphs with a given forbidden subgraph is a central topic in extremal graph theory. For a given graph F we define the homomorphism threshold as the infimum α such that every n-vertex F-free graph G with minimum degree $> \alpha n$ has a homomorphic image H of bounded size (independent of n), which is F-free as well. Without the restriction of H being F-free we recover the definition of the chromatic threshold, which was determined for every graph F by Allen et al. The homomorphism threshold is less understood and we present recent joint work with O. Ebsen on the homomorphism threshold for odd cycles.

Phase transitions in inference problems on sparse random graphs

Guilhem Semerjian

Tuesday, 10th of July, 11:00-11:45

Random graphs generated from the Stochastic Block Model possess a hidden community structure and constitute a natural testbed for graph inference algorithms. This model exhibit phase transitions, both for the information-theoretically optimal estimation of the underlying communities and for the accuracy of efficient estimation algorithms. One of these phase transitions corresponds to the Kesten-Stigum threshold for an associated tree reconstruction problem. I will present in this talk some systematic moment expansions around this bifurcation that shed new light on these problems, in particular for the reconstruction of the 4-state Potts model and of the asymmetric Ising one.

Joint work with Federico Ricci-Tersenghi and Lenka Zdeborová.

Two Erdős-Hajnal-type Theorems in Hypergraphs

Asaf Shapira

Wednesday, 11th of July, 09:00-09:45

The Erdős-Hajnal Theorem asserts that non-universal graphs, that is, graphs that do not contain an induced copy of some fixed graph H, have homogeneous sets of size significantly larger than one can generally expect to find in a graph. We obtain two results of this flavor in the setting of r-uniform hypergraphs.

A theorem of Rödl asserts that if an n-vertex graph is non-universal then it contains an almost homogeneous set (i.e one with edge density either very close to 0 or 1) of size $\Omega(n)$. We prove that if a 3-uniform hypergraph is non-universal then it contains an almost homogeneous set of size $\Omega(\log n)$. An example of Rödl from 1986 shows that this bound is tight.

Let $R_r(t)$ denote the size of the largest non-universal r-graph G so that neither G nor its complement contain a complete r-partite subgraph with parts of size t. We prove an Erdős-Hajnal-type stepping-up lemma, showing how to transform a lower bound for $R_r(t)$ into a lower bound for $R_{r+1}(t)$. As an application of this lemma, we improve a bound of Conlon-Fox-Sudakov by showing that $R_3(t) \geq t^{\Omega(t)}$.

This is joint work with M. Amir and M. Tyomkyn.

Extremal Cuts and Isoperimetry in Random Cubic Graphs

Gregory Sorkin

Tuesday, 10th of July, 09:00-09:45

The minimum bisection width of random cubic graphs is of interest because it is one of the simplest questions imaginable in extremal combinatorics, and also because the minimum bisection of (general) cubic graphs plays a role in the construction of efficient exponential-time algorithms, and it seems likely that random cubic graphs are extremal.

It is known that a random cubic graph has a minimum bisection of size at most $1/6$ times its order (indeed this is known for all cubic graphs), and we reduce this upper bound to below $1/7$ (to 0.13993) by analyzing an algorithm with a couple of surprising features. We increase the corresponding lower bound on minimum bisection (from $1/9.9$ to 0.10133) using the Hamilton cycle model of a random cubic graph. We use the same Hamilton cycle approach to decrease the upper bound on maximum cut (from 1.4026 to 1.40031). We will discuss some related conjectures.

Derandomizing Martingale inequalities with Applications to Hypergraph Vertex Covering

Anand Srivastav

Wednesday, 11th of July, 11:00-11:45

In this talk we present a derandomized form of the famous martingale inequality of Kazuoki Azuma (1967), and the bounded differences inequality of Colin McDiarmid (1988) based on it. We further show how to embed limited independence in the concentration bounds of Angluin-Valiant, motivated by work of Svante Janson (2003) on sums of partially dependent random variables for the Chernov-Hoeffding inequality. We then demonstrate that the derandomized McDiarmid-inequality is an easy applicable and elegant frame work for derandomization in presence of dependent random variables. As an example we choose the randomized algorithm for the vertex cover (or hitting set) problem in hypergraphs due to Mourad El Ouali, Helena Fohlin and Anand Srivastav (2016), which for hypergraphs with bounded vertex degree gives the presently best approximation bounds.

This is joint work with Mayank (2018).

On the size-Ramsey number of the grid

Anusch Taraz

Thursday, 12th of July, 15:00-15:45

The size-Ramsey number of a graph H is the smallest number of edges in a graph G with the Ramsey property for H, that is, with the property that any 2-colouring of the edges of G contains a monochromatic copy of H. We prove that the size-Ramsey number of the grid graph on $n \times n$ vertices is bounded from above by $n^{(3+o(1))}$.

This is joint work with Dennis Clemens, Meysam Miralaei, Damian Reding, and Mathias Schacht.

A bandwidth theorem for locally dense graphs

Andrew Treglown

Friday, 13th of July, 09:00-09:45

A fundamental topic in extremal graph theory is to find minimum degree conditions that force a spanning substructure in a graph. One of the most general results in this direction is the so-called Bandwidth Theorem of Boettcher, Schacht and Taraz. This result gives a minimum degree condition which forces a graph G to contain every spanning subgraph of bounded chromatic number, bounded degree and sublinear bandwidth. In this talk I will describe a version of the Bandwidth Theorem where now one substantially lowers the degree condition at the expense of ensuring the host graph G is "locally dense".

This is joint work with Katherine Staden.