Department of Mathematics

Seminar and PhD Seminar on Combinatorics, Games and Optimisation in 2019/20

Seminars are listed in reverse chronological order, most recent first

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Thursday 9 July - Jesús De Loera (University of California, Davis)

The Space of Monotone Paths of a Linear Program: Some geometric/topological meditations about the behavior of the Simplex Method
George Dantzig's Simplex method is a work horse of modern optimization. But despite its popularity we still do not understand its complexity. To bound the number of iterations of the Simplex method we take a geometric point of view and investigate the possible lengths of monotone paths inside the oriented graphs of polyhedra (oriented by the objective function). We consider both the shortest and the longest monotone paths possible and estimate the (monotone) diameter and the height of some famous combinatorial polyhedra (such as TSP, fractional matching polytopes, and others).

But how far apart are two monotone paths of an LP? E.g., if I use two pivot rules the Simplex method traces two paths, is there a notion of distance between them? Surprisingly, as we look at all monotone paths together we see a metric space structure which can be used to count how many are there or to generate them randomly. Our main enumerative results include bounds on the number of monotone paths, and on the the diameter of the space of monotone paths (how far are two monotone paths from each other?) The picture is fairly complete in dimension three, but plenty of open problems remain for high dimensional polytopes.
The new theorems presented in my talk come from two papers (in Arxiv), the first joint work with Moise Blanchard (MIT) and Quentin Louveaux (U. Liege) and the second joint work with Christos Athanasiadis (U. Athens) and Zhenyang Zhang (UC Davis)

Thursday 4 June - Ashwin Sah (MIT).

Lecture slides can be found here.
Seminar recording can be found here.
(Password: 5F@8.Qa^)

Diagonal Ramsey via effective quasirandomness
We improve the upper bound for diagonal Ramsey numbers to \[R(k+1,k+1)\le\exp(-c(\log k)^2)\binom{2k}{k}\] for $k\ge 3$. To do so, we build on a quasirandomness and induction framework for Ramsey numbers introduced by Thomason and extended by Conlon, demonstrating optimal ``effective quasirandomness" results

about convergence of graphs. This optimality represents a natural barrier to improvement.

Thursday 7 May - Daniel Korandi (University of Oxford)

Seminar slides can be found here.
Seminar recording can be found here.
(Password: 2B*a0S5k)

Exact stability for Turán's theorem
Turán's theorem says that an extremal K_{r+1}-free graph is r-partite. The Stability Theorem of Erdős and Simonovits shows that if a K_{r+1}-free graph with n vertices has close to the maximal t_r(n) edges, then it is close to being r-partite. In this talk we determine exactly the K_{r+1}-free graphs with at least m edges that are farthest from being r-partite, for any m > t_r(n) - δn^2. This extends work by Erdős, Győri and Simonovits, and proves a conjecture of Balogh, Clemen, Lavrov, Lidický and Pfender. Joint work with Alexander Roberts and Alex Scott.

Friday 13 March - Xinyi Xu (LSE)

Correspondence colouring on multigraphs
In this talk we discuss a variant of vertex colouring of graphs called correspondence colouring. This concept generalises normal and list vertex colouring. Whilst multi-edges do not provide additional restrictions for normal or list colouring setting, as we always forbid the same colour on adjacent vertices, additional constraints in correspondence colouring appear when multiple edges are present. These observations also lead to interesting phenomena when we make small changes to a (multi)graph, such as edge or vertex deletion, identifying vertices, contracting edges, or increasing edge multiplicity.

Wednesday 4 March - Vera Traub (University of Bonn)

Reducing Path TSP to TSP
We present a black-box reduction from the path version of the Traveling Salesman Problem (Path TSP) to the classical tour version (TSP). More precisely, we show that given an α-approximation algorithm for TSP, then, for any ϵ>0, there is an (α+ϵ)-approximation algorithm for the more general Path TSP. This reduction implies that the approximability of Path TSP is the same as for TSP, up to an arbitrarily small error. This avoids future discrepancies between the best known approximation factors achievable for these two problems, as they have existed until very recently.
A well-studied special case of TSP, Graph TSP, asks for tours in unit-weight graphs. Our reduction shows that any α-approximation algorithm for Graph TSP implies an (α+ϵ)-approximation algorithm for its path version. By applying our reduction to the 1.4-approximation algorithm for Graph TSP by Sebő and Vygen, we obtain a polynomial-time (1.4+ϵ)-approximation algorithm for Graph Path TSP, improving on a recent 1.497-approximation algorithm of Traub and Vygen.
We obtain our results through a variety of new techniques, including a novel way to set up a recursive dynamic program to guess significant parts of an optimal solution.

At the core of our dynamic program we deal with instances of a new generalization of (Path) TSP which combines parity constraints with certain connectivity requirements. This problem, which we call Φ-TSP, has a constant-factor approximation algorithm and can be reduced to TSP in certain cases when the dynamic program would not make sufficient progress.
This is joint work with Jens Vygen and Rico Zenklusen.

Friday 28 February - Coulter Beeson (LSE)

The Empirical Core of the Multicommodity Flow Game Without Side Payments
Policy makers focus on stable strategies as the ones adopted by rational players. If there are many such solutions an important question is how to select amongst them. We study this question for the Multicommodity Flow Coalition Game, used to model cooperation between autonomous systems (AS) in the Internet. In short, strategies are flows in a capacitated network. The payoff to a node is the total flow which it terminates. Markakis-Saberi show this game is balanced and hence has a non-empty core by Scarf's Theorem. In the transferable utility (TU) version this gives a polynomial-time algorithm to find core elements, but for ASs side payments are not natural. Finding core elements in NTU games tends to be computationally more difficult. For this game, the only previous result gives a procedure to find a core element when the supply graph is a path. We extend their work with an algorithm, Incorporate, which produces many different core elements.

Thursday 27 February - [Oliver Roche-Newton] (Linz)

Hypergraph containers with applications in discrete geometry and additive combinatorics
In recent years, the newly developed theory of hypergraph containers has resulted in several remarkable results in graph theory and extremal combinatorics. Essentially, this theory gives detailed information about the independent sets of hypergraphs, provided that the edges are distributed reasonably well. I will discuss recent joint works with Audie Warren and Cosmin Pohoata, in which these tools were applied to problems in discrete geometry and additive combinatorics. In particular, an upper bound for the number of subsets of the finite plane with no collinear triples is given.

Wednesday 26 February - [Nathanaël Fijalkow] (CNRS)

Parity games, the quasipolynomial era
Parity games is a model of zero-sum two-player games played in graphs which play a central role in logic, automata, and verification, among others. Whether there exists a polynomial time algorithm for solving parity games is a long standing open question. In 2017 a quasipolynomial time algorithm was constructed, quickly followed by some more algorithms with the same complexity. In this talk I will present a combinatorial notion called universal trees and explain that all existing quasipolynomial time algorithms for solving parity games exploit universal trees in some way. I will then discuss how to extend this notion to universal graphs for the study of mean payoff games.

Friday 21 February - Edin Husic (LSE)

Approximating Nash Social Welfare for asymmetric agents with Rado-valuations
The Nash Social Welfare problem asks for an allocation of a set of indivisible goods to the agents that maximises the geometric mean of their utilities, a well-studied objective for fair resource allocation. Finding an optimal allocation is NP-complete already for two agents with additive valuation functions. Constant-factor approximation algorithms have been known for additive valuations and some simple extensions, and under the assumption that the agents are symmetric: every agent is considered with the same weight in the objective. We present the first constant-factor approximation algorithm for agents with Rado-valuations. Rado-valuations form a general class of valuation functions that arise from maximum weight independent matching problems, including as special cases assignment valuations as well as weighted matroid rank functions. The algorithm generalises to a constant-factor approximation algorithm for asymmetric agents (i.e., with different entitlements), provided the ratio between the weights is bounded by a constant. This is joint work with Jugal Garg and László Végh.

Thursday 20 February - Heinrich Nax (ETH Zürich)

Dynamic matching in assignment games
We examine two-sided markets where players arrive stochastically over time and are drawn from a continuum of types. The cost of matching a client and provider varies, so a social planner is faced with two contending objectives: a) to reduce players' waiting time before getting matched; and b) to form efficient pairs in order to reduce matching costs. We show that such markets are characterized by a quick or cheap dilemma: Under a large class of distributional assumptions, there is no `free lunch', i.e., there exists no clearing schedule that is simultaneously optimal along both objectives. We further identify a unique breaking point signifying a stark reduction in matching cost contrasted by an increase in waiting time.
Generalizing this model, we identify two regimes: one, where no free lunch exists; the other, where a window of opportunity opens to achieve a free lunch. Remarkably, greedy scheduling is never optimal in this setting.

Wednesday 19 February - Jim Orlin (MIT)

On the Design of Fully Polynomial Time Approximation Schemes
A fully polynomial time approximation scheme (FPTAS) is an algorithm that guarantees the following: for any fixed positive , the FPTAS finds an -optimal solution while running in time polynomial in the size of the problem and in 1/. Many of the FPTASes that have been developed over the past 45 years have relied on dynamic programming.

In this talk, we briefly review some of the classical FPTASes. We then describe two frameworks. The first is the Calculus of K-approximation sets, which helps guide the development of FPTASes. The second is a a framework for the development of new FPTASes. The framework uses a relatively small set of subroutines that operate on non-negative monotone functions of a single variable. This framework permits the development of computer codes for FPTASes with the following properties:

- The FPTASes can be expressed simply and concisely.
- The output of each FPTAS includes a proof that the solution is within a factor of 1+ of optimal.

We illustrate the framework by developing an FPTAS for the stochastic lot-size problem. This research on FPTASes has been joint with many collaborators including Nir Halmon, CL Li, Giacomo Nannicini, and David Simchi-Levi.

Thursday 13 February - Hubie Chen (Birkbeck)

One Hierarchy Spawns Another: Graph Deconstructions and the Complexity Classification of Conjunctive Queries

We study the classical problem of conjunctive query evaluation. This problem admits multiple formulations and has been studied in numerous contexts; for example, it is a formulation of the constraint satisfaction problem, as well as the problem of deciding if there is a homomorphism from one relational structure to another (which transparently generalizes the graph homomorphism problem).

We here restrict the problem according to the set of permissible queries; the particular formulation we work with is the relational homomorphism problem over a class of structures A, wherein each instance must be a pair of structures such that the first structure is an element of A. We present a comprehensive complexity classification of these problems, which strongly links graph-theoretic properties of A to the complexity of the corresponding homomorphism problem. In particular, we define a binary relation on graph classes and completely describe the resulting hierarchy given by this relation. This binary relation is defined in terms of a notion which we call graph deconstruction and which is a variant of the well-known notion of tree decomposition. We then use this graph hierarchy to infer a complexity hierarchy of homomorphism problems which is comprehensive up to a computationally very weak notion of reduction, namely, a parameterized form of quantifier-free reductions. We obtain a significantly refined complexity classification of left-hand side restricted homomorphism problems, as well as a unifying, modular, and conceptually clean treatment of existing complexity classifications, such as the classifications by Grohe-Schwentick-Segoufin (STOC 2001) and Grohe (FOCS 2003, JACM 2007).

After presenting these advances, we will compare this line of research with another that aims to classify the complexity of the homomorphism problem where the second (target) structure is fixed, and that is currently being studied using universal-algebraic methods. We will also present and discuss two intriguing variants, injective homomorphism (also called embedding) and surjective homomorphism.

This talk is mostly based on joint work with Moritz Muller.

Thursday 6 February - Rida Laraki (Paris-Dauphine and Liverpool)

Stable Games of Matching
Gale and Shapley defined in 1962 a matching problem between two finite sets of distinct agents M and W (men/women, workers/firms, students/universities, doctors/hospitals) who should be paired or matched. They call a matching is stable if no unmatched couple can strictly improve its utility by being together and constructed a stable matching for every instance (thanks to an algorithm). Our article proposes a new extension by assuming that a matched couple obtains its payoff as the outcome of a strategic interaction. Agents, beside choosing partners, play now a non-cooperative game in which they choose a strategy that maximises their payoff under the constraint that their partner does not want to quit the relationship. We call a matching externally stable if no unmatched couple can find a strategy profile which provides both of them a strictly higher payoffs than the ones they have. It is internally stable if no agent can, by deviating and changing her strategy inside her couple, increases her payoff without breaking the external stability of her couple. We provide a sufficient condition on a strategic game (feasibility) under which there exists matching profiles that are externally and internally stable. We prove that the class of feasible games includes zero-sum, potential, infinitely repeated and perfect information games. We also provide a 3 by 3 game in mixed strategies which is not feasible. Finally, we show how our model extends the Shapley-Shubik's model with monetary transferts and the Milgrom-Hatfield???s model with contracts.

Joint work with my PhD student Felipe Garrido.

Thursday 30 January - Christina Pawlowitsch (Université Panthéon-Assas)

Evolutionary dynamics of costly signaling
Costly-signaling games have a remarkably wide range of applications (education as a costly signal in the job market, handicaps as a signal for fitness in mate selection, politeness in language). The formal analysis of evolutionary dynamics in costly-signaling games has only recently gained more attention. In this paper, we study evolutionary dynamics in two basic classes of games with two states of nature, two signals, and two possible reactions in response to signals: a discrete version of Spence's (1973) model and a discrete version of Grafen's (1990) formalization of the handicap principle. We first use index theory to give a rough account of the dynamic stability properties of the equilibria in these games. Then, we study in more detail the replicator dynamics and to some extent the best-response dynamics. (Joint work with Josef Hofbauer.)

Friday 13 December - Gal Kronenberg (University of Oxford)
Venue: 32L.B.09 from 12:00 - 13:00

Turán numbers of long cycles in random graphs
For a graph G on n vertices and a graph H, denote by ex(G,H) the maximal number of edges in an H-free subgraph of G. We consider a random graph G~G(n,p) where

p=C/n, and study the typical value of ex(G,H), where H is a long cycle.
We determine the asymptotic value of ex(G,C_t), where G~G(n,p), p> C/n and A*log(n)< t< (1- Ɛ)n. The behaviour of ex(G,C_t) can depend substantially on the parity of t. In particular, our results match the classical result of Woodall on the Turán number of long cycles, and can be seen as its random version. In fact, our techniques apply in a more general sparse pseudo-random setting.
We also prove a robustness-type result, showing the likely existence of cycles of prescribed lengths in a random subgraph of a graph with a nearly optimal density.

Joint work with Michael Krivelevich and Adva Mond.

Thursday 12 December - Spyros Angelopoulos (CNRS and Sorbonne University)

Online Computation with Untrusted Advice
The advice model of online computation captures the setting in which an online algorithm is given some partial information concerning the request sequence. This paradigm allows to establish tradeoffs between the amount of this additional information and the performance of the online algorithm. However, unlike real life in which advice is a recommendation that we can choose to follow or to ignore based on trustworthiness, in the current advice model, the online algorithm typically treats it as infallible. This means that if the advice is corrupt or, worse, if it comes from a malicious source, the algorithm may perform poorly. In this work, we study online computation in a setting in which the advice is provided by an untrusted source.
Our objective is to quantify the impact of untrusted advice so as to design and analyze robust online algorithms that are resilient and perform well even when the advice is generated in a malicious, adversarial manner. We show how the new paradigm can be applied to well-studied online problems such as ski rental, online bidding, bin packing, and list update.

Joint work with Christoph Dürr, Shendan Jin, Shahin Kamali and Marc Renault.

Friday 6 December - Bento Natura (LSE)

A scaling-invariant algorithm for linear programming whose running time depends only on the constraint matrix
Following the breakthrough work of Tardos (Oper. Res. '86) in the bit-complexity model, Vavasis and Ye (Math. Prog. '96) gave the first exact algorithm for linear programming in the real model of computation with running time depending only on the constraint matrix. For solving a linear program (LP), Vavasis and Ye developed a primal-dual interior point method using a layered least squares step, and showed that O(n^3.5 * log chi) iterations suffice to solve linear programs exactly, where chi is a condition measure controlling the size of solutions to linear systems related to the constraint matrix.

Monteiro and Tsuchiya (SIAM J. Optim. '03), noting that the central path is invariant under rescalings of the columns of the constraint matrix and the objective function, asked whether there exists an LP algorithm depending instead on the measure chi*, defined as the minimum chi value achievable by a column rescaling of the constraint matrix, and gave strong evidence that this should be the case. We resolve this open question affirmatively.

We will illustrate the central ideas on how to develop a scaling-invariant algorithm for LP and how to find a near-optimal rescaling.

Thursday 5 December - Victor Verdugo (LSE)

Prophet Inequalities and Mechanism Design
In many situations finding the optimal revenue pricing policy requires to solve a hard optimisation problem. Posted price mechanism are simple and efficiently implementable. In this talk I'll show the connection between this type of mechanisms and optimal stopping rules for online selection problems, and how the guarantees from one problem to the other are preserved.

Thursday 28 November - László Végh (LSE)

An improved constant-factor approximation algorithm for the asymmetric travelling salesman problem
In this talk, I will speak about a recent result by Vera Traub and Jens Vygen. For the asymmetric variant of the classical travelling salesman problem, the first constant-factor approximation algorithm was given in our 2018 paper with Ola Svensson and Jakub Tarnawski. The result used a combination of combinatorial and linear programming tools, and reduced the problem to more structured special cases in a number of reduction steps.

The approximation ratio in the first version of our paper was 5500, which we later improved to 506. The new paper by Traub and Vygen dramatically improves this to 22. Whereas they follow the same overall strategy as our previous paper, they manage to find substantial simplifications in the chain of reductions that not only improve the performance guarantee, but also make the result more accessible.

Friday 22 November - Nora Frankl (LSE)

On the number of discrete chains in the plane
Determining the maximum number of unit distances that can be spanned by n points in the plane is a difficult problem, which is wide open. The following more general question was recently considered by Eyvindur Ari Palsson, Steven Senger, and Adam Sheffer. For given distances t_1,...,t_k a (k+1)-tuple (p_1,...,p_{k+1}) is called a k-chain if ||x_i-x_{i+1}||=t_i for i=1,...,k. What is the maximum possible number of k-chains that can be spanned by a set of n points in the plane? Improving the result of Palsson, Senger and Sheffer, we determine this maximum up to a small error term (which, for k=1 mod 3 involves the maximum number of unit distances). We also consider some generalisations, and the analogous question in R^3. Joint work with Andrey Kupvaskii.

Thursday 21 November - Joonkyung Lee (Universität Hamburg)

Convex graphon parameters and graph norms
Sidorenko's conjecture states that the number of a bipartite graph H in a graph~G is asymptotically minimised when G is a quasirandom graph. A notorious example that this conjecture remains open is the case $H=K_{5,5}\setminus C_{10}$. It has been even unknown whether this graph possesses the weakly norming property, a strictly stronger property than satisfying the conjecture.
We take a step towards understanding the graph $K_{5,5}\setminus C_{10}$ by proving that it is not weakly norming. More generally, we show that `twisted' blow-ups of cycles, which include $K_{5,5}\setminus C_{10}$ and $C_6\square K_2$, are not weakly norming. This answers two questions of Hatami, who asked whether the two graphs are weakly norming. The method relies on analysing Hessian matrices defined by graph homomorphisms, by using the equivalence between the (weakly) norming property and convexity of graph homomorphism densities. We also prove that $K_{t,t}$ minus a perfect matching, proven to be weakly norming by Lov\'asz, is not norming for every~$t>3$. Joint work with Bjarne Sch\"ulke.

Wednesday 20 November - Franziska Eberle (Universität Bremen)

Commitment in online scheduling made easy
We study a fundamental online job admission problem where jobs with processing times and deadlines arrive online over time at their release dates, and the task is to determine a preemptive single-server schedule which maximizes the number of jobs that complete on time. To circumvent known impossibility results, we make a standard slackness assumption by which the feasible time window for scheduling a job is at least (1+epsilon) times its processing time, for some epsilon>0. We consider a variant of the online scheduling problem where the provider has to satisfy certain commitment requirements. These requirements arise, for example, in modern cloud-services, where customers do not want last-minute rejections of critical tasks and request an early-enough provider-side commitment to completing admitted jobs.

Our main contribution is an optimal algorithm for online job admission with commitment. When a provider must commit upon starting a job, our bound is O(1/epsilon). This is best possible as there is a lower bound of Omega(1/epsilon) for online admission even without commitment. If the commitment decisions must be made before a job's slack becomes less than a delta-fraction of its size, we prove a competitive ratio of O(epsilon/((epsilon - delta) delta)) for 0 <delta<epsilon. This result interpolates between commitment upon starting a job and commitment upon arrival. For the latter commitment model, it is known that no (randomized) online algorithm does admit any bounded competitive ratio.

Friday 15 November - Cosmin Pohoata (Caltech)

Sets without 4APs but with many 3APs
It is a classical theorem of Roth that every dense subset of $\left\{1,\ldots,N\right\}$ contains a nontrivial three-term arithmetic progression. Quantitatively, results of

Sanders, Bloom, and Bloom-Sisask tell us that subsets of relative density at least $1/(\log N)^{1-\epsilon}$ already have this property. In this talk, we will discuss about some sets of N integers which unlike $\left\{1,\ldots,N\right\}$ do not contain nontrivial four-term arithmetic progressions, but which still have the property that all of their subsets of relative density at least $1/(\log N)^{1-\epsilon}$ must contain a three-term arithmetic progression. Perhaps a bit surprisingly, these sets turn out not to have as many three-term progressions as one might be inclined to guess, so we will also address the question of how many three-term progressions can a four-term progression free set may have. Finally, we will also discuss about some related results over $\mathbb{F}_{q}^n$. Based on joint works with Jacob Fox and Oliver Roche-Newton.

Thursday 14 November - Eliza Jablonska (University of Cracow)

On generically Haar-"small" sets in Abelian Polish groups

A subset A of an Abelian Polish group X is *Haar-null* (following Christensen) if there are a Borel set B covering A and a Borel probability measure m on X such that $m(x+B)=0$ for all x in X.

Dodos proves that for every Haar-null Borel subset A of X the set of all test measures

$$T(A):=\{m \in P(X) \ : \ m(x+A)=0 \text{ for all } x \in X\}$$

is dense, coanalytic, and either meagre or co-meagre in the space $P(X)$ of all probability Borel measures on X (with Lévy-Prokhorov metric).

Christensen's measure-theoretic notion has a topological analogue due to Darji: a subset A of X is *Haar-meagre* if there are a Borel set B covering A, a compact metric space K and a continuous function $f: K \to X$ such that

$$f^{-1}(B+x) \text{ is meagre in } K \text{ for all } x \in X$$

We prove an analogue of the Dodos theorem: for every Haar-meager Borel subset A, the set of all witness functions

$$W(A):=\{ f \in C(2^{\omega},X) : \ f^{-1}(x+A) \text{ is meagre in } 2^{\omega} \text{ for all } x \in X\}$$

is dense, coanalytic, and either meager or comeager in in the space $C(2^{\omega}, X)$ of all continuous functions $f: 2^{\omega} \to X$ with the supremum metric. The first step is to show that the compact metric space K in Darji's definition can always be replaced by the Cantor cube 2^{ω}.

Wednesday 13 November - Gyorgy Turan (UIC)

Interpretability in machine learning

In many applications of machine learning, learned models or their decisions need to be interpretable (or explainable, comprehensible). For example, `why was my credit application rejected?'. Neural networks, for example, are typically not interpretable, while decision trees are more so. We give a general overview of the topic, and discuss some recent projects.

The theoretical part is about efficient approximation of Bayesian networks with `interpretable' models.

Friday 8 November - Olaf Parczyk (LSE)

The size-Ramsey number of tight 3-uniform paths
Given a hypergraph H, the size-Ramsey number is the smallest integer m such that there exists a graph G with m edges with the property that in any colouring of the edges of G with two colours there is a monochromatic copy of H. Extending on results for graphs we prove that the size Ramsey number of the 3-uniform tight path on n vertices is linear in n.

This is joint work with Jie Han, Yoshiharu Kohayakawa, and Guilherme Mota.

Thursday 7 November - Miquel Oliu-Barton (Université Paris-Dauphine)

A Solution for Stochastic Games
Shapley (1953) introduced stochastic games in order to model dynamic interactions in which the environment changes in response to the players' behavior, and proved that finite competitive stochastic games admit a Î»-discounted value for any discount rate Î». The case where Î» is close to zero is of particular interest, as it corresponds to an interaction in the long run, far from opportunistic behavior. Bewley and Kohlberg (1976) proved that the Î»-discounted values converge as Î» goes to zero. Building on this result, Mertens and Neyman (1981) proved that finite competitive stochastic games admit a value, and that the value coincides with the limit of the Î»-discounted values as Î» goes to zero. Finding a tractable formula for the value of finite competitive stochastic games was a major open problem for nearly 40 years. The present contribution resolves this problem.

Joint work with Luc Attia.

Friday 1 November - Anupam Gupta (CMU)

K-way-cuts in graphs
For an undirected graph, a k-way cut is a set of edges whose deletion breaks the graph into at least k pieces. How fast can we find a minimum-weight k-way cut? And how many minimum k-way cuts can a graph have? The two problems seem to be closely linked --- in 1996 Karger and Stein showed how to find a minimum k-way cut in time approximately n^{2k-2}, and also that the number of minimum k-way cuts is at most n^{2k-2}. Both these results are not known to be tight, except for the case of k=2, that of finding graph min-cuts.
In this talk, we report on recent progress beating these bounds. We discuss how extremal bounds for set systems, when combined with other ideas, can improve on the Karger-Stein bound.

This is joint work with Euiwoong Lee (NYU) and Jason Li (CMU).

Thursday 31 October - Hervé Moulin (University of Glasgow)

Guarantees in Fair Division, under informational parsimony
Steinhaus's Diminishing Share (DS) algorithm (generalizing Divide & Choose D&C), as well as Dubins and Spanier's Moving Knife (MK) algorithm, guarantee to all participants a Fair Share of the manna (its worth at least 1/n-th of that of the whole manna) while eliciting parsimonious information from them. However DS and MK are only defined when 1. preferences are represented by additive utilities; and 2. every part of the manna to be divided is desirable to every participant (a cake), or every part is unpleasant to everybody (a chore).

Our n-person Divide & Choose rule takes care of issue 2 when utilities are additive: it requires no trimming or padding, and works for mixed manna with subjective goods and bads. It also implements the canonical approximation of the Fair Share (up to one item) when we allocate indivisible items.

Issue 1 is much deeper, it challenges us to define a Fair Share Guarantee when 1/n-th of the whole manna makes no sense. The same D&C rule implements such a bound, for very general preferences restricted by a continuity assumption but no monotonicity whatsoever. The minMax utility of an agent is that of his best share in the worst possible partition. It is lower than his Maxmin utility (that of his worst share in the best possible partition), that cannot be guaranteed to all agents.

When the manna contains only goods, or only bads, the minMax Guarantee can be improved in infinitely many ways. Our Bid & Choose rules improve upon the MK rules by fixing a benchmark value of shares, and asking agents to bid the smallest size of an acceptable share. The resulting Guarantees fall between their minMax and Maxmin.

Joint work with Anna Bogomolnaia.

Friday 25 October - Liana Yepremyan (LSE)

On the size Ramsey number of graphs with bounded degree and bounded treewidth
A graph G is Ramsey for a graph H if every red/blue edge-colouring of the edges of G contains a monochromatic copy of H. We consider the following question: if H has bounded treewidth, is there a `sparse' graph G that is Ramsey for H? We show that if the maximum degree and treewidth of H are bounded, then there is a graph G with $O(|V(H)|)$ edges that is Ramsey for H. This was previously known for the smaller class of graphs H with bounded bandwidth by the work of by Clemens, Jenssen, Kohayakawa, Morrison, Mota, Reding and Roberts. We actually prove a more general off-diagonal version of the above result: For graphs H_1 and H_2, the \emph{size Ramsey number} $\hat{r}(H_1, H_2)$ is the minimum number of edges in a graph G such that every red/blue-colouring of the edges of G contains a red copy of H_1 or a blue copy of H_2. We prove that if H_1 and H_2 both have n vertices, bounded degree and bounded treewidth, then $\hat{r}(H_1, H_2)= O(n)$.

This is joint work with Nina Kam\v{c}ev, Anita Liebenau and David Wood.

Friday 18 October - Oliver Janzer (University of Cambridge)

The extremal number of subdivisions
For a graph H, the extremal number ex(n,H) is defined to be the maximal number of edges in an H-free graph on n vertices. For bipartite graphs H, determining the order of magnitude of ex(n,H) is notoriously difficult. In this talk I present recent progress on this problem.
The k-subdivision of a graph F is obtained by replacing the edges of F with internally vertex-disjoint paths of length k+1. Most of our results concern the extremal number of various subdivided graphs, especially the subdivisions of the complete graph and the complete bipartite graph.

Partially joint work with David Conlon and Joonkyung Lee.

Thursday 17 October - Anurag Bishnoi (FU Berlin)

Clique-free pseudorandom graphs
One of the outstanding open problems in the theory of pseudorandom graphs is to find a construction of K_s-free (n, d, λ)-graphs, for $s > 3$, with $\lambda = O(\sqrt{d})$ and the highest possible edge density of $d/n = \Theta(n^{-1/(2s - 3)})$.
For $s = 3$, there is a famous construction of Alon from 1994 that provides such a family of triangle free graphs.
For $s \geq 5$, the best known construction is due to Alon and Krivelevich from 1996 that has edge density $\Theta(n^{-1/(s - 2)})$.
Very recently, Mubayi and Verstraete have shown that a construction with edge density $\Omega(n^{-1/(s + \epsilon)})$, for any $\epsilon > 0$, would imply an improvement in the best known lower bounds on the off-diagonal Ramsey numbers $R(s, t)$, s fixed and $t \rightarrow \infty$.

In this talk I will present a new construction of K_s-free pseudorandom graphs with an edge density of $\Theta(n^{-1/(s - 1)})$, thus improving the Alon-Krivelevich construction but still falling short of improving the lower bounds on Ramsey numbers.

Joint work with Ferdinand Ihringer and Valentina Pepe.

Thursday 10 October - Ahmad Abdi (LSE)

Graphs, Matroids and Clutters (talk 2)
In a series of two talks, I will try to motivate and describe my area of research, and the mathematical objects that I deal with on a daily basis. The talks will be self-contained and will only assume basic knowledge of Linear Algebra, Polyhedral Theory, and Graph Theory.

The two talks center around the following conjecture that I made together with Gerard Cornuejols and Dabeen Lee:

"Let A be a 0,1 matrix where every row has at least two 1s and the polyhedron { x>=0 : Ax >= 1 } is integral. We conjecture that the columns of A can be partitioned into 4 color classes such that every row gets two 1s with different colors. This is still open even if 4 is replaced by any universal constant."

In the first talk, I will give two other equivalent formulations of this conjecture, one being the blocking version of this conjecture, the other being the "cuboidal" version.

In the second talk, I will talk about how this conjecture extends known prominent results in Graph Theory and Matroid Theory. In particular, we will see how the conjecture extends Jaeger's 8-flow theorem, and how a variation of it extends Tutte's 4-flow conjecture.

Friday 4 October - Natalie Behague (QMUL)

Semi-perfect 1-factorizations of the Hypercube
A 1-factorization of a graph H is a partition of the edges of H into disjoint perfect matchings {M_1 , M_2 , . . . , M_n}, also known as 1-factors. A 1-factorization M = {M_1 , M_2 , . . . , M_n} of a graph G is called perfect if the union of any pair of distinct 1-factors M_i , M_j is a Hamilton cycle. The existence or non-existence of perfect 1-factorizations has been studied for various families of graphs. Perhaps the most famous open problem in the area is Kotzig's conjecture, which states that the complete graph K_2n has a perfect 1-factorization. In this talk we shall focus on another well-studied family of graphs: the hypercubes Q_d in d dimensions. There is no perfect 1-factorization of Q_d for d > 2. As a result, we need to consider a weaker concept.
A 1-factorization M is called k-semi-perfect if the union of any pair of 1-factors M_i , M_j with 1 ≤ i ≤ k and k + 1 ≤ j ≤ n is a Hamilton cycle. It was proved that there is a 1-semi-perfect 1-factorization of Q_d for every integer d ≥ 2 by Gochev and Gotchev, Královič and Královič, and Chitra and Muthusamy, in answer to a conjecture of Craft. My main result is a proof that there is a k-semi-perfect 1-factorization of Q_d for all k and all d, except for one possible exception when k = 3 and d = 6. I will sketch the proof and explain why this is, in some sense, best possible. I will conclude with some questions concerning other generalisations of perfect 1-factorizations.

Thursday 3 October - Ahmad Abdi (LSE)

Clutters, blockers, and cuboids (talk 1)
In a series of two talks, I will try to motivate and describe my area of research, and the mathematical objects that I deal with on a daily basis. The talks will be self-contained and will only assume basic knowledge of Linear Algebra, Polyhedral Theory, and Graph Theory.

The two talks center around the following conjecture that I made together with Gerard Cornuejols and Dabeen Lee:

"Let A be a 0,1 matrix where every row has at least two 1s and the polyhedron { x>=0 : Ax >= 1 } is integral. We conjecture that the columns of A can be partitioned into 4 color classes such that every row gets two 1s with different colors. This is still open even if 4 is replaced by any universal constant."

In the first talk, I will give two other equivalent formulations of this conjecture, one being the blocking version of this conjecture, the other being the "cuboidal" version.

In the second talk, I will talk about how this conjecture extends known prominent results in Graph Theory and Matroid Theory. In particular, we will see how the conjecture extends Jaeger's 8-flow theorem, and how a variation of it extends Tutte's 4-flow conjecture.