Department of Mathematics

Seminar on Combinatorics, Games and Optimisation in 2016/17

Seminars are listed in reverse chronological order, most recent first

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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.

8 December - Clément Canonne (Columbia)

Alice and Bob Show Distribution Testing Lower Bounds (They don't talk to each other anymore.)
We present a new methodology for proving distribution testing lower bounds, by establishing a connection between distribution testing and the simultaneous message passing (SMP) communication model. Extending the framework of Blais, Brody, and Matulef [BBM12], we show a simple methodology of reducing lower

bounds on (private-coin) SMP problems to distribution testing problems. This reduction allows us to prove several new distribution testing lower bounds, as well as to provide simpler proofs of known lower bounds.

Our main result is concerned with testing identity to a specific distribution p, given as a massive parameter. Valiant and Valiant [VV14] showed that the sample complexity of the foregoing question is closely related to the 2/3-pseudonorm of

p. We obtain alternative, nearly tight bounds on the complexity of this problem, in terms of an arguably more intuitive measure and using simpler proofs. Specifically, we show that the sample complexity is essentially determined by the size of the effective support of p, which loosely speaking is the number of supported elements that constitute the vast majority of the mass of p.This result, in turn, stems from an unexpected connection to the theory of interpolation spaces, namely the K-functional between L_1 and L_2 spaces.

6 December - Herve Moulin (Glasgow)

Fair Division of goods, bads, and satiable items
How to divide items that can be desirable (goods), or not (bads), and can also allow satiation? When all items are goods and preferences are represented by utility functions homothetic and concave, the Competitive Equilibrium with Equal Incomes (CEEI) is famously compelling because it maximizes the Nash product of utilities, is single-valued and easy to compute. The CEEI to divide only bads captures similarly all critical points of the Nash product in the eç cient frontier. But it is far from resolute or easy to compute: the number of allocations distinct welfare-wise can be exponential in the number of agents and items.

General problems behave as if we divide only goods, or as if we divide only bads. In the former case, everyone who can is strictly better o§ than zero (the ex anteutility), the CEEI is unique and maximizes the Nash product of utilities. In the latter everyone is strictly worse off than zero, and the CEEI collects all critical points of the Nash product of disutilities. Thus the task of dividing a mixed manna is either good news for everyone, or bad news for everyone.

We refine our results in the practically important case of linear preferences, where the axiomatic comparison between the division of goods and that of bads is especially sharp. When we divide goods and the manna improves, everyone weakly benefits under the CEEI rule; but no reasonable rule to divide bads can be similarly Resource Monotonic. Also, the much larger set of Non Envious and Efficient divisions of bads can be disconnected so that it will admit no continuous selection.

23 November - Itai Arieli (Technion)

How to aggregate information if you must?
The decisions an economic agent is required to make are often based upon the likelihood of an uncertain future event. We study the case where an ignorant agent can use predictions of experts over the likelihood of the event to form his own prediction. We ask how the agent should aggregate the information provided by the experts when he knows

24 November - Neil Olver (VU Amsterdam)

A Simpler and Faster Strongly Polynomial Algorithm for Generalized Flow Maximization
I will present a new strongly polynomial algorithm for generalized flow maximization. The first strongly polynomial algorithm for this problem was given in [Végh16]; our new algorithm is much simpler, and much faster. The complexity bound O((m+nlogn)mnlog(n2/m)) improves on the previous estimate in [Végh16] by almost a factor O(n2). Even for small numerical parameter values, our algorithm is essentially as fast as the best weakly polynomial algorithms. The key new technical idea is relaxing primal feasibility conditions. This allows us to work almost exclusively with integral flows, in contrast to all previous algorithms for the problem.

This is joint work with László Végh (LSE).

17 November - Timm Oertel (Cardiff)

Integrality gaps of integer knapsack problems
We obtain optimal lower and upper bounds for the (additive) integrality gaps of integer knapsack problems. In a randomised setting, we show that the integrality gap of a “typical” knapsack problem is drastically smaller than the integrality gap that occurs in a worst case scenario.

This is joint work with Iskander Aliev and Martin Henk.

16 November - Peter Richtarik (Edinburgh)

Stochastic reformulations of linear systems and efficient randomized algorithms
We propose a new paradigm for solving linear systems. In our paradigm, the system is reformulated into a stochastic problem, and then solved with a randomized algorithm. Our reformulation can be equivalently seen as a stochastic optimization problem, stochastically preconditioned linear system, stochastic fixed point problem and as a probabilistic intersection problem. We propose and analyze basic and

accelerated stochastic algorithms for solving the reformulated problem, with linear convergence rates.

10 November - Daniel Dadush (CWI)

Making Banaszczyk's Bound Constructive for the Komlos Problem
We first consider the problem of finding a low discrepancy coloring for sparse set systems where each element lies in at most t sets. We give an efficient algorithm that finds a coloring with discrepancy O((t log n)^{1/2}), matching the best known non-constructive bound for the problem due to Banaszczyk. The previous algorithms only achieved an O(t^{1/2} log n) bound. The result also extends to the more general Komlos setting, where each vector has norm at most 1, and gives an algorithmic O(log^{1/2} n) bound.

Joint work with Nikhil Bansal and Shashwat Garg.

9 November - Sven Rady (HCM/Bonn)

Strongly Symmetric Equilibria in Bandit Games
This paper studies strongly symmetric equilibria (SSE) in continuous-time games of strategic experimentation with Poisson bandits. SSE payoffs can be studied via two functional equations similar to the HJB equation used for Markov equilibria. This is valuable for three reasons. First, these equations retain the tractability of Markov equilibrium, while allowing for punishments and rewards: the best and worst equilibrium payoff are explicitly solved for. Second, they capture behavior of the discrete-time game: as the period length goes to zero in the discretized game, the SSE payoff set converges to their solution. Third, they encompass a large payoff set: there is no perfect Bayesian equilibrium in the discrete-time game with frequent interactions with higher asymptotic efficiency.

3 November - Felix Joos (Birmingham)

Packing and Covering Graphs
Menger's Theorem is one of the most satisfactory results in graph theory. It say that either there are k (vertex-)disjoint paths joining two specified vertex sets or there is a vertex set of size k-1 meeting all such paths. Observe that both statements exclude each other. This theorem is one prime example for the duality between packing and covering objects contained in graphs.

For many other objects (instead of paths between specified vertex sets) in graphs such a duality does not hold. One can consider a weaker form of this duality which is also known as the Erdos-Posa property of graphs. Results in this direction mainly

deal with vertex-disjoint objects. We consider edge-disjoint objects (cycles of length l for some integer l) and show why it is much harder to investigate this question.

This is joint work with Henning Bruhn and Matthias Heinlein.

26 October - Michal Feldman (Tel Aviv)

Welfare Maximization via Posted Prices
Posted price mechanisms are simple, straightforward, and strategyproof. We study two scenarios of combinatorial markets where sequential posted price mechanisms achieve optimal or nearly optimal welfare. The first scenario is matching markets with full information, where optimal welfare is obtained. The second is markets with submodular (and XOS) valuations with Bayesian information, where half of the optimal welfare is obtained. We distinguish between static and dynamic pricing, and present various extensions of the above findings. Finally, we mention surprising relations between price of anarchy results and posted price mechanisms.

Based on joint works with Vincent Cohen-Addad, Alon Eden and Amos Fiat (2016), with Nick Gravin and Brendan Lucier (2015) and with Paul Duetting, Thomas Kesselheim and Brendan Lucier (2016).

20 October - Bhargav Narayanan (Cambridge)

Symmetric Intersecting Families
A family of sets is said to be intersecting if any two sets in the family have nonempty intersection. Families of sets subject to various intersection conditions have been studied over the last fifty years and a common feature of many of the results in the area is that the extremal families are often quite asymmetric.

Motivated by this, P{\'e}ter Frankl conjectured in 1981 that symmetric intersecting families must generally be very small; more precisely, Frankl conjectured that if a family of subsets of $\{1, 2, \dots, n\}$ with the property that any three sets in the family intersect has a transitive automorphism group, then the family must have size $o(2^n)$. In this talk, I shall prove this conjecture.

Joint work with David Ellis.

12 October - Heinrich Nax (ETH Zurich)

Payoff-based dynamics in transferable-utility matching markets
We consider simple, payoff-driven learning dynamics that we derive from laboratory evidence of how individuals adjust their behavior when interacting in low-information environments. We study the resulting convergence properties of such

dynamics for transferable-utility matching markets (i.e. multi-player bargaining, assignment game, TU many-to-one matching). The dynamics are driven by individuals' continued efforts to fulfill their aspirations and resulting aspiration adaptation. Agents have no knowledge of other agents' strategies, payoffs, or of the structure of the game, and there is no central authority with such knowledge either. Our dynamics constitute a class of simple learning processes that converge to stable and optimal outcomes (the core). Based on stability properties, and not on any ex ante fairness considerations, a subset of the core with a natural equity interpretation may even be selected.

6 October - Annika Heckel (Oxford)

The chromatic number of dense random graphs
We establish new upper and lower bounds for the chromatic number of the dense random graph G(n,p) where p is constant. These bounds are the first that match each other up to a term of size o(1) in the denominator, and in particular, they determine the average colour class size in an optimal colouring for the first

time. Somewhat surprisingly, the behaviour of the chromatic number changes around p=1-1/e^2, with a different limiting effect being dominant below and above this value. In contrast to earlier results, the upper bound is obtained through the second moment method, and some aspects of the proof will be discussed.

Furthermore, the same method can be used to show that a related graph parameter, the equitable chromatic number of the dense random graph G(n,m), is concentrated on just one value on a subsequence of the integers.

5 October - Panayiotis Kolios (Cyprus)

Resilient Drone-based Patrolling through Optimized Path Planning Strategies
Drones have become both affordable and highly capable platforms for watch-keeping and patrolling of particular Regions of Interest (ROI). However current practices assume manual control of flight paths for each drone that tamper scalability and result to operating inefficiencies. In accordance, this talk formulates optimized path planning strategies that would allow drones to autonomously operate both efficiently and effectively across ROIs. To address efficiency, the formulated problem considers all major flying aspects (including topography, weather, etc). To address effectiveness, the derived paths opt for resilience to unexpected events and faults that might occur. As shown, the resulting mathematical programming framework can address different objectives and accommodate and benefit from the availability of multiple drone platforms.

29 September - Hal Kierstad (Arizona State)

Some history and applications of generalized coloring numbers

The notion of generalized coloring numbers arose from an idea of Chen and Schelp for extending a Ramsey theoretic result from the class of graphs with bounded degree to a larger class including planar graphs. Trotter, Zhu, and I, as well as other authors, developed their idea to bound the game chromatic number of various graph classes, including planar graphs. For a graph G, Yang and I formalized these ideas by introducing hierarchies of *weak k-coloring numbers* $\mathrm{wcol}_k(G)$, *k-coloring numbers* $\mathrm{col}_k(G)$, *and game k-colorings* $\mathrm{gcol}_k(G)$ *numbers*, and showed each hierarchy is bounded in terms of each other hierarchy. Shortly after Nešetřil and Ossona de Mendez introduced the notion of *classes with bounded expansion*, and Zhu proved these are exactly the classes whose k-coloring numbers are all bounded. Grohe, Kreutzer, Rabinovich, Siebertz, and Stavropoulos proved that tree-width can be characterized in terms of *infinite* coloring number, and Nešetřil and Ossona de Mendez proved that tree-depth can be characterized in terms of *infinite* weak coloring number. I will give examples of applying these notions to graph theoretic problems concerning **coloring**, **games**, and **packing**.