Department of Mathematics

Seminars on Combinatorics, Games and Optimisation in 2017

Seminars are listed in reverse chronological order, most recent first.

Wednesday 29 November - in combination with SEDs Data Science Seminar series
Elisa Celis and Nisheeth Vishnoi (EPFL)
Controlling Bias in Artificial Intelligence

Bias is an increasingly observed phenomenon in the world of artificial intelligence (AI) and machine learning: From gender bias in online search to racial bias in court bail pleas to biases in worldviews depicted in personalized newsfeeds. How are societal biases creeping into the seemingly “objective” world of computers and programs? At the core, what is powering today’s AI are algorithms for fundamental computational problems such as classification, data summarization, and online learning. Such algorithms have traditionally been designed with the goal of maximizing some notion of “utility” and identifying or controlling bias in their output has not been a consideration. In this talk, Nisheeth and Elisa will explain the emergence of bias in algorithmic decision making and present the first steps towards developing a systematic framework to control biases in several of the aforementioned problems. This leads to new algorithms that have the ability to control and alleviate bias, often without a significant compromise to the utility that the current algorithms obtain.

Wednesday 22 November - Justin Ward (Queen Mary)
Improved Approximation for K-Means in Arbitrary Dimension

In the general K-Means problem in which we are given n input points in a Euclidean space and seek to find k "center" points in the space so that the sum of the squared distances of each input point to its nearest center is minimized. While there have been several recent results for the special case in which the Euclidean space has some bounded dimension d, the best known approximation in arbitrary Euclidean spaces has remained (9+\epsilon) since 2002. In this talk I will present a new algorithm that achieves a 6.36-approximation for this problem, as well as an improved 2.64 approximation for the Euclidean k-median problem. The algorithm is based on a new Lagrangian multiplier preserving primal dual approach. This talk is based on joint work with Sara Ahmadian, Ashkan Norouzi-Fard, and Ola Svensson.

Thursday 16 November - Tim Roughgarden (Stanford & LSE)
Distribution-Free Models of Social and Information Networks

The mathematical study of social and information networks has historically centered around generative models for such networks (preferential attachment, the

Chung-Lu random graph model, Kronecker graphs, etc.). This talk proposes distribution-free models of social and information networks --- novel classes of graphs that capture all plausible such networks. Our models are motivated by triadic closure, the property that vertices with one or more mutual neighbors tend to also be neighbors; this is one of the most universal signatures of social networks. We prove structural results on the clustering properties of such graphs, and give algorithmic applications to clustering and clique-finding problems.

Includes joint work with Jacob Fox, Rishi Gupta, C. Seshadhri, Fan Wei, and Nicole Wein.

9 November - **Christoph Koch (Warwick)**
How to re-establish a brand: bootstrap percolation in social networks

We consider a classical and well-studied graph process called \emph{bootstrap percolation}. While bootstrap percolation originally arose in the context of disordered magnetic systems, it has become an important model in the description and analysis of dynamics in social networks. Initially some vertices in a graph are \emph{activated}, and subsequently each vertex with at least $r\ge 2$ active neighbours is activated as well. Once a vertex is active, it remains so forever. On a variety of random graph models it is known that even (reasonably) sparse initial activations are likely to cause an activation of most vertices in the graph. However, for other models this \emph{critical phenomenon} does not occur. We investigate this dichotomy in detail and determine almost tight criteria on the degree sequence of random graphs for both the existence and non-existence of this critical phenomenon.

These results are joint work with M. Kang (TU Graz), T. Makai (TU Graz), and N. Fountoulakis (Birmingham).

2 November - **Liana Yepremyan (Oxford)**
Rainbow matchings in properly edge-colored multigraphs

Aharoni and Berger conjectured that in any bipartite multigraph that is properly edge-coloured by n colours with at least $n + 1$ edges of each colour there must be a matching that uses each colour exactly once (such a matching is called rainbow). This conjecture recently have been proved asymptotically by Pokrovskiy. In this talk I will consider the same question without the bipartiteness assumption. It turns out that in any multigraph with bounded edge multiplicities that is properly edge-coloured by n colours with at least $n + o(n)$ edges of each colour there must be a matching of size $n-O(1)$ that uses each colour at most once. This is joint work with Peter Keevash.

1 November - **Peter Csikvari (Budapest)**

Schrijver's theorem on the number of perfect matchings and its variants

In this talk we will sketch a new proof of Schrijver's theorem. This theorem asserts that a d-regular bipartite graph on 2n vertices has at least C_d^n perfect matchings, where C_d=(d-1)^(d-1)/d^(d-2). (I will explain where the constant comes from.) The new proof uses ideas from graph limit theory, and relies on the work of Heilmann and Lieb concerning the matching polynomial. Then we will survey several further applications of the method.

25 October - **Péter Pál Pach (Warwick/Technical University Budapest)**
On some recent applications of the polynomial method

In this talk we will look at a new variant of the polynomial method which was first used to prove that sets avoiding 3-term arithmetic progressions in groups like Z_4^n and F_q^n are exponentially small (compared to the size of the group). Since then many interesting applications of this method were shown, for instance, the solution of the Erdős-Szemerédi sunflower conjecture, tight bound for Green's arithmetic triangle removal lemma and growth rate of tri-colored sumfree sets. Finally, I will also mention some open problems.

26 October - **He Sun (Edinburgh)**
Heat kernels in graphs: A journey from random walks to geometry, and back

Heat kernels are one of the most fundamental concepts in physics and mathematics. In physics, the heat kernel is a fundamental solution of the heat equation and connects the Laplacian operator to the rate of heat dissipation. In spectral geometry, many fundamental techniques are based on heat kernels. In finite Markov chain theory, heat kernels correspond to continuous-time random walks and constitute one of the most powerful techniques in estimating the mixing time. In this talk, we will briefly discuss this line of research and its relation to heat kernels in graphs. In particular, we will see how heat kernels are used to design the first nearly-linear time algorithm for finding clusters in real-world graphs. Some interesting open questions will be addressed in the end.

11 October - **Haris Aziz (University of New South Wales, Sydney)**
A discrete and bounded envy-free cake cutting protocol for any number of agents

We consider the well-studied cake cutting problem in which the goal is to find an envy-free allocation. The problem has received attention in computer science, mathematics, and economics. It had been an open problem whether there exists a discrete and bounded envy-free protocol. In this talk I will discuss our discrete and bounded envy-free protocol that resolved the problem.
(Based on joint work with Simon Mackenzie)

12 October - **Michelle Delcourt (Birmingham)**
On the List Coloring Version of Reed's Conjecture

Reed conjectured in 1998 that the chromatic number of a graph should be at most the average of the clique number (a trivial lower bound) and maximum degree plus one (a trivial upper bound); in support of this conjecture, Reed proved that the chromatic number is at most some nontrivial convex combination of these two quantities. King and Reed later showed that a fraction of roughly 1/130000 away from the upper bound holds. Motivated by a paper by Bruhn and Joos, last year Bonamy, Perrett, and Postle proved for large enough maximum degree, a fraction of 1/26 away from the upper bound holds, a significant step towards the conjectured value of 1/2. Using new techniques, we show that the list-coloring version holds; for large enough maximum degree, a fraction of 1/13 suffices for list chromatic number. This result implies that 1/13 suffices for ordinary chromatic number as well. This is joint work with Luke Postle.

6 October - **Pablo Moscato (University of Newcastle, Australia)**
"We have it all wrong"… so what are you doing to change practice?

Along with many other researchers, I share the view that a systematically coherent research program, in both theory and applications of algorithms, is definitely needed to accelerate innovation in computing. We routinely design computational approaches and engage in healthy competitions where the performance of our methods is tested… but what if "We have it all wrong"? What if we need a paradigmatic change in our practice for the development and design of computational methods? We may need to enrich our practice with a new approach. In fact, John N. Hooker already alerted the computing and mathematical community more than 20 years ago [Hooker, 1995; Journal of Heuristics]: "Competitive testing tells us which algorithm is faster but not why." Hooker argued for a more scientific approach and he proposed the use of 'controlled experimentation'. This is common in empirical sciences. "Based on one's insights into an algorithm", he said, "one may expect good performance to depend on a certain problem characteristic". Then "design a controlled experiment that checks how the presence or absence of this characteristic affects performance" and, finally, "build an exploratory mathematical model that captures the insight [...] and deduce from its precise consequences that can be put to the test". In this talk, I will address how a new thinking is needed for the development of our field. I will have an with emphasis in our success on both speeding up solutions for the traveling salesman problem as well as our success to create very hard instances for the world's fastest solver.

4 October - **Martin Hoefer (Frankfurt)**
Algorithms for Nash Social Welfare and Markets with Satiation

Nash social welfare is an interesting objective with many appealing properties for item allocation in markets. The algorithmic problem of optimizing or approximating this objective, however, is only poorly understood. In this talk, I discuss the first constant-factor approximation algorithm when agents have budget-additive valuation functions. Budget-additive functions are an important class of submodular functions, and they attracted significant interest in approximation algorithms and algorithmic game theory in recent years.

Our algorithm relies on rounding an approximate equilibrium in a linear Fisher market where sellers have earning limits (upper bounds on the amount of money they want to earn) and buyers have utility limits (upper bounds on the amount of utility they want to achieve). In contrast to markets with either earning or utility limits, these markets have not been studied before, and they have fundamentally different properties. We design an FPTAS to compute an approximate equilibrium, a result that may be of independent interest.

29 September - **Jens Vygen (Bonn)**
Approaching 3/2 for the s-t-path TSP

The s-t-path TSP is a variant of the traveling salesman problem in which the endpoints of the tour are given and distinct. The integrality ratio of the natural linear programming relaxation is believed to be 3/2, but all approximation algorithms known so far have worse performance ratio. We show that there is a polynomial-time algorithm with approximation guarantee 3/2+epsilon, for any fixed \epsilon>0.

It is well known that Wolsey's analysis of Christofides' algorithm also works for the s-t-path TSP except for the narrow cuts (in which the LP solution has value less than two). A fixed optimum tour has either a single edge in a narrow cut (then call the edge and the cut lonely) or at least three (then call the cut busy). Our algorithm "guesses" (by dynamic programming) lonely cuts and edges. Then we partition the instance into smaller instances and strengthen the LP, requiring value at least three for busy cuts. By setting up a k-stage recursive dynamic program, we can compute a spanning tree (V,S) and an LP solution y such that 1/2+O(2^{-k}))y is in the T-join polyhedron, where T is the set of vertices whose degree in S has the wrong parity.

This is joint work with Vera Traub.

15 June - Ryan Martin (Iowa State)
The Saturation Number of Induced Subposets of the Boolean Lattice

Given a poset ${\mathcal P}$, a family ${\mathcal F}$ of points in the Boolean lattice is said to be ${\mathcal P}$-saturated if (1) ${\mathcal F}$ contains no copy of ${\mathcal P}$ as a subposet and (2) every strict superset of ${\mathcal F}$

contains a copy of ${\mathcal P}$ as a subposet. The maximum size of a ${\mathcal P}$-saturated subposet is denoted by ${\rm La}(n,{\mathcal P})$, which has been studied for a number of choices of ${\mathcal P}$.

Here, we are interested in ${\rm sat}(n,{\mathcal P})$, the size of the smallest family in ${\mathcal B}_n$ which is ${\mathcal P}$-saturated. This notion was introduced by Gerbner et al. (2013), and parallels the deep literature on the saturation function for graphs.

In particular, we introduce and study the concept of saturation for induced subposets. As opposed to induced saturation in graphs, the above definition of saturation for posets extends naturally to the induced setting. We give several exact results and a number of bounds on the induced saturation number for several small posets. We also use a transformation to the biclique cover problem to prove a logarithmic lower bound for a rich infinite family of target posets.

This is joint work with M. Ferrara, B. Kay, L. Kramer, B. Reiniger, H. Smith and E. Sullivan.

8 June - Éva Tardos (Cornell)
Learning and Efficiency in Games with Dynamically Changing Population

Selfish behavior can often lead to suboptimal outcome for all participants. Over the last decade we have developed good understanding how to quantify the impact of strategic user behavior on overall performance via studying stable Nash equilibria of the games. In this talk we will consider the quality of outcomes when players use a form of learning that helps them to adapt to the environment, will discuss the speed at which learning dynamic approaches the Nash equilibrium welfare. We will also consider games with dynamically changing populations, where participants have to adapt to the dynamic environment. We show that in large classes of games, learning players ensure outcome with high social welfare, even under very frequent changes.

7 June - Oktay Gunluk (IBM)
Cutting planes from extended LP formulations

Given a mixed-integer set defined by linear inequalities and integrality requirements on some of the variables, we consider extended formulations of its continuous (LP) relaxation and study the effect of adding cutting planes in the extended space. In terms of optimization, extended LP formulations do not lead to better bounds as their projection onto the original space is precisely the original LP relaxation. However, adding cutting planes in the extended space can lead to stronger bounds. We show that for every 0-1 mixed-integer set with n integer and k continuous variables, there is an extended LP formulation with (2n+k-1) variables whose

elementary 0-1 split closure is integral. The proof is constructive but it requires an inner description of the LP relaxation.

We then extend this idea to general mixed-integer sets and construct the best extended LP formulation for such sets with respect to lattice-free cuts. We also look at the Sherali-Adams and Lovasz-Schrijver lift-and-project operator hierarchies in this framework and observe that they can be viewed as applying specific 0-1 split cuts to an appropriate extended formulation. This leads to a new and stronger operator that obtains the integer hull in (n/2) steps compared to n steps for the original operator. We also present some computational results showing the strength of cutting planes derived from extended LP formulations.

25 May - Jan van den Heuvel (LSE)
Improper Colourings inspired by Hadwiger's Conjecture

Hadwiger's Conjecture (1943) asserts that every graph without the complete graph K_t as a minor has a proper vertex-colouring using t-1 colours. Since the conjecture is stubbornly refusing to be proved, we should look at relax versions of it.

In the talk we relax the conclusion by considering two types of improper colourings for K_t-minor-free graphs: (1) colourings in which each monochromatic component has small degree, and (2) colourings in which each monochromatic component has small size. In both cases our new results greatly improve the existing results on these colourings.

Moreover, all we use is an elementary decomposition result for graphs without K_t-minor that might be of independent interest.

This is joint work with David Wood (Monash Univ., Melbourne)

24 May - Sylvain Sorin (University Pierre and Marie Curie, Paris)
Learning procedures and evolutionary dynamics: some recent advances

This talk will be a general presentation of the field and a survey of recent results. Starting with the replicator dynamics we describe recent advances on the links between on-line learning and dynamics in games. The presentation will in particular focus on: properties of the unilateral process, interaction between discrete and continuous time, and applications to games were equilibrium conditions have a "Variational Inequalities" form.

18 May - Graham Farr (Monash University, Melbourne)
Powerful sets: a generalisation of binary linear spaces

A set S of binary vectors, with positions indexed by E, is said to be a /powerful code/ if, for all X\subseteq E, the number of vectors in S that are zero in the positions indexed by X is a power of 2. By treating binary vectors as characteristic vectors of subsets of E, we say that a set S of subsets of E is a/powerful set/ if the set of characteristic vectors of sets in S is a powerful code. Powerful sets (codes) include binary linear codes (equivalently, cocircuit spaces of binary matroids), but much more besides.

In this talk we investigate the combinatorial properties of powerful sets. We prove fundamental results on special elements (loops, coloops, frames, near-frames, and stars), their associated types of single-element extensions, various ways of combining powerful sets to get new ones, and constructions of nonlinear powerful sets. We show that every powerful set is determined by its clutter of minimal nonzero members. Finally, we show that the number of powerful sets is doubly exponential, and hence that almost all powerful sets are nonlinear.

Joint work with Yezhou Wang, University of Electronic Science and Technology of China (UESTC).

17 May - Bary Pradelski (ETH Zurich)
Evolution of institutions in the medium run?

The evolution of institutions and conventions is commonly modeled as a stochastic dynamical system. Stochastic stability analysis predicts the long-run stable states independent of the starting distribution when noise is vanishingly small. We complement this analysis by first deriving tight bounds on the limiting distribution for non vanishing noise. We then show which states are meta-stable in the medium run and present a straightforward method to compute these states.
Joint work with Pierre Tarrès.

9 May - Tao Jiang (Miami University Ohio)
Extremal results on cycles in hypergraphs

We discuss several extremal results on cycles in hypergraphs, with an emphasis on the methods involved:

1. Extension of Bondy-Simonovits' theorem on the Turan number of an even cycle in graphs to an analogous result for Turan numbers of linear cycles in linear hypergraphs.
   This is joint work with Collier-Cartaino and Graber.
2. Supersaturation of linear even cycles in linear hypergraphs, which extends Simonovits' supersaturation theorem for even cycles in graphs.
   This is joint work with Liana Yepremyan.

3. Proof of a conjecture of Verstraete on the existence of Berge cycles of consecutive lengths in hypergraphs with given degree conditions.
   This is joint work with Jie Ma.

Some new ideas and lemmas (compared to the usual Bondy-Simonovits lemma) were introduced in proving some of these results, which could be useful for related problems in the area.

3 May - Françoise Forges (CEREMADE and LEDa, Université Paris-Dauphine)
Strategic information transmission: sender's approval matters

We modify the standard model of finite sender-receiver games by introducing an outside option for the sender. We assume that, after the cheap talk phase, the sender can reject the receiver's proposal and that the sender's approval is crucial to the receiver. We ask whether the modified sender-receiver game has a Nash equilibrium. We construct a counter-example (with three types for the sender, three actions for the receiver and a type-dependent utility function for the receiver) in which there is no Nash equilibrium, but there is a communication equilibrium. We find a variety of sufficient conditions for existence of a Nash equilibrium: (i) two types (and arbitrary number of actions), (ii) two actions (and arbitrary number of types), (iii) type-independent utility function for the receiver (and arbitrary number of types and actions). We conjecture that a communication equilibrium always exists. We show that the conjecture holds for three types.

Ongoing research project with Jérôme Renault (Toulouse School of Economics)

26 April - William Zame (UCLA)
Endogenous Matching in a Dynamic Assignment Model

This paper formulates and analyzes a dynamic assignment model with unobserved worker characteristics and effort. It defines a notion of steady state equilibrium in which workers are matched to tasks endogenously on the basis of observable output. For each given payment schedule, such an equilibrium exists and is unique. At equilibrium, workers and tasks are matched assortatively and workers are incentivized to expend greater effort. Firm profit in equilibrium is compared against natural benchmarks.

This is joint work with Mihaela van der Schaar and Yuanzhang Xiao.

23 March - Maryam Sharifzadeh (Warwick)
Proof of Komlós's conjecture on Hamiltonian subsets

Komlós conjectured in 1981 that among all graphs with minimum degree at least d, the complete graph K_{d+1} minimises the number of Hamiltonian subsets,

where a subset of vertices is Hamiltonian if it contains a spanning cycle. We prove this conjecture when d is sufficiently large. In fact we prove a stronger result: for large d, any graph G with average degree at least d contains almost twice as many Hamiltonian subsets as K_{d+1}, unless G is isomorphic to K_{d+1} or a certain other graph which we specify.

This is joint work with Jaehoon Kim, Hong Liu and Katherine Staden.

22 March - **John (Yehuda) Levy (Glasgow)**
Projections and functions of Nash equilibria

We show that any non-empty compact semi-algebraic subset of mixed action profiles on a fixed player set can be represented as the projection of the set of equilibria of a game in which additional binary players have been added. Even stronger, we show that any semi-algebraic continuous function, or even any semi-algebraic upper-semicontinuous correspondence with non-empty convex values, from a bounded semi-algebraic set to the unit cube can be represented as the projection of an equilibrium correspondence of a game with binary players in which payoffs depend on parameters from the domain of the function or correspondence in a multi-affine way. Some extensions are also presented.

15 March - **Adam Zsolt Wagner (Illinois)**
Families with few k-chains

A central theorem in combinatorics is Sperner's Theorem, which determines the maximum size of a family in the Boolean lattice that does not contain a 2-chain. Erdos later extended this result and determined the largest family not containing a k-chain. Erdos and Katona and later Kleitman asked how many such chains must appear in families whose size is larger than the corresponding extremal result.

This question was resolved for 2-chains by Kleitman in 1966, who showed that amongst families of size M in the Boolean lattice, the number of 2-chains is minimized by a family whose sets are taken as close to the middle layer as possible. He also conjectured that the same conclusion should hold for all k, not just 2. The best result on this question is due to Das, Gan and Sudakov who showed roughly that Kleitman's conjecture holds for families whose size is at most the size of the k+1 middle layers of the Boolean lattice. Our main result is that for every fixed k and epsilon, if n is sufficiently large then Kleitman's conjecture holds for families of size at most (1-epsilon)2^n, thereby establishing Kleitman's conjecture asymptotically. Our proof is based on ideas of Kleitman and Das, Gan and Sudakov.

9 March - **Marco Scarsini (LUISS, Rome)**
On the Asymptotic Behavior of the Price of Anarchy

This paper examines the asymptotic behavior of the price of anarchy as a function of the total traffic inflow in nonatomic congestion games with multiple origin-destination pairs. We first show that the price of anarchy may remain bounded away from 1, even in simple three-link parallel networks with convex cost functions. On the other hand, empirical studies show that the price of anarchy is close to 1 in highly congested real-world networks, thus begging the question: under what assumptions can this behavior be justified analytically? To that end, we prove a general result showing that for a large class of cost functions (defined in terms of regular variation and including all polynomials), the price of anarchy converges to 1 in the high congestion limit. In particular, specializing to networks with polynomial costs, we show that this convergence follows a power law whose degree can be computed explicitly.

This is joint work with Riccardo Colini-Baldeschi, Roberto Cominetti, and Panayotis Mertikopoulos.

8 March - **Thomas Norman (Oxford)**
Endogenous Market Selection

According to the "market selection hypothesis", markets favour traders with more accurate beliefs, but this ignores the effect of beliefs on markets. I model market selection in general equilibrium when the economy's path is endogenously determined by the evolving profile of beliefs. Under certain conditions, the wealth shares of different beliefs are determined by an evolutionary dynamic, under which perfect-foresight equilibria are rest points. Adding noise in beliefs, "stochastic stability" can be used to select between multiple such equilibria in the long run. This technique is applied to the question of determinacy with Taylor rules, selecting the equilibrium at target inflation. In the presence of a lower bound to nominal interest rates, a liquidity trap is shown to be unstable.

2 March - **Eoin Long (Oxford)**
Forbidden vector-valued intersections

Given vectors V = (v_i: i \in [n]) in R^D, we define the V-intersection of A,B \subset [n] to be the vector sum_{i \in A \cap B} v_i. In this talk I will discuss a new, essentially optimal, supersaturation theorem for V-intersections, which can be roughly stated as saying that any large family of sets contains many pairs (A,B) with V-intersection w, for a wide range of V and w. A famous theorem of Frankl and Rödl corresponds to the case D=1 and all v_i=1 of our theorem. The case D=2 and v_i=(1,i) solves a conjecture of Kalai.

Joint work with Peter Keevash.

1 March - Alejandro Jofre (Chile)
Pricing, mechanism design and allocation for energy markets with network externalities

Motivated by electricity markets we introduce in this paper a general network market model, in which agents are located on the nodes of a graph, a traded good can travel from one place to another through edges considering quadratic losses. An independent operator has to match locally production and demand at the lowest expense. As argued in our previous paper ???Cost-minimizing regulations for a wholesale electricity market??? this setting is relevant to describe some electricity markets, pricing behavior and market power coming from the fact that generators can bid above their true value. In a general setting of many distributed generator agents connected by a transmission network, bidding piece-wise linear cost functions, we propose a pricing optimal mechanism model to reduce market power. Our main results are the existence of an equilibrium for this discontinuous game, an expression for the optimal mechanism, market power estimations and a numerical approximation for computing a Nash equilibrium on a network.

This is joint work with Juan Escobar (U. Chile) and Benjamin Heymann (Ecole Polytechnique)

23 February - Stefan Glock (Birmingham)
Designs beyond quasirandomness

In a recent breakthrough, Peter Keevash proved the Existence conjecture for combinatorial designs, which has its roots in the 19th century. In joint work with Daniela Kühn, Allan Lo and Deryk Osthus, we gave a new proof of this result, based on the method of iterative absorption. In fact, `regularity boosting' allows us to extend our main decomposition result beyond the quasirandom setting and thus to generalise the results of Keevash. In particular, we obtain a resilience version and a minimum degree version. In this talk, we will present our new results within a brief outline of the history of the Existence conjecture and provide an overview of the proof.

16 February - Luitgard Veraart (LSE)
Adjustable Network Reconstruction with Applications to CDS Exposures

This paper is concerned with reconstructing weighted directed networks from the total in-and out-weight of each node. This problem arises for example in the analysis of systemic risk of partially observed financial networks. Typically a wide range of networks is consistent with this partial information. We develop an empirical Bayesian methodology that yields consistent networks that also have certain desired global topological properties such as a given mean density. Furthermore we propose a new fitness based model within this framework. We

apply our methodology to a novel data set containing 89 financial networks of credit default swap exposures. The performance of the reconstruction methodology is very good under a wide range of performance criteria and also compared to other existing reconstruction methods. In particular, we are able to reconstruct the degree distribution of the underlying networks with remarkable precision if a good estimate of the true density of the underlying network is available.

This is joint work with Axel Gandy (Imperial College London)

15 February - **Samuel Fiorini (UL de Bruxelles)**
Characterizing Polytopes in the 0/1-Cube with Bounded Chvátal-Gomory Rank

Let $S \subseteq \{0,1\}^n$ and R be any polytope contained in $[0,1]^n$ with $R \cap \{0,1\}^n = S$. We prove that R has bounded Chvátal-Gomory rank (CG-rank) provided that S has bounded *pitch* and bounded *gap*, where the pitch is the minimum integer p such that all p-dimensional faces of the $0/1$-cube have a nonempty intersection with S, and the gap is a measure of the size of the facet coefficients of $\conv(S)$.

Let $H[\bar{S}]$ denote the subgraph of the n-cube induced by the vertices not in S. We prove that if $H[\bar{S}]$ does not contain a subdivision of a large complete graph, then both the pitch and the gap are bounded. By our main result, this implies that the CG-rank of R is bounded as a function of the treewidth of $H[\bar{S}]$. We also prove that if S has pitch 3, then the CG-rank of R is always bounded. Both results generalize a recent theorem of Cornuéjols and Lee \cite{CL2016}, who proved that the CG-rank is always bounded if the treewidth of $H[\bar{S}]$ is at most 2.

Joint work with Yohann Benchetrit (Brussels), Tony Huynh (Brussels) and Stefan Weltge (Zurich)

9 February - **Kristina Vuskovic (Leeds)**
Coloring square-free Berge graphs

We consider the class of graphs that does not contain as induced subgraphs chordless cycles of odd length greater than 3, their complements and chordless cycles of length 4 (square-free Berge graphs). We present a purely-graph theoretical algorithm that produces an optimal coloring for the graphs in this class.This is a subclass of perfect graphs, that have been extensively studied in the last 50 years. In 1981 Grötschel, Lovász and Schrijver showed that perfect graphs can be optimally colored in polynomial time. Their algorithm uses the ellipsoid method. The last big open problem in the area is to find a purely combinatorial polynomial time coloring algorithm for perfect graphs.

This is joint work with Chudnovsky, Lo, Maffray and Trotignon.

8 February - **Edith Elkind (Oxford)**
Justified Representation

We consider approval-based committee voting, i.e., the setting where each voter approves a subset of candidates, and these votes are then used to select a fixed-size set of winners (committee). We propose a natural axiom for this setting, which we call justified representation (JR). This axiom requires that if a large enough group of voters exhibits agreement by supporting the same candidate, then at least one voter in this group has an approved candidate in the winning committee. We show that for every list of ballots it is possible to select a committee that provides JR. We then check if this axiom is fulfilled by well-known approval-based voting rules, and find several rules that satisfy it. Further, we introduce two strengthenings of the JR axiom, which we call extended justified representation (EJR) and proportional justified representation (PJR), use them to characterize a popular voting rule known as Proportional Approval Voting, and analyze their computational complexity.

Based on joint work with Haris Aziz, Markus Brill, Vince Conitzer, Rupert Freeman, Toby Walsh, Luis Sanchez Fernandez, Martin Lackner, Norberto Fernandez, Pedro Basanta Val and Piotr Skowron.

2 February - Alexey Pokrovskiy (ETH)
Rainbow cycles

A subgraph of an edge-coloured complete graph is called rainbow if all its edges have different colours. Andersen conjectured that every properly n-edge-coloured complete graph Kn has a rainbow Hamiltonian path. This seminar will be about a proof of an approximate version of this conjecture - that every properly edge-coloured Kn has a rainbow cycle of length n - O(n^{3/4}). One of the main ingredients of our proof, which is of independent interest, shows that a random subgraph of a properly edge-coloured Kn formed by the edges of a random set of colours has a similar edge distribution as a truly random graph with the same edge density. In particular it has very good expansion properties.

This is joint work with Noga Alon and Benjamin Sudakov.

1 February - **Stanislav Zivny (Oxford)**
Power and limits of LP and SDP relaxations

We will discuss precise characterisations of the power of convex relaxations for constraint satisfaction problems (CSPs). In particular, we will present characterisations of general-valued CSPs that can be solved optimally using the

Basic LP relaxation, the Sherali-Adams LP relaxation, and the Lasserre SDP relaxation. These characterisations, in terms of certain algebraic objects known as fractional polymorphisms, have been instrumental in obtaining several complexity classifications for CSPs.

Based on joint work with J. Thapper.

26 January - Robert Simon (LSE)
A Bayesian Game without Measurable Approximate Equilibria

We present a Bayesian game that has no measurable epsilon equilibrium for sufficiently small and positive epsilon, yet it has non-measurable equilibria that utilize only pure strategies. In doing so we solve a long standing open problem**.**

19 January - Gautier Stauffer (Grenoble)
The Stochastic Shortest Path Problem: A polyhedral combinatorics perspective

The Stochastic Shortest Path problem (SSP) is a natural extension of the deterministic shortest path problem whereby traversing an `arc' may now lead to several destinations with different probabilities. In this setting, vertices are called states and arcs are called actions. The goal is to decide in each time step and each state which action to take so as to converge to a predefined target with probability one over an infinite time horizon. Taking an action has a cost and we wish to find a policy that minimizes the average cost over all possible realizations. SSP forms an important class of Markov Decision Processes (MDP) and it is extensively used in practice~: it arises naturally in robot motion planning, from maneuvering a vehicle over unfamiliar terrain, steering a flexible needle through human tissue or guiding a swimming micro-robot through turbulent water for instance ; and it has also many applications in operations research, artificial intelligence and economics, from inventory control, reinforcement learning to asset pricing. The SSP was studied thoroughly by Bertsekas and Tsitsiklis (1991) and later by Bertsekas and Yu (2016) and it is well understood when there is no nonpositive cost `transition cycles'. In particular, it is known that standard methods like Value Iteration and Policy Iteration converge in this case. In this talk we give a fresh look at the problem from a polyhedral combinatorics perspective. We study the natural linear programming relaxation of the problem and we show that actually standard methods also converge when there is no negative cost transition cycles. This closes the gap with the deterministic shortest path problem. Finally we show that we can also extend Dijkstra's algorithm to the stochastic setting.

12 January - Milan Vojnovic (LSE)
How to Hire a Team using Individual Test Scores?

We consider the problem of maximising a utility function, defined as the expected

value of a given function of a set of independent random variables according to given prior distributions, subject to a cardinality constraint. We are interested in approximation algorithms that are restricted to value oracle calls evaluated by using only some parameters of the input prior distributions, such as a mean or a quantile, we refer to as test scores. This problem arises in the context of online labour platforms and other productivity systems, where a team of given size needs to be selected based on individual test scores.

We show that for a class of submodular utility functions, a constant-factor approximation can be achieved by using test scores, whenever this can be achieved by a special type of test scores, we refer to as replication test scores. We provide sufficient conditions under which replication test scores guarantee a constant-factor approximation. We also study a more general submodular welfare maximisation problem, which is a natural generalisation to productivity systems that consist of one or more projects. In this case, we establish a $\Omega(1/\log(k))$ approximation guarantee, where k is the maximum team size of a project.

This is a joint work with Shreyas Sekar and Se-Young Yun.