IP1

Accuracy, Privacy, and Validity: When Right is Wrong and Wrong is Right

In 2008 a simple pen-and-paper privacy attack on aggregate allele frequency statistics in a Genome-Wide Association Study rocked the world of genomics research and resulted in a change in access policy for aggregate statistics in studies funded by the US National Institutes of Health. After describing the original attack and summarizing recent advances in attack strategies, we shift to the defense, discussing differential privacy, a notion of privacy tailored to statistical analysis of large datasets. Signal properties of differential privacy include its resilience to arbitrary side information and the ability to understand cumulative privacy loss over multiple statistical analyses. Finally, we describe a tight connection between differential privacy and statistical validity under adaptive (exploratory) data analysis.

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IP2

From Algorithm to Theorem (in Probabilistic Combinatorics)

The general question is let X be a set of interesting "things" (permutations, graphs, partitions, ...). Pick x in X at random; what does x "look like"? There are a host of results for taking theorems(e.g., the Gale-Ryser theorem) and turning them into algorithms for efficient generation. This talk goes in the opposite direction: given an algorithm for random generation, what (limit) theorems does it imply? One key example, drawn from joint work with Chern, Kane, and Rhoades—there is a clever algorithm for generating a random set partition due to Stam. This allowed us to prove the limiting normality of the number of crossings (and many other functionals), a long-open problem.

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IP3

Stabilisation in Algebra, Geometry, and Combinatorics

Throughout mathematics, one encounters sequences of algebraic varieties—geometric structures defined by polynomial equations. As the dimension of the variety grows, typically so does its complexity, measured, for instance, by the degrees of its defining equations. And yet, many sequences stabilise in the sense that from some member of the sequence on, all complexity is inherited from the smaller members by applying symmetries. I will present several examples of this, as yet, only partially understood phenomenon. Beautiful combinatorics of well-quasi-ordered sets plays a key role in the proofs. The hope is that, conversely, algebraic stabilisation may in the future also shed new light on well-quasi-orders.

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IP4

Mathematical Models: Uses, Abuses, and Non-uses

Models are indispensable, but have to be used with caution. Some early quantitative models, drawn from the early history of British railways and related to the ubiquitous gravity models of transportation, urban planning, spacial economics, and related areas, will be presented. They demonstrate how even clearly false models can be useful, and how sometimes they are misused or tragically not used.

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IP5

Tangles and the Mona Lisa: Connectivity Versus Tree Structure

Tangles, first introduced by Robertson and Seymour in their work on graph minors, are a radically new way to define regions of high connectivity in a graph. The idea is that, whatever that highly connected region might 'be', low-order separations of the graph cannot cut through it, and so it will orient them: towards the side of the separation on which it lies. A tangle, thus, is simply a consistent way of orienting all the low-order separations in a graph. The new paradigm this brings to connectivity theory is that such consistent orientations of all the low-order separations may, in themselves, be thought of as highly connected regions: rather than asking exactly which vertices or edges belong to such a region, we only ask where it is, collecting pointers to it from all sides. Pixellated images share this property: we cannot tell exactly which pixels belong to the Mona Lisa's nose, rather than her cheek, but we can identify 'low-order' separations of the picture that do not cut right through such features, and which can therefore be used collectively to delineate them. This talk will outline a general theory of tangles that applies not only to graphs and matroids but to a broad range of discrete structures. Including, perhaps, the pixellated Mona Lisa.

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IP6

Induced Matchings, Arithmetic Progressions and Communication

Extremal combinatorics is one of the central branches of discrete mathematics that deals with the problem of estimating the maximum possible size of a combinatorial structure which satisfies certain restrictions. Often, such problems also have applications to other areas including theoretical computer science, additive number theory and information theory. In his talk, we will illustrate this fact using several closely related examples, focusing on the recent works with Alon, Fox, Huang and Moitra.

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IP7

Quasirandomness, Sidorenko's Conjecture and Graph Norms

Using the theory of quasirandomness as an underlying theme, we will discuss recent progress on a number of problems in extremal graph theory, including Sidorenko's conjecture and a question of Lovász asking for a classification of graphs that define norms.

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IP8

Excluded Grid Theorem: Improved and Simplified

One of the key results in Robertson and Seymour's seminal work on graph minors is the Excluded Grid Theorem. The theorem states that there is a function f, such that for every positive integer g, every graph whose treewidth is at least f(g) contains the (gxg)-grid as a minor. This theorem has found many applications in graph theory and algorithms. An important open question is establishing tight bounds on f(g) for which the theorem holds. Robertson and Seymour showed that $f(g) \geq \Omega(g^2 logg)$, and this remains the best current lower bound on f(g). Until recently, the best upper bound was super-exponential in g. In this talk, we will give an overview of a recent sequence of results, that has lead to the best current upper bound of $f(g) = O(g^{19} polylog(g))$.

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SP0

Hot Topics Session: Graph Isomorphism in Quasipolynomial Time - Part II of II

I will explain the core "Local Certificates' algorithm in detail and sketch the aggregation of the local certificates. Familiarity with basic concepts of group theory (such as kernel of a homomorphism) will be assumed.

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SP1

2016 Dnes Knig Prize Lecture - Phase Transitions in Random Graph Processes

One of the most interesting features of Erdős-Rényi random graphs is the 'percolation phase transition', where the global structure intuitively changes from only small components to a single giant component plus small ones. In this talk, we discuss the percolation phase transition of Achlioptas processes, which are a class of time-evolving variants of Erdős-Rényi random graphs that (i) can exhibit somewhat surprising phenomena, and (ii) are difficult to analyze due to dependencies between the edges.

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SP2

Hot Topics Session: Graph Isomorphism in Quasipolynomial Time - Part I of II

In the first talk I will sketch the main ingredients of the algorithm and indicate how they lead to quasipolynomial recurrence. Familiarity with basic concepts of group theory (such as kernel of a homomorphism) will be assumed.

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CP1

The Family of Plane Graphs with Face Sizes 3 or 4

A reduction theorem will be proved for the family of plane graphs with faces sizes 3 or 4. Each reduction produces large proper minors in the same family. Each reduction is shown to be necessary.

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CP1

Bijections to Split Graphs

A graph G is a split graph if its vertices can be partitioned into a clique and a stable set. We call a split graph balanced if its partition is unique and unbalanced otherwise. In this talk, we present several proofs, using natural bijections, that the number of unbalanced split graphs on n vertices is equal to the number of split graphs on $n-1$ vertices. These proofs demonstrate connections between split graphs and other well-known combinatorial families.

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CP1

Unhinging Cycles: An Approach to Universal Cycles Under Equivalence Relations

For all prime numbers p, we investigate universal cycles of string equivalence classes of length-p under equivalence relations based on non-transitive group actions. We offer two types of equivalences which admit a universal cycle of all length-p equivalence classes: first any equivalence with p greater than a constant dependent on the group action, second for any p and an equivalence satisfying certain orbit space conditions. We will also introduce a new method, called unhinging, to construct the De Bruijn-like graph that is used to prove the existence of universal cycles.

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CP1

Monotone Paths in Dense Edge-Ordered Graphs

In a graph whose edges are are totally ordered, a *monotone path* is a path that traverses edges in increasing order. Let $f(G)$ be the minimum, over all total orderings of $E(G)$, of the maximum length of a monotone path in G. In 1973, Graham and Kleitman proved that $f(K_n) \geq (\sqrt{4n-3}-1)/2$. The best known upper bound on $f(K_n)$ is due to Calderbank, Chung, and Sturtevant, who proved that $f(K_n) \leq \left(\frac{1}{2}+o(1)\right)n$ in 1984. We show that $f(K_n) \geq \Omega((n/\log n)^{2/3})$.

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CP1

A Generalization of α-Orientations to Higher Genus Surfaces

We obtain a generalization of Stephen Felsner's theory of α-orientations on planar graph embeddings (with associated lattice structures) to graph embeddings on higher genus surfaces. We obtain several applications to bijective methods in map enumeration and reconstruction. In particular, we identify an application in the structural theory of combinatorial models of moduli spaces of complex curves, with possible further applications in quantum physics.

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CP2

The Region of Critical Probabilities in Bootstrap Percolation on Inhomogeneous Periodic Trees

We study bootstrap percolation process where nodes in a given graph do not all receive the same probabilities within the initial configuration. Instead of a simple percolation threshold, now regions of possible probabilities emerge. To keep a problem tractable we consider infinite periodic trees. We show the existence, and convexity of the critical region of the initial probabilities for which the tree becomes a.a.s. active. We also specify the boundary of the critical region, and show how it can be numerically computed.

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CP2

The Emergence of Patterns of Cooperative Behaviour in Grids

The Prisoner's Dilemma is played on a graph by assigning to each vertex a strategy and the sum of the payoffs of a single round of the game played with each of the vertex's neighbours. We imagine vertices having the desire to alter their strategies if they observe one of their neighbours with a higher total payoff. Iterating the process, we observe the evolution of patterns of cooperative and selfish behaviour. We examine this process on the toroidal grid, considering how the initial distribution of strategies affect the distribution of the strategies in a limiting configuration.

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CP2

Counting Spanning Trees in Random Regular Graphs

The number of spanning trees in a graph is an important parameter in many contexts. Particular attention has been given to regular graphs. We obtain a sharp asymptotic formula for the expected number of spanning trees in a random d-regular graph on n vertices, $d = o(n^{1/3})$. The proof involves some interesting techniques, including an analysis of the Prüfer code algorithm to establish concentration of a certain function over random trees.

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CP2

l-Cycles in Randomly Perturbed Hypergraphs

Krivelevich, Kwan and Sudakov showed that any k-graph of linear minimum degree contains a Hamilton 1-cycle if a linear number of random edges are added to the graph. This demonstrates that far below the extremal threshold for Hamiltonicity, graphs are still, in a sense, close to Hamiltonian. We generalise this to any l-cycle and consider other degree conditions.

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CP2

Recovering the Structure of Random Linear

Graphs

We investigate a class of random graphs defined from the following model: on a set of vertices $\{v_1, v_2 \ldots, v_n\}$ there is an edge between v_i and v_j with probability p if $|i-j| \leq k$ and with probability q otherwise. This model describes graphs with a linear nature. Our problem is to reconstruct its linear embedding by recovering the order of vertices. In this work, we show how this order can be recovered with minimal error from the eigenvectors of its adjacency matrix.

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CP2
Modularity of Random Graphs

Modularity is a quality function on partitions in networks which may be used to identify highly clustered components [M. Newman and M. Girvan, *Phys. Rev. E*, 69 (2004)]. It is commonly used to analyse large real networks. Given graph G, the modularity of a partition of the vertex set measures the extent to which edge density is higher within parts than between parts, and the maximum modularity $q^*(G)$ of G (where $0 \leq q^*(G) < 1$) is the maximum modularity over all partitions. Knowledge of the maximum modularity of random graphs is important to determine the statistical significance of partitions in real networks [J. Reichardt and S. Bornholdt, *Physica D*, 224 (2006), pp.20–26]. We show Erdős-Rényi random graphs have three different phases of likely maximum modularity. For $np = 1 + o(1)$ the maximum modularity is $1 + o(1)$ whp and for $np \to \infty$ the maximum modularity is $o(1)$ whp. For $np = c$ with $c > 1$ a constant, functions are constructed with $0 < a(c) < b(c) < 1$ and $b(c) \to 0$ as $c \to \infty$ such that whp the maximum modularity is bounded between these functions.

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CP3
Construction of 4-Connected Graphic Matroids with Essential Elements

An element e of an n-connected matroid M is called essential element if neither M n e nor M=e is n-connected. Tutte proved that in a 3- connected matroid M every element is essential if and only if M is wheel or whirl. We give construction of some families of 4-connected graphic matroids in which every element is essential.

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CP3
Counting Hamiltonian Cycles in a Matroid Basis Graph

A graph is *edge Hamiltonian* if every edge is in a Hamiltonian cycle. The work of Bondy and Ingleton about pancyclic graphs implies that the basis graph BG(M) of every matroid M is edge Hamiltonian. We prove that the number of Hamiltonian cycles passing through an edge of the basis graph of the cycle matroid of a graph G grows exponentially in the number of vertices of G. A similar result is proved por generalized Calatan lattice path matroids.

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CP3
The Generalized Onsager Model for a Binary Gas Mixture with Swirling Feed

The generalized Onsager model (Pradhan & Kumaran (JFM-2011); Kumaran & Pradhan (JFM-2014)) for the secondary flow field in a high speed rotating cylinder is extended for a binary gas mixture to incorporate the effect of the angular momentum of the feed gas in a high speed rotating cylinder. The base flow is an isothermal solid body rotation (Wood & Morton (JFM- 1980)) in which there is a balance between the radial pressure gradient and the centrifugal force density for each species. Explicit expressions for the radial variation of the pressure, mass/mole fractions, and from these the radial variation of the viscosity, thermal conductivity and diffusion coefficient, are derived, and these are used in the computation of the secondary flow. For the secondary flow, the mass, momentum and energy equations in axisymmetric coordinates are expanded in an asymptotic series in a parameter $\epsilon = (\Delta m/m_{av})$, where Δm is the difference in the molecular masses of the two species, and the average molecular mass m_{av} is defined as $m_{av} = ((\rho_{w1} m_1 + \rho_{w2} m_2)/\rho_w)$, where ρ_{w1} and ρ_{w2} are the mass densities of the two species at the wall, and $\rho_w = \rho_{w1} + \rho_{w2}$. An important finding is that with the angular momentum of the feed gas (swirling feed), the peak value of the axial mass flux increases significantly, as well as significant reduction of the angular momentum loss of the rotating gas due to feed injection near the feed point, and also reduction of the axial spreading of the feed gas, and further avoid the formation of small secondary vortices near the feed zone, indicating a strong coupling between the secondary flow field and the angular momentum of the feed gas in a high speed rotating cylinder. This can be fruitfully used for the separation of isotopes in systems of practical interest.

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CP3

Fractal Graphs and Their Combinatorial Properties

Lately there is a growing applications-inspired interest in studying self-similarity and fractal properties of graphs. Such studies often employ statistical physics methods, while rigorous combinatorial theory still has not been developed. We study discrete analogues of Lebesgue and Hausdorff dimensions for graphs. We show that they are closely related to well-known graph parameters such as Krausz and Nesetril-Rdl(Prague) dimensions. It allowed us to formally define fractal graphs and determine fractality of some graph classes.

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CP3

A Faster Algorithm for Computting Tutte Polynomials of Lattice Path Matroids

Lattice path matroids were introduced as a nice class of matroids that show up naturally in many places. It has been known for some time that computing the Tutte polynomial of such matroids can be done in polynomial time. Using ideas from tensor networks and holographic algorithms, we give a simple algorithm with improved running time of $O(n^4)$ in the size of the ground set.

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CP4

Coloring the Square of Subcubic Planar Graphs

Given a graph G, the square of G is the graph formed from G by adding edges between vertices that are distance at most two apart. A graph is subcubic if the maximum degree is at most 3. In 1977, Wegner showed that the square of a subcubic planar graph can be properly colored with at most 8 colors and conjectured that 7 colors suffice. We prove this conjecture using discharging and computation for the reducible configurations.

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CP4

Universal Cycles of Graph Colorings

A universal cycle enumerates the elements of a set in such a way that cycling through the set one k-window at a time exhibits each element exactly once. U-cycles have been shown to exist for k-ary strings, permutations, graphs, discrete functions, posets, and even juggling patterns. We consider whether u-cycles exist for k-colorings of a labeled graph G, and discover this actually encompasses and expands on many of the other combinatorial objects previously studied.

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CP4

Connectedness of the Graph of Neighborhood Distinguishing Colorings and Irregular Colorings

Let G be a simple Graph. If $\pi = \{V_1, V_2, \ldots, V_k\}$ is a proper color partition and u is a vertex then the code for u is the ordered $k-tuple$ $C_\pi(u) = (|N(u) \cap V_1|, |N(u) \cap V_2|, \ldots, |N(u) \cap V_k|)$ and π is distinguishing if $C_\pi(u) \neq C_\pi(v)$ when $u \neq v$. The minimum value of the cardinality of Neighborhood distinguishing proper color partition is called the neighborhood distinguishing coloring number of G and is denoted by $\chi_{NDC}(G)$. Irregular coloring(ir-coloring) has been introduced by Mary Radcliffe and Ping Zhang in 2006. The irregular chromatic number denoted by $\chi_{ir}(G)$ is the minimum positive integer k for which G has an irregular $k-coloring$. For any simple graph G, ir-coloring exists but ND-coloring is not guaranteed. For example, $K_{1,n}$ does not admit ND-coloring. Study of Connectedness of the graph of vertex-colorings done by Luis Cereceda in 2008. In this paper, some results on the connectedness of the graph with respect to Neighborhood Distinguishing Coloring and ir-coloring has been done with Hajos construction.

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CP4

Coloring Intersection Graphs of Curves Crossing a Fixed Line

We prove, for every $t \geq 1$, that the class of intersection graphs of curves in the plane such that each curve crosses a fixed line L in at least one and at most t points is χ-bounded. As a corollary, the upper bound on the number of edges in a k-quasi-planar topological graph drawn with at most t crossings between any pair of edges is improved to $c_{k,t} n \log n$.

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CP5

On the Competition Graphs of d-Partial Orders

In this talk, we study the competition graphs of d-partial orders and obtain their characterization. We also show that any graph can be made into the competition graph of a d-partial order for some positive integer d as long as adding isolated vertices is allowed. We then introduce the notion of the partial order competition dimension of a graph and study graphs whose partial order competition dimensions are at most three.

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CP5

Shifted Young Diagrams and Binary I/D Error-Correcting Codes

We consider a correspondence between shifted Young diagrams and binary sequences and define an ordering for binary sequences. Based on the correspondence, we discuss partially ordered structure of shifted Young diagram with an inclusion ordering from coding theory. In particular, from some recent results on insertion/deletion (I/D) errors in coding theory, we obtain a bounded and graded sub-poset of shifted Young diagrams.

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CP5

The Nested Chain Decompositions of Some Normalized Graded Posets of Rank Three

It is conjectured by Griggs in 1975 that every finite normalized matching rank-unimodal poset has a nested chain decomposition. This conjecture is widely open and is only verified for posets of rank 2. In this talk, we will learn the early results of Shahriari et al. on the normalized matching posets of rank 3. Moreover, we will modify their approach to show more posets satisfying the Griggs's conjecture.

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CP5

Unavoidable Trees in Tournaments

An oriented tree T on n vertices is *unavoidable* if every n-vertex tournament contains a copy of T. Alon raised the question of which trees are unavoidable. Only a few examples of such trees are known, such as oriented paths (as demonstrated by Thomason). We exhibit a large class of unavoidable trees, including almost all orientations of large balanced q-ary trees for any fixed q.

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CP5

Unit Tolerance Orders with Open and Closed Points

A poset $P = (X, \prec)$ is a *unit OC interval order* if there exists a representation that assigns an open or closed real interval $I_x = [L(x), R(x)]$ of unit length to each $x \in P$ so that $x \prec y$ in P precisely when each point of I_x is less than each point of I_y. In this talk we consider a tolerance version of OC interval orders in which for each $x \in X$, the center point $c(x)$ is designated as either open or closed. This results in four types of intervals A, B, C, D, and we define $x \prec y$ if and only if either (i) $R(x) < c(y)$ or (ii) $R(x) = c(y)$ and at least one of $R(x), c(y)$ is open, and at least one of $L(y), c(x)$ is open. For any subset S of $\{A, B, C, D\}$ we have a polynomial time algorithm for determining if a poset can be represented by intervals whose types belong to the set S. When a representation is possible, our algorithm produces one. In addition, we provide a hierarchy of these 16 classes of posets with separating examples between unequal classes.

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CP6

A Relative of the Odd Hadwiger's Conjecture

Gerards and Seymour conjectured that a graph with no odd K_t minor is $(t-1)$-colorable, which strengthens Hadwiger's conjecture. We have two variants of the conjecture. For $t \geq 2$, a graph with no odd K_t minor has a partition $V_1, \ldots, V_{7t-10}$ of the vertex-set such that each induced subgraph on V_i has bounded maximum degree. Furthermore, a graph with no odd K_t minor has a partition $W_1, \ldots, W_{16t-19}$ of the vertex-set such that each induced subgraph on W_i has bounded component size. This improves a result of Kawarabayashi(2008), which states the vertex-set can be partitioned into $496t$ sets.

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CP6

Colorings of Hypergraphs with Large Number of Colors

The paper deals with the well-known problem of Erdős and Hajnal concerning colorings of uniform hypergraphs with few edges. Let $m(n,r)$ denote the minimum possible number of edges in an n-uniform non-r-colorable hypergraph. We show that for $r > n$ and some absolute constants $c_1, C_1 > 0$,

$$c_1 \frac{n}{\ln n} \le \frac{m(n,r)}{r^n} \le C_1\, n^3 \ln n,$$

We also obtain similar bounds for $d(n,r)$, the minimum possible value of the maximum edge degree in an n-uniform non-r-colorable hypergraph.

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CP6

(2,0,0)-Coloring of Planar Graphs Without 4-Cycles or Close Triangles

Some classes of planar graphs have been conjectured to be 3-colorable, such as those without 4- or 5-cycles, and those avoiding 5-cycles and intersecting triangles. We take a step toward these conjectures by showing that a planar graph without 4-cycles whose triangles are at least distance 2 apart can be colored with 3 colors such that the subgraph induced by one color class has maximum degree 2, and the other color classes form independent sets.

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CP6

Precoloring Extensions Using a Generalization of Hall's Marriage Theorem

Hall's condition (a generalization of Hall's Marriage Theorem) is necessary (though not sufficient) for a graph to admit a precoloring extension. We discuss results related to sufficiency. A graph is Hall k-extendible if every k-precoloring that satisfies Hall's condition is extendible. We prove every graph G is Hall $\Delta(G)$-extendible, discuss behavior under certain graph operations, and outline some graphs for which the complete set of values of k making them Hall k-extendible is known.

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CP6

Gyárfás Conjecture Is Almost Always True

Gyárfás conjectured that for every tree T, there is a function f such that every T-free graph G (i.e. graph without T as an induced subgraph) whose largest clique has size ω, has chromatic number at most $f(\omega)$. We show that almost every T-free G has chromatic number at most $(1+o(1))\omega(G)$ and that for most trees T almost every T-free G, satisfies $\chi(G) = \omega(G)$. Key to doing so is a structural characterization of almost all T-free graphs.

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CP6

A Vizing Type Adjacency Theorem on g_c-Colorings

A g_c-coloring of graph G is an edge-coloring with k colors in such a way that, for each vertex $v \in V(G)$, each color appears at least $g(v)$ times. It is well known that Vizing's Adjacency Lemma saying that, if G is an edge-chromatic critical simple graph and $xy \in E(G)$, then x is adjacent to at least $\Delta(G) - d(y) + 1$ vertices ($\neq y$) of degree $\Delta(G)$. Recently, we obtain a Vizing Type's result in critical graphs on g_c-colorings.

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CP7

Realization Graphs of Degree Sequences

Given a degree sequence d, the realization graph $R(d)$ has as its vertices the labeled realizations of d, with edges corresponding to edge-switching operations. It is known that $R(d)$ is connected and conjectured that it is Hamiltonian, but many questions remain about its structure. We prove that a degree sequence decomposition due to Tyshkevich yields a Cartesian product decomposition of realization graphs, and we characterize the degree sequences whose realization graphs are hypercubes or triangle-free.

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CP7

Generating Near-Bipartite Bricks

A 3-connected graph G is a brick if for any two vertices u and v, the graph $G - \{u,v\}$ has a perfect matching. A brick G is near-bipartite if it has two edges e and f such that $G - \{e, f\}$ is bipartite and matching covered. Norine and Thomas (2007) showed that all simple bricks may be generated from five infinite families and the Petersen graph. Likewise, we show that all simple near-bipartite bricks may be generated from eight infinite families. Some applications will be discussed.

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CP7

Antimagic Labelings of Weighted Graphs

In 1990, Hartsfield and Ringel conjectured that every connected graph of order at least 3 is antimagic, meaning there is a bijective labeling $\phi : E(G) \to [|E(G)|]$ such that vertex sums are pairwise distinct. Using the Combinatorial Nullstellensatz (CN) and a relaxation of antimagic we show that graphs having no K_1 or K_2 components are $\lfloor \frac{4n}{3} \rfloor$-weighted-antimagic, improving upon a result of Wong and Zhu. In this talk, we discuss the application of CN and related results.

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CP7

Hamiltonian Cycles in Directed Toeplitz Graphs

An matrix is called a Toeplitz matrix if it has constant values along all diagonals parallel to the main diagonal. A directed Toeplitz graph is a digraph with Toeplitz adjacency matrix. In this talk I will discuss conditions for the existence of hamiltonian cycles in directed Toeplitz graphs.

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CP7

Ore's Condition for Spanning Halin Subgraphs

A *Halin graph*, which consists of a plane tree with no vertices of degree 2 and a cycle connecting its leaves according to the cyclic order determined by the embedding, possesses rich hamiltonicity properties such as being hamiltonian, hamiltonian-connected, and almost pancyclic. It was shown that there exists a positive integer n_0 such that any graph G with $n \geq n_0$ vertices and $\delta(G) \geq (n+1)/2$ contains a spanning Halin subgraph. We generalize this result in showing that there exists a positive integer n_0 such that any graph G with $n \geq n_0$ vertices and $\sigma_2(G) \geq n+1$ contains a spanning Halin subgraph.

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CP8

Spatial Networks with Random Connections

Spatial networks of interest (including climate, communications, nanowire and neuronal networks) may be modelled by randomly located nodes with a distance-dependent link probability. We show that the connection probability can be estimated from just a few moments of the link probability function for many domain geometries. Random connection models more accurately estimate connectivity and resilience than older deterministic connection models such as the random geometric graph.

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CP8

Algebraic Bounds for Heterogeneous and Correlated Percolation

We consider percolation with positively correlated site probabilities. The corresponding multi-variate Bernoulli distribution is modeled using clusters: multiple sites are marked open all at once, independently from other clusters. We bound the correlated percolation transition by heterogeneous percolation on a specially constructed cluster connectivity graph, and apply our recent results to construct algebraic bounds for connectivity, cluster susceptibility, and self-avoiding cycle susceptibility in terms of weighted adjacency and backtracking matrices.

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CP8

Using Optimization to Define Unbiased Treatment Effect Estimators for Causal Inference Using Observational Data

Matching is used to estimate treatment effects in observational studies in the social science, public health, and medicine. One mechanism for overcoming its restrictiveness is to relax the exact matching requirement to one of balance on the covariate distributions for the treatment and control groups. The Balance Optimization Subset Selection (BOSS) model is introduced to identify a control group featuring optimal covariate balance. This presentation discusses conditions under which the BOSS model yields unbiased estimators for the treatment effect.

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CP8

Uniform Distribution, Stein-Like Characterizations and Identities

An overview of Prokhorov's school results on the uniform distribution is presented, including some refinement of Diaconis–Freedman theorem on the uniform distribution on multidimensional spheres. A new method to get Stein- and Chen-like characterizations for all distributions defined by their moments is presented and applied to uniform and equiprobable distributions. The method is partly based on Weyl–Heisenberg non-commutative algebras. Starting from Burchnall-like recurrent formulas for classical orthogonal polynomials, some generalized Stein- and Chen-like identities of higher orders for classical distributions are derived to solve linearization problems for these polynomials. This makes it possible to get enumerations in discrete mathematics.

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CP8

Corners in Tree-Like Tableaux

Tree–like tableaux are combinatorial objects which exhibit a natural tree structure and are connected to the partially asymmetric simple exclusion process (PASEP). There was a conjecture made on the total number of corners in tree–like tableaux and the total number of corners in symmetric tree–like tableaux. We have proven both conjectures based off of a bijection with permutation tableaux and type–B permutation tableaux. Consequently, we also have results for these tableaux.

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CP8

Evolutionary Dynamics in Finite Populations Mix Rapidly

We prove that the mixing time of a broad class of evolutionary dynamics in finite, unstructured populations is roughly logarithmic in the size of the state space. An important special case of such a stochastic process is the Wright-Fisher model from evolutionary biology (with selection and mutation) on a population of size N over m genotypes. Our main result implies that the mixing time of this process is $O(\log N)$ for all mutation rates and fitness landscapes, and solves the main open problem from [Dixit, N., Srivastava, P., and Vishnoi, N. K., A finite population model of molecular evolution: Theory and computation]. Biologically, such models have been used to study the evolution of viral populations with applications to drug design strategies countering them. Technically, we make a novel connection between Markov chains arising in evolutionary dynamics and dynamical systems on the probability simplex. This allows us to use the local and global stability properties of the fixed points of such dynamical systems to construct a contractive coupling in a fairly general setting. We expect that our mixing time result would be useful beyond the evolutionary biology setting, and the techniques used here would find applications in bounding the mixing times of Markov chains which have a natural underlying dynamical system.

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CP9

Cycle Decompositions with No Subsystems

A k-cycle decomposition of G is a partition of the edge set of G such that each element of the partition induces a k-cycle. The necessary and sufficient conditions for the existence of a k-cycle decomposition of K_n have already been determined. We are concerned with showing there exists a k-cycle decomposition $\mathcal{P}$ of K_n such that **no** subset of $\mathcal{P}$ forms a k-cycle decomposition of K_t where $2 < t < n$; if we can show this, we say that $\mathcal{P}$ contains no subsystems. In this talk, we will see how to construct a k-cycle decomposition of K_n with no subsystems when n and k are odd.

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CP9

The Decomposition Threshold of a Given Graph

A fundamental theorem of Wilson states that, for every graph F, the edge-set of every sufficiently large clique (satisfying a trivially necessary divisibility condition) has a decomposition into copies of F. One of the main open problems in this area is to determine the minimum degree threshold which guarantees an F-decomposition in an incomplete host graph. We solve this problem for the case when F is bipartite and make significant progress towards the general case.

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CP9

Proof of the Barát-Thomassen Conjecture

The Barát-Thomassen conjecture asserts that for every tree T on m edges, there exists a constant k_T such that every k_T-edge-connected graph with size divisible by m can be edge-decomposed into copies of T. So far this conjecture has only been verified when T is a path or when T has diameter at most 4. We prove the full statement of the conjecture.

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CP9

Clique Decompositions of Multipartite Graphs and Completion of Latin Squares

We give the best known bounds on the minimum degree which ensures an edge-decomposition of an r-partite graph into r-cliques (subject to necessary divisibility conditions). Our proof essentially reduces the problem to the problem of finding a fractional r-clique decomposition or an approximate one. The case of triangles translates into the setting of partially completed Latin squares and more generally the case of r-cliques translates into the setting of partially completed mutually orthogonal Latin squares.

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CP9

Strong Oriented Graphs with Largest Directed Metric Dimension

Let D be a strongly connected oriented graph with vertex-set V and arc-set E. The distance from a vertex u to another vertex v, $d(u, v)$ is the minimum length of oriented paths from u to v. Suppose $B = \{b_1, b_2, b_3, ...b_k\}$ is a nonempty ordered subset of V. The representation of a vertex v with respect to B, $r(v|B)$, is defined as a vector $(d(v, b_1), d(v, b_2), \ldots, d(v, b_k))$. If any two distinct vertices u, v satisfy $r(u|B) \neq r(v|B)$, then B is a resolving set of D. If the cardinality of B is minimum then B is a basis of D and the cardinality of B is the directed metric dimension of D, $dim(D)$. We proved that if D is a strongly connected oriented graph of order $n \geq 4$, then $dim(D) \leq n - 3$. Furthermore, we characterized strong oriented graphs attaining the upper bound, i.e., strong oriented graphs of order n and metric dimension $n - 3$.

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CP9

On (Strongly) Chordal-(k, l) Graph Sandwich Problem

In the graph sandwich problem, given $G_1 = (V, E_1)$, $G_2 = (V, E_2)$, $E_1 \subseteq E_2$, we seek $G = (V, E)$ with some property and $E_1 \subseteq E \subseteq E_2$. A graph is (strongly) chordal-(k, l) if it is (strongly) chordal and its vertex-set partitions into at most k independent sets and l cliques. We consider the complexity of seeking a sandwich that is (strongly) chordal-(k, l) and settle many previously open cases.

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CP10

Stability Number Linear Programs

We introduce new constraints for relaxations of the stability number integer program. Optima for these LPs give upper bounds for the stability number of a graph. Cuts or constraints that have been used in stability number LPs include edge, clique, odd cycle, wheel, anti-hole and circulant constraints. Many of these constraints are either alpha-critical graph constraints or are implied by them. Alpha-critical graphs are graphs where the removal of any edge increases its stability number. And every graph has an alpha-critical subgraph with the same stability number. We will also discuss a generalization of a result of Nemhauser and Trotter which guarantees that the 1s in an optimal solution of the edge-constraint stability number LP correspond to nodes which can be extended to a maximum stable set.

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CP10

Spectral Graph Properties in Combined Routing-Facility Location Problems

The facility location problem (FLP) models the cost of allocating demands originated by a given customer independently of other customer demands. Its combination with routing removes the allocation independence property, leading in turn to strongly interrelated location and routing decisions -facility location aggregates demands whereas multiple demand points may or not be served simultaneously by a common path. This paper proposes to exploit the conductance and expansion properties of the underlying graph to determine when common paths are more suited in the joint decision process.

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CP10

Approximate Recognition of Nonregular Languages by Finite Automata

A measure μ_L of approximation of language L by a finite automaton is 1 - $\frac{f_L(n) \bigoplus f_{L(M)}(n)}{c^n}$ in the limit where $f_L(n)$ denotes the number of strings of length n in L and $f_{L(M)}(n)$ is the number of strings of length n in $L(M)$. In this paper, we study a trade-off between the size of a DFA M and how well a language L can be approximated by the DFA. We use as case study two languages - one of which is a non-regular language and the other is a regular language.

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CP10

A Minimum-Change Version of the Chung-Feller Theorem

In this talk we present a new combinatorial Gray code on Dyck paths that provides a strengthening of the classical Chung-Feller theorem from 1949. We also present a corresponding constant-time generation algorithm, and, as an application on the graph-theoretical side, the construction of cycle-factors in the middle levels graph and the odd graph (two intensively studied families of vertex-transitive graphs) that consist of cycles of the same length.

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CP10

Modified Linear Programming and Class 0 Bounds for Graph Pebbling

Given a configuration of pebbles on the vertices of a connected graph G, a *pebbling move* removes two pebbles from some vertex and places one pebble on an adjacent vertex. The *pebbling number* of a graph G is the smallest integer k such that for each vertex v and each configuration of k pebbles on G, there exists a sequence of pebbling moves that places at least one pebble on v. If the pebbling number of G equals the number of vertices of G, we say the graph is Class 0. In this talk, we investigate and improve on bounds related to the minimum number of edges in a Class 0 graph via a discharging approach. We also discuss improvements to Glenn Hurlbert's linear programming technique.

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CP11

On Solution-Free Sets of Integers

Given a linear equation $\mathcal{L}$, a set $A \subseteq [n]$ is $\mathcal{L}$-free if A does not contain any 'non-trivial' solutions to $\mathcal{L}$. We prove a number of results concerning $\mathcal{L}$-free sets. For example, we determine the size of the largest $\mathcal{L}$-free set where $\mathcal{L}$ is the equation $px + qy = z$ for fixed p, q with $p \geq 2$. We also give various bounds on the number of maximal $\mathcal{L}$-free sets for three-variable homogeneous linear equations.

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CP11

Combinatorial Approaches Stanley Depth: Where Do We Stand?

In light of the recent counterexample of Duval et al. to Stanley's conjecture on the relationship between the depth of a module and its Stanley depth, it is appropriate to evaluate what is known, what (if any) weakening of Stanley's conjecture may be salvageable, and what additional insight into the structure of the subset lattice have we gained from studying this problem through interval partitions. This talk will summarize some recent results in this area.

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CP11

On Zeros of a Polynomial in a Finite Grid: The Alon-Füredi Bound

The Alon-Füredi Theorem gives a sharp upper bound on the number of zeros of a multivariate polynomial over an integral domain in a finite grid in terms of the degree of the polynomial. We give a generalization of their theorem, which provides a sharp upper bound when the degrees of the polynomial in each variable are also taken into account. We show how this implies well-known results of DeMillo-Lipton, Schwartz and Zippel.

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CP11

The (u,v) Calkin Wilf Tree

In this paper we consider a refinement, due to Nathanson, of the Calkin-Wilf tree. In particular, we study the properties of such trees associated with the matrices $L_u = \begin{bmatrix} 1 & 0 \\ u & 1 \end{bmatrix}$ and $R_v = L_v^T$, where u and v are nonnegative integers. We extend several known results of the original Calkin-Wilf tree. In this presentation emphasis will be placed on the symmetric and skew symmetric properties in this setting.

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CP11

Orphans in Forests of Linear Fractional Transformations

Nathanson showed that the set of positive linear fractional transformations (PLFTs) can be partitioned into an infinite forest of PLFT Calkin-Wilf-trees. The roots of these trees are called orphans. In this talk, we will provide a combinatorial formula for the number of orphan PLFTs (with fixed determinant) and show how these trees are connected to the original Calkin-Wilf tree. This is joint work with Sandie Han, Ariane M. Masuda, and Satyanand Singh.

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CP12

Involution Factorizations of Random Permutations Chosen from the Ewens Distribution

Given a permutation σ of $[n]$, let $\mathbf{N}_n(\sigma)$ denote the number of ways to write σ as a product of two involutions of $[n]$. If we endow S_n with the Ewens distribution, then the random variables $\mathbf{N}_n$ are asymptotically lognormal. The proof is based upon the observation that, for most permutations σ, $\mathbf{N}_n(\sigma)$ is well approximated by $\mathbf{B}_n(\sigma)$, the product of the cycle lengths of σ. Asymptotic lognormality of $\mathbf{N}_n$ can therefore be deduced from Erdős and Turán's theorem that $\mathbf{B}_n$ is itself asymptotically lognormal.

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CP12

Plane Permutations and their Applications

Plane permutations are motivated by a new way to look at one-face fatgraphs. Surprisingly, a natural transposition action on plane permutations allows us to study several other interesting problems. As consequences, we obtain several recurrences for enumerating hypermaps. We also obtain lower bounds for sorting (signed) permutations by transpositions, block-interchanges and reversals in a unified way. Furthermore, all these bounds can be interpreted as topological genus of certain fatgraphs associated to permutations.

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CP12

Grids, Diamonds, and the Comb Algorithm

In this talk, we briefly survey tools from discrete Morse theory useful for analyzing the independence complex of graphs. More specifically, we develop particular matching tree algorithms applied to certain grid graphs that obey cell-counting recursions connecting back to other seemingly unrelated combinatorial sequences.

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CP12

Generalizations of ErdŐs-Ko-Rado Theorem to $\{0, \pm 1\}$-Vectors

We discuss two generalizations of Erdős-Ko-Rado theorem to vectors with coordinates from the set $\{0, \pm 1\}$. In the first case we deal with vectors that have fixed number of 1's and -1's, while in the second case we fix only the number of nonzero coordinates. Consider families of such vectors which additionally avoid "small" scalar products. In several scenarios we determine the maximum of the size of such families. Several interesting tools from extremal set theory arise while solving these problems.

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CP12

Saturation Multiplicity of Graphs

Given a graph F, a graph G is *F-saturated* if G does not contain a copy of F, but the addition of any edge to G completes a copy of F. In this talk we explore the average number of copies of F that are completed when a single edge is added to an F-saturated graph G, which we call the *F-saturation multiplicity* of G. We will focus on the extreme values of this parameter when F is fixed, in particular the maximum value when F is a tree. This is joint work with Derrick Stolee.

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CP13

Characterization of Unit Interval Bigraphs of Open and Closed Intervals

The class of finite intersection graphs of the open and closed real intervals of unit length is a strict superclass of the well-known class of unit interval graphs. Rautenbach and Szwarcfiter characterized this class of graphs. Analogously we show that the finite intersection bigraphs of open and closed intervals of unit length are a strict superclass of the class of unit interval bigraphs. We also characterize this class of bigraphs in terms of forbidden bigraphs.

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CP13

On the Largest Number of Colorings of a Graph

Let $\mathcal{C}_k(n)$ be the family of all connected k-chromatic graphs of order n. We discuss recent results on the following problem: given a natural number $x \geq k$, what is the maximum number of x-colorings among graphs in $\mathcal{C}_k(n)$?

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CP13

Short Containers in Modified Line Digraphs

A container of a graph gives a measure of the minimum distance from any node to several other nodes through node disjoint paths. For a class of Uniform Modified Line Digraphs good upper bounds on the container length is determined in terms of the number of nodes and degree. Small bounds on the w-wide and w-star diameters results in good applications to fault tolerant networks based on these graphs.

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CP13

Large Induced Forests in Planar and Subcubic Graphs of Girth 4 and 5

An induced forest in a graph is an induced subgraph with no cycles. We prove lower bounds on the number of vertices in the largest induced forest of a subcubic graph with girth at least 4 or 5 or of a planar graph with girth at least 5. The bounds for subcubic graphs extend a result of Alon, Mubayi and Thomas. The bounds for planar graphs improve a result of Dross, Montassier, and Pinlou and confirm a case of one of their conjectures. The lower bounds are tight for infinitely many graphs. Joint work with Chun-Hung Liu.

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CP13

When Every Minimal Separator is Complete Multipartite

Complete multipartite graphs range from complete graphs (with every partite set a singleton) to edgeless graphs (with a unique partite set). Requiring every minimal vertex separator to be one of these extremes characterizes, respectively, the classical chordal graphs and the recently studied unichord-free graphs. I will discuss what happens when minimal separators are just required to be complete multipartite or special cases that arise from generalizing chordal graphs and generalizing unichord-free graphs.

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CP13

A New Proof of Seymour's 6-Flow Theorem

Tutte's famous 5-flow conjecture asserts that every bridgeless graph has a nowhere-zero 5-flow. Seymour proved that every such graph has a nowhere-zero 6-flow. We give two new proofs of Seymour's Theorem. Both are roughly equal to Seymour's in terms of complexity, but they offer an alternative perspective which we hope will be of value.

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CP13

On Forbidden Induced Subgraphs for Unit Disk Graphs

A unit disk graph is the intersection graph of disks of equal radii in the plane. The class of unit disk graphs is hereditary, and therefore can be characterized in terms of minimal forbidden induced subgraphs. In spite of quite active study of unit disk graphs very little is known about minimal forbidden induced subgraphs for this class. We found only finitely many minimal non unit disk graphs in the literature. In this paper we study in a systematic way forbidden induced subgraphs for the class of unit disk graphs. We develop several structural and geometrical tools, and use them to reveal infinitely many new minimal non unit disk graphs. Further we use these results to investigate structure of co-bipartite unit disk graphs. In particular, we give structural characterization of those co-bipartite unit disk graphs whose edges between parts form a C_4-free bipartite graph, and show that bipartite complements of these graphs are also unit disk graphs. Our results lead us to propose a conjecture that the class of co-bipartite unit disk graphs is closed under bipartite complementation.

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CP14

On Ordered Ramsey Numbers of Bounded-Degree Graphs

The ordered Ramsey number of an ordered graph $\mathcal{G}$ is the minimum N such that every 2-coloring of the ordered $\mathcal{K}_N$ contains a monochromatic copy of $\mathcal{G}$. We show that there are 3-regular graphs on n vertices with the ordered Ramsey numbers superlinear in n, regardless of the ordering. This solves a problem of Conlon, Fox, Lee, and Sudakov. We also prove that the above statement does not hold for 2-regular graphs.

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CP14

Ramsey Goodness of Bounded Degree Trees

Given a connected graph G and a graph H with chromatic number $\chi(H)$ and size of the smallest color class in an optimal coloring $\sigma(H)$, it is easy to show that the Ramsey number $R(G, H) \geq (|G| - 1)(\chi(H) - 1) + \sigma(H)$. When equality occurs G is called H-good, a notion introduced by Burr and Erdős in 1983. In this paper, we show that any bounded degree tree T is H-good, provided that $|T| \geq \Omega(|H| \log^4 |H|)$. This substantially improves an old result of Erdős, Faudree, Rousseau, and Schelp, who proved it when $|T| \geq \Omega(|H|^4)$.

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CP14

Online Ramsey Theory for C_3

Online Ramsey theory is a study on the online version of Ramsey theory. Given a fixed graph H and a class $\mathcal{C}$ of graphs, an *online Ramsey game* for H on $\mathcal{C}$ is a game between two players Builder and Painter with the following rules: On each round, Builder draws a new edge with the constraint that the resulting graph must be in $\mathcal{C}$ and

Painter colors the new edge either red or blue. Builder wins if Builder can force Painter to make a monochromatic copy of H at some point of the game, and Painter wins if a monochromatic copy of H can be avoided forever. Online Ramsey game was first investigated in 2004 by Grytczuk, Hałuszczak, and Kierstead where they studied online Ramsey game on forests, k-colorable graphs, outerplanar graphs, and planar graphs. Recently, Petříčková continued the study on planar graphs further by disproving a conjecture by Grytczuk, Hałuszczak, and Kierstead. We focus on characterizing the classes where Builder wins the online Ramsey game for C_3 on F-free graphs when F-free graphs is the class of graphs not containing F as a subgraph; we succeed the characterization except for when F is one particular graph. We also prove that Builder wins the online Ramsey game for C_3 on K_4-minor-free graphs; this extends a result by Grytczuk, Hałuszczak, and Kierstead.

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CP14

Bounded Colorings of Multipartite Graphs

The problem of finding properly colored and rainbow Hamilton cycles in an edge-coloring of K_n was initiated in 1976 by Bollobás and Erdős. We study its multipartite analogues, giving optimal sufficient conditions for a coloring c of the complete m-partite graph to contain a properly colored or rainbow copy of a given graph G with maximum degree Δ. Our bounds exhibit a surprising transition in the growth rate, showing that the problem is fundamentally different in the regimes $\Delta \gg m$ and $\Delta \ll m$.

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CP14

Diagonal Forms of Incidence Matrices Arising from Bipartite Graphs and Applications to Zero-Sum Ramsey Problems

Let G be a subgraph of $K_{n,n}$. Let $N(G)$ be the incidence matrix with edges against isomorphic copies of G in $K_{n,n}$. I will present a general formula for a diagonal form of $N(G)$ for every G, and give a new proof of Caro and Yuster's results on zero-sum (mod 2) bipartite Ramsey numbers. Finding diagonal forms also interests Chandler, Sin, Xiang, and Wilson, while zero-sum Ramsey problems also interest Bialostocki, Dierker, and Alon.

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CP15

On the Widom-Rowlinson Occupancy Fraction in Regular Graphs

We consider the Widom-Rowlinson model of two types of interacting particles on d-regular graphs. We prove a tight upper bound on the expected fraction of vertices occupied by a particle in a random configuration from the model. The bound is achieved uniquely by unions of complete graphs on $d+1$ vertices, K_{d+1}'s. As a corollary, K_{d+1} also maximizes the normalized partition function of the Widom-Rowlinson model over the class of d-regular graphs, proving a conjecture of Galvin.

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CP15

The Graded Lexicographic Polytope and Two New Families of Dantzig Figures

A Dantzig figure is a d-polytope with $2d$ facets that has an isolated pair of vertices. We contribute two new families of Dantzig figures and also analyze their diameters and volume. The first family is the convex hull of $\{x \in \mathbb{Z}^d_+ : x \preceq \theta\}$, for any fixed integer vector θ and $\preceq$ being the grevlex monomial order. We characterize its vertices and obtain its H-representation using a cone lemma for general polyhedra. This polytope has a unique isolated pair of vertices. The second family we analyze is the divisible knapsack polytope, whose H-representation is well-known.

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CP15

Local Polyhedrality of Integer Hulls of Strict Convex Sets

A strict convex set is called a costrict convex set if it is either closed or relatively open. We will show that the integer hull(closed convex hull of integer points) of a costrict convex set is locally polyhedron if the integer hull is contained in it.

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CP15

Discrete Curvature and Abelian Groups

We discuss a discrete Bochner-type inequality on graphs, and explore its merit as a notion of curvature in discrete spaces. An appealing feature of this version of the so-called Γ_2-calculus is that it is straightforward to compute the curvature parameter for several specific graphs of interest, particularly, abelian groups. We develop this notion by deriving Buser-type inequalities, providing a tight bound on the Cheeger constant in terms of the spectral gap for graphs with nonnegative curvature.

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CP15

Reconstructing a Finite Topological Space from Quotient-Spaces

Given a topology defined on a finite set T with n points, consider the n-1 quotient-spaces obtained by identification of one point of T with each one of the other n-1 points. We look at the inverse problem: Given (up to homeomorphism) the topologies on the quotient-spaces, reconstruct the topology on T.

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MS1

On Polar and Reed-Muller Codes via Independence

This talk overviews our recent results with A. Shpilka and A. Wigderson on RM codes, and Y. Wigderson on polar codes, for the BEC and the BSC. In particular, we discuss how the probability of sampling independent columns in the parity-check matrix can be estimated in some regimes, yielding results for both channels.

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MS1

Generalized Hamming Weights of Projective Reed-Muller Codes

An important parameter of a linear error-correcting code C is its minimum distance. This parameter has been generalized to what is known as generalized (Hamming) weights of a code. The r-th generalized Hamming weight is the minimum support of an r-dimensional subcode of C. The first generalized weight is exactly the minimum distance. Projective Reed–Muller codes are natural extensions of the usual Reed–Muller codes. In this talk I will discuss recent work together with M. Datta and S.R. Ghorpade on the generalized weights of these codes. In particular for the projective Reed–Muller codes $\mathrm{PRM}_q(d,m)$ with $d \leq q$ we determined the r-th generalized Hamming weights for $r \leq m+1$.

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MS1

Signature Codes for Multiple-Access Channels - Part II

In this talk we give an overview of rather old and very recent results related to the performance of signature codes for the following most interesting and well-investigated examples of noiseless multiple-access channels: adder channel, M-frequency channel with and without intensity information, disjunctive (or superimposed) channel. We discuss not only results on signature codes for these channels but their applications also, namely, adder and disjunctive channels to group testing, and M-frequency channel to multimedia fingerprinting.

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MS1

Signature Codes for Multiple-Access Channels - Part I

In this talk we give an overview of rather old and very recent results related to the performance of signature codes for the following most interesting and well-investigated examples of noiseless multiple-access channels: adder channel, M-frequency channel with and without intensity information, disjunctive (or superimposed) channel. We discuss not only results on signature codes for these channels but their applications also, namely, adder and disjunctive channels to group testing, and M-frequency channel to multimedia fingerprinting.

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MS1

Decoding Reed-Muller Codes from Random Errors

Reed-Muller codes encode an m-variate polynomial of degree r by its evaluations over all points in $\{0,1\}^m$. In this talk we will see an efficient algorithm for correcting random errors in Reed-Muller codes far beyond the minimal distance, and discuss its connections with recent advances regarding decoding *erasures* in Reed-Muller codes. Based on a joint work with Ramprasad Saptharishi and Amir Shpilka.

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MS2

Extremal Properties of Vertex Attributes in Trees

For tree T and vertex v, define the eccentricity $ecc(v) := \max_{u\in V(T)} d(u,v)$, the distance $d(v) := \sum_{u\in V(T)} d(u,v)$ and the number of subtrees $F(v)$ containing vertex v. Each defines a "middle" of the tree consisting of the vertices with the maximum (or minimum) value. First, we explore the interactions of $ecc(v)$ and the total eccentricity $Ecc(T) := \sum_{v\in V(T)} ecc(v)$ by examining extremal values and structures for the ratios $\frac{ecc(v)}{ecc(u)}$ and $\frac{Ecc(T)}{ecc(v)}$. Analogous studies have been done for distance [Barefoot, Entringer, Székely, Discrete Appl. Math. **80** (1997), 37-56] and number of subtrees [Székely, Wang, Electron. J. Combin. **20** (2013) 1-20]. We also compare the three different middles, determining how far apart they can appear in a single tree and characterizing many of the extremal structures.

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MS2

Subtrees of Trees: Labeled and Unlabeled

This talk surveys results on subtrees (in particular quartet trees) of binary phylogenetic trees, and results on the number of subtrees (or isomorphism types of subtrees) for all subtrees and for subtrees of particular size.

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MS2

The Number of Automorphisms of Random Trees

By means of an asymptotic analysis of generating functions, we determine the limiting distribution of the order of the automorphism group of a random labeled tree. To be precise, we show that the logarithm of the number of automorphisms, suitably renormalized, converges weakly to a standard normal distribution. This result is also further extended to other random tree models.

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MS2

Extremal Ratio Questions in Binary Trees

The values of various important topological indices, when considered as a local function associated with vertices of trees, tend to achieve the extrema at leaves or in the "middle' of a tree. To consider the extremal ratios of such values turns out to be a much more difficult question than general extremal problems. Such problems were considered for the distance function and number of subtrees in general trees. We examine the same questions on binary trees as an effort to generalize this study. Some new results will be provided along with many questions.

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MS2

Species Tree Estimation in the Presence of Incomplete Lineage Sorting

Species tree estimation in the presence of gene tree incongruence is one of the challenges in mathematical phylogenetics. However, coalescent-based estimation methods are impacted by gene tree estimation error, so that they can be less accurate than the traditional approach of concatenation in many cases. I will also present two new methods, ASTRAL (Mirarab et al., Bioinformatics 2014) and statistical binning (Mirarab et al., Science 2014, Bayzid et al., PLOS One 2015) for estimating species trees in the presence of gene tree conflict due to ILS. Statistical binning and weighted statistical binning are used to improve gene tree estimation, while ASTRAL is a coalescent-based method that is provably statistically consistent and that can construct very accurate large species trees. Finally, I will present theoretical results investigating whether statistically consistent accurate species tree estimation is possible when gene trees have estimation error, and discuss the controversy about statistical binning (Liu and Edwards, Science 2015, Mirarab et al. Science 2015).

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MS3

New Results on Packing Odd Trails

There is no packing-covering duality for odd edge-disjoint (u, v)-paths: a graph with no two edge-disjoint (u, v)-paths may need an arbitrarily large number of edges to cover all such paths. In contrast, the relaxed problem of packing odd trails does have an approximate duality. We first show that a graph has either k edge-disjoint odd (u, v)-trails or a set of at most $6k$ edges intersecting all such trails. Then, we present a new, alternate proof for Eulerian graphs that yields a sharper bound.

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MS3

Decomposing 4-Regular Random Graphs into Claws

In 2006 Barát and Thomassen conjectured that every planar 4-regular 4-edge-connected graph has an edge decomposition into claws; shortly after, Lai constructed a counterexample. Using the small subgraph conditioning method of Robinson and Wormald, we show that a.a.s. a random 4-regular graph has an edge decomposition into claws. If time permits, then we will explore more general star decomposition results.

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MS3

Finding Immersions of Digraphs with Parity Restrictions

We introduce the concept of odd immersion of a directed graph D, which is an immersion where the length of the image of every arc in D has prescribed parity. We explore plausible settings for the problem of finding an odd immersion of a digraph and present results about it.

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MS3

Notions of Convergence for Sequences of Graphs

There are various notions of convergence for graph sequences. Some involve local properties of the graph, and some involve more global properties. Implications between these convergences give rise to implications between certain properties of graphs. In some cases, local properties end up implying global properties of graphs. We discuss some recent results in this area.

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MS3

Normal Graph Covers

A graph is normal if it admits a clique cover $\mathcal{C}$ and a stable set cover $\mathcal{S}$ such that each clique in $\mathcal{C}$ and each stable set in $\mathcal{S}$ have a vertex in common. The pair $(\mathcal{C}, \mathcal{S})$ is a normal cover of the graph. We present the following extremal property of normal covers. For positive integers c, s, if a graph with n vertices admits a normal cover with cliques of sizes at most c and stable sets of sizes at most s, then $c + s \geq \log_2(n)$. For infinitely many n, we also give a construction of a graph with n vertices that admits a normal cover with cliques and stable sets of sizes less than $0.87 \log_2(n)$. When c or s are small, we can describe all normal graphs with the largest possible number of vertices that allow a normal cover with cliques of sizes at most c and stable sets of sizes at most s. However, such extremal graphs remain elusive even for moderately small values of c and s.

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MS4

The Packing/Covering Conjecture

I'll introduce the Packing/Covering Conjecture (also known as the Infinite Matroid Intersection Conjecture), which is the most important open problem in the theory of infinite matroids. I'll explain why it is interesting and what progress has been made on solving it.

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MS4

The Cunningham-Geelen Method in Practice: Branch-Decompositions and Integer Programming

Consider the integer program $\max(c^T x : Ax = b, x >= 0,)$ where A is non-negative and the column-matroid of A (denoted by $M(A)$) has constant branch width. Cunningham and Geelen introduce a pseudo-polynomial time algorithm for solving this integer program that takes a branch decomposition T of $M(A)$ as input. We describe a heuristic for finding T and report on computation results of a C++ implementation of this algorithm, where the input branch decomposition T is produced by this heuristic.

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MS4

Excluded Minors for Matroids of Rank Three

As a means to characterize matroids, the subject of excluded minors has been actively investigated. A class of matroids representable over finite fields is known to have a finite number of excluded minors, while there are other matroids having infinitely many excluded minors. In this talk, given a class of matroids with infinitely many excluded minors, we ask the question: does the number of excluded minors for the class become finite when we impose the rank of the matroids to be three?

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MS4

A Matroid Analogue of a Theorem of Brooks for Graphs

Brooks proved that the chromatic number of a loopless connected graph G is at most the maximum degree of G unless G is an odd cycle or a clique. This talk will present an analogue of this theorem for $GF(q)$-representable matroids when q is prime, thereby verifying a natural generalization of a conjecture of Peter Nelson.

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MS4

When Matroids are Highly Connected

A general theme in matroid structure theory is that highly connected matroids exhibit more structure than matroids with a low-order separation. We will explore several examples of this, focussing mostly on matroids that have high branch-width.

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MS5

Planar Graphs of Girth at Least Five are Square $(\Delta+2)$-Choosable

We prove a conjecture of Dvořák, Král, Nejedlý, and Škrekovski that planar graphs of girth at least five are square $(\Delta+2)$-colorable for large enough Δ. In fact, we prove the stronger statement that such graphs are square $(\Delta+2)$-choosable and even square $(\Delta+2)$-paintable. This is joint work with Marthe Bonamy and Luke Postle.

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MS5

Two-Coloring Number of Planar Graphs

Two-coloring number (also known as arrangeability) is an interesting graph parameter related to acyclic chromatic number and game chromatic number, but also appearing in the contexts of structural and Ramsey graph theory. Kierstead and Trotter proved that two-coloring number of planar graphs is bounded by 10, and this bound was improved to 9 by Kierstead et al. in 2009. We show that two-coloring number of planar graphs is bounded by 8, which is tight.

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MS5

Precoloring Extension for Planar Graphs

Aksenov proved that in a planar graph G with at most one triangle, every precoloring of a 4-cycle can be extended to a 3-coloring of G. We give an exact characterization of planar graphs with two triangles in that some precoloring of a 4-cycle does not extend. We apply this characterization to solve the precoloring extension problem from two 4-cycles in a triangle-free planar graph in the case that the precolored 4-cycles are separated by many disjoint 4-cycles. As a corollary, we prove that there exists a constant $D > 0$ such that if H is a planar triangle-free graph and $S \subseteq V(H)$ consists of vertices at pairwise distances at least D, then every precoloring of S extends to a 3-coloring of H. This gives a positive answer to a conjecture of Dvořák, Král' and Thomas, and implies an exponential lower bound on the number of 3-colorings of triangle-free planar graphs of bounded maximum degree.

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MS5

Clique Immersion in Graph Products

Immersion is a containment relation in graphs that is similar to the well-known minor relation, but is incomparable. In this talk, we ask: given a graph G_1 with a K_t-immersion and a graph G_2 with a K_r-immersion, what is the largest clique immersion in $G_1 * G_2$ (where $*$ defines a particular graph product)? Jointly with Collins and Heenehan, we have best possible results for certain products, and conjectures for others. All is considered in the context of an immersion-analog of Hadwiger's Conjecture, due to Abu-Khazm and Langston, which says that when $\chi(G) \geq k$, G should contain a K_k-immersion.

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MS5

Common Vertex of Longest Cycles of Special Chordal Graphs

It is conjectured that all longest cycles in any 2-connected chordal graph have a common vertex, where a chordal graph can be considered as the intersection graphs of a collection of subtrees of a host tree. We prove the case that the host tree has at most two vertices with degree at least three.

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MS6
On Graphs Decomposable into Induced Matchings of Linear Sizes

A Ruzsa-Szemeredi graph is a graph on n vertices whose edge set can be partitioned into induced matchings of size cn. The study of these graphs goes back more than 35 years and has connections with number theory, combinatorics, complexity theory and information theory. In this talk we will discuss the history and some recent developments in this area. In particular, we show that when $c > 1/4$, there can be only constantly many matchings. On the other hand, for $c = 1/4$, the maximum number of induced matchings is logarithmic in n. This is joint work with Jacob Fox and Benny Sudakov.

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MS6
Turan Numbers of Small Subdivisions

Existence of subdivisions in a graph has been extensively studied. Here, we study the density threshold for the existence of a subdivision with bounded size. Let H be a given graph and p a positive even integer at least 2. Let $ex(n, H^{\leq p})$ denote the maximum number of edges in an n-vertex graph that does not contain a subdivision of H in which each edge of H is subdivided at most $p-1$ times. Jiang showed that $ex(n, H^{\leq p}) = O(n^{1+10/p})$. Here we substantially improve the bound for bipartite graphs H. We show that for any bipartite graph H, $ex(n, H^{\leq p}) = O(n^{1+2.76/p})$. On the other hand, random graphs show that $ex(n, K^{\leq p}_{m,m}) \geq \Omega(n^{1+1/p-2/mp+1/m^2p})$. We also give sharper bounds for some small values of p and some related results. Our method uses a combination of dependent random choice and other combinatorial arguments. This is joint work with Jie Ma.

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MS6
On the Edit Distance of Powers of Cycles

The edit distance between two graphs on the same labeled vertex set is defined to be the size of the symmetric difference of the edge sets, divided by $\binom{n}{\lfloor n/2 \rfloor}$. The edit distance function of a hereditary property $\mathcal{H}$ is a function of $p \in [0,1]$ that measures, in the limit, the maximum normalized edit distance between a graph of density p and $\mathcal{H}$. It is also, again in the limit, the edit distance of the Erdős-Rényi random graph $G(n,p)$ from $\mathcal{H}$. In this talk, we address the edit distance function for Forb(H), where $H = C_h^t$, the t^{th} power of the cycle of length h. For $h \geq 2t(t+1)+1$ and h not divisible by $t+1$, we determine the function for all values of p. For $h \geq 2t(t+1)+1$ and h divisible by $t+1$, the function is obtained for all but small values of p. We also obtain some results for smaller values of h.

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MS6
How Unproportional Must a Graph Be?

Let $u_k(G,p)$ be the maximum over all k-vertex graphs F of by how much the number of induced copies of F in G differs from its expectation in the Erdős-Rényi random graph with the same number of vertices as G and with edge probability p. This may be viewed as a measure of how close G is to being p-quasirandom. For a positive integer n and $0 < p < 1$, let $D(n,p)$ be the distance from $p\binom{n}{2}$ to the nearest integer. Our main result is that, for fixed $k \geq 4$ and for n large, the minimum of $u_k(G,p)$ over n-vertex graphs has order of magnitude $\Theta\Big(\max\{D(n,p), p(1-p)\}n^{k-2}\Big)$ provided that $p(1-p)n^{1/2} \to \infty$.

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MS6
Locally Common Graphs and Locally Sidorenko Graphs

A graph H is common if, in any two-edge-coloring of K_n, the number of monochromatic copies of H is asymptotically at least the expected number in a uniform random coloring. Erdős conjectured in 1962 that every clique is common, and Burr and Rosta in 1980 further conjectured that all graphs are common. Thomason disproved these conjectures by showing that no K_t with $t \geq 4$ is common. Sidorenko and independently Erdős and Simonovits conjectured that every bipartite graph H is common and further has the following stronger property: the minimum possible number of copies of H in a graph on n vertices with fixed edge density p is asymptotically the expected number in the random graph $G(n,p)$. Lovász began the study of the local Sidorenko property and locally common graphs, and proved that bipartite graphs have the local Sidorenko property. We discuss recent work extending this result, proving that a graph has the local Sidorenko property if and only if it has even girth. We also discuss further progress toward characterizing the locally common graphs.

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MS7

The Role of Completely Regular Codes

Neumaier conjectured in 1992 that the only completely regular code with $|C| > 2$ and minimum distance at least eight is the extended binary Golay code. A slightly corrected version of this conjecture remains open. In recent work with W.S. Lee, J.H. Koolen, and H. Tanaka, we classify all linear completely regular codes whose dual codes have weights $0, t, 2t, \ldots$. This family of codes forms a beautiful chapter in the theory of association schemes.

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MS7

Locally Repairable Codes and Index Coding

Given an n-vertex graph $G(V \equiv \{1, 2, \ldots, n\}, E)$, let $N(i) \equiv \{j \in V : (i, j) \in E\}$ be the set of neighbors of vertex i. Also let $H(X)$ be the Shannon entropy of the random variable X. For identical random variables $X_i, i \in V$ with finite support, consider the solution of the optimization problem: max $H(X_1, \ldots, X_n)$ such that $H(X_i|\{X(j), j \in N(i)\}) = 0$, for all $i \in V$. This is the optimum rate of a locally repairable code over the graph G. On the other hand, consider the solution of the following optimization problem: min $H(Y)$ where Y is such that $H(X_i|Y, \{X(j), j \in N(i)\}) = 0$, for all $i \in V$. This is called the optimum index coding rate for the graph G. Both of these quantities have been subject to a lot of recent research in the information and coding theory communities. In this talk we will present several new results regarding these two quantities, including bounds and constructions.

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MS7

DNA Profile Codes

We consider the problem of storing and retrieving information from synthetic DNA media. The mathematical basis of the problem is the construction and design of sequences that may be discriminated based on their collection of substrings observed through a noisy channel. This problem of reconstructing sequences from traces was first investigated in the noiseless setting under the name of "Markov type' analysis. Here, we explain the connection between the reconstruction problem and the problem of DNA synthesis and sequencing, and introduce the notion of a DNA storage channel. We analyze the number of sequence equivalence classes under the channel mapping and propose new asymmetric coding techniques to combat the effects of synthesis and sequencing noise. In our analysis, we make use of restricted de Bruijn graphs and Ehrhart theory for rational polytopes.

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MS7

Maximally Recoverable Codes - Part II

Data storage applications require erasure-correcting codes with prescribed sets of dependencies between data symbols and parity symbols (topology). A code as above is maximally recoverable, if it corrects all erasure patterns that are information theoretically correctable given the dependency constraints. Applications furthermore need codes over small finite fields in order to facilitate encoding and decoding operations. In this talk we present the first super-polynomial lower bound for the field size of maximally recoverable codes (in any topology) and survey the state of the art in code constructions.

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MS7

Maximally Recoverable Codes - Part I

Data storage applications require erasure-correcting codes with prescribed sets of dependencies between data symbols and parity symbols (topology). A code as above is maximally recoverable, if it corrects all erasure patterns that are information theoretically correctable given the dependency constraints. Applications furthermore need codes over small finite fields in order to facilitate encoding and decoding operations. In this talk we present the first super-polynomial lower bound for the field size of maximally recoverable codes (in any topology) and survey the state of the art in code constructions.

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MS8

Metric Graphs with Prescribed Gonality

We prove that in the moduli space of genus-g metric graphs the locus of graphs with gonality at most d has the classical dimension min3g-3,2g+2d-5. Here, gonality is geometric gonality rather than divisorial gonality, i.e., it is the minimal degree of a non-degenerate harmonic map to a tree that satisfies the Riemann-Hurwitz condition everywhere. Our theorem follows from a careful parameter count to establish the upper bound and a construction of sufficiently many graphs with gonality at most d to establish the lower bound. In particular, we give an elementary (combinatorial) proof of the fact that for each combinatorial type given by a trivalent graph of genus g, there is an open cone in edge-length space where the metric graph has gonality equal to (g+2)/2 rounded upwards.

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MS8

A Tropical Bott-Samelson Variety from Matroids Over Valuation Rings

Matroids over a valuation ring, in the sense of Fink and Moci, are complicated objects, by comparison with matroids over the tropical hyperfield in the recent sense of Baker – while the latter contain only the data of a tropical linear space, the former contain much more. We review matroids over a valuation ring, discuss their parameter space, and explain how this space can be interpreted as a flavour of tropical Bott-Samelson variety.

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MS8

A Grassmann Algebra for Matroids

I'll discuss joint work with J.H. Giansiracusa in which we introduce an exterior algebra in the idempotent setting which plays the role for tropical linear spaces (and hence for valuated matroids) that the exterior algebra does for linear spaces over a field. In the special case of the Boolean semifield, this yields a mulitlinear-algebraic cryptomorphism for matroids.

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MS8

Tropical Ideals

The past few years have seen a significant effort to give tropical geometry a solid algebraic foundation. In this talk I will introduce tropical ideals, which are homogeneous ideals over the tropical semiring in which each graded piece is "matroidal". I will discuss joint work with Diane Maclagan studying some of their main properties, and in particular showing that their underlying varieties are always finite polyhedral complexes. This supports the proposal that subschemes of tropical projective space should be defined by tropical ideals.

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MS9

Monochromatic Covers and Partitions of Random Graphs

Suppose the edges of a graph G are colored with r colors. How many monochromatic trees (or cycles, or paths) are needed to partition (or cover) the vertex set? When $G = K_n$, these types of questions have been addressed by many authors. For example, Haxell and Kohayakawa proved that r monochromatic trees suffice to partition the vertex set of K_n when n is sufficiently large. In this talk, we will discuss such questions when G is a random graph.

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MS9

Covering by Monochromatic Subgraphs – A Survey

In 1970, Ryser conjectured that every r-edge colored complete graph can be covered with at most $r-1$ monochromatic components. In 1989, Gyárfás conjectured that every r-edge colored complete graph can be partitioned into at most r monochromatic paths (and later Erdős, Gyárfás, and Pyber conjectured that the same result should hold for cycles). We will survey the current status of these conjectures and highlight some avenues of research which have developed as a result of their study.

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MS9

Partitioning a Graph into a Cycle and a Sparse Graph

Lehel conjectured that any graph G can be partitioned into cycle C_1 in G and cycle C_2 in the complement of G. This was proved by Bessy and Thomassé (after previously being proven for large graphs by Łuczak, Rödl, and Szemerédi, and by Allen). We'll discuss strengthenings of this conjecture which replace C_2 by an induced subgraph of G with small maximum degree. In particular G can be partitioned into a cycle C and a set A satisfying $\Delta(G[A]) \leq \frac{1}{2}(|A|-1)$.

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MS9

Monochromatic Paths in Graphs and Hypergraphs

Gyarfas conjectured any r-edge coloured complete graph can be partitioned into r monochromatic paths, and the conjecture has been confirmed for $r \leq 3$. This talk is about extensions of the Gyarfas' conjecture to hypergraphs, for the two colour case. This is based on joint work with Bustamante and Han.

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MS10

The Game of Zombies and Survivors on Graphs

In the game of Zombies and Survivors, a set of zombies attempts to eat a lone survivor loose on a given graph. The zombies randomly choose their initial location, and always move directly toward the survivor via randomly chosen geodesics. We provide an update on the zombie number of a graph for families such as toroidal graphs, as well as new results on the introduction of deterministic cops (or necromancers) in the game.

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MS10

Cops and Robber with Decoys

We introduce a variation in which the robber side consists of a robber and a decoy which are indistinguishable to the cops except under certain conditions. The robber can throw the decoy to a neighbouring vertex on any move beyond his first. The decoy disappears after the cops' next move. We characterize decoy copwin graphs if the cop can distinguish between the robber and decoy only when on the same vertex as one of them.

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MS10

Watching Block Intersection Graphs

The watchman's walk on a graph G is a minimum closed dominating walk on G. We give bounds on the length of a watchman's walk on the block intersection graphs of Steiner triple systems, and show that the minimum bound is attainable for all orders of STS(v).

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MS10

Walker-Breaker Game

We consider a variation on Maker-breaker games. Walker walks along the edges of a graph, claiming them as her own, while Breaker in turn deletes edges. We discuss the question of how many vertices can Walker visit before she gets stuck. We also discuss a paper by Clements and Tran on creating cycles.

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MS11

The Erdős-Hajnal Conjecture and Structural Theory of H-Free Graphs

The celebrated Erdős-Hajnal conjecture formulated in 1989 states that for every undirected graph H there exists $\epsilon(H) > 0$ such that every H-free n-vertex graph contains either a clique or a stable set of order at least $n^{\epsilon(H)}$. In its equivalent directed version undirected graphs are replaced by tournaments and cliques/stable sets by transitive subtournaments. Even though the conjecture is still open, very recently several new techniques were proposed to prove many difficult special cases of the conjecture. In particular, the conjecture was proven to be true for infinitely many prime tournaments. Furthermore, the weaker version of the conjecture, where one excludes both H and the complement of H, was proven to be true for all trees on at most six vertices. In this talk I will summarize these results as well as explain some of the aforementioned techniques. Finally, I will explain how the conjecture and techniques developed to prove the conjecture can be applied in other fields of computer science such as machine learning.

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MS11

Title Not Available

Abstract not available

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MS11

The Clique Number and the Smallest Q-Eigenvalue of Graphs

Let $q_{\min}(G)$ stand for the smallest eigenvalue of the signless Laplacian of a graph G of order n. This talk presents some results on the following extremal problem: *How large can* $q_{\min}(G)$ *be if* G *is a graph of order* n, *with no complete subgraph of order* $r+1$? It is shown that this problem is related to the well-known topic of making graphs bipartite. Using known classical results, several bounds on $q_{\min}$ are obtained, thus extending previous work of Brandt for regular graphs. This is joint work with Leonardo de Lima and Carla Oliveira.

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MS11

Improperly Coloring K_{t+1} Minor-Free Graphs

We show that every $t \geq 0$ there exists c_t such that, if a graph G has no K_{t+1} minor, then its vertex set can be partitioned into at most t parts such that every part induces a subgraph with maximum component of size $\leq c_t$. This relaxation of Hadwiger's conjecture improves previous results of Kawarabayashi and Mohar, Wood, and Liu and Oum, who proved that the conclusion holds for partitions into $\lceil 31(t+1)/2 \rceil$, $\lceil 7t/2 - 1/2 \rceil$ and $3t$ parts, respectively

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MS11

Turan Number of Hypergraphs via Lagrangians

Abstract not available

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MS12

Biclustered Matrix Completion

We consider the problem of performing matrix completion with side information on row-by-row similarities and column-by-column similarities. We build upon recent proposals for matrix estimation with smoothness constraints with respect to row and column graphs. In this talk, we address the unaddressed issue in model selection in these approaches, namely how to choose an appropriate amount row and column smoothing. We also discuss how to exploit the sparsity structure of the problem to scale up the estimation and model selection procedure. We present simulation results and an application to predicting associations in high-dimensional imaging-genomics studies.

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MS12

On the Origin of Locality in Algorithms for Graph Analysis on Massive Graphs

Abstract not available

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MS12

Sampling Paths in Graphs: A Simple Technique for Not So Simple Problems

Consider the following important graph analysis problems: (i) given a graph G, estimate the number of triangles in G. (ii) Estimate the frequency of small subgraphs (especially cliques) in G. Seemingly unrelated, consider these other problems. (i) Given a set of high-dimensional points, rapidly answer nearest neighbor queries (ii) Given two matrices, determine the largest entries in their product. Surprisingly, a fairly simple technique provides algorithms for all these problems. That technique is path sampling, where we set up data structures to, well, sample paths in graphs. This method leads to provable algorithms that have excellent practical performance. This talk will give a survey of this method and its connection to numerous data analysis problems.

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MS12

Accurate Inferences Beyond the Empirical Distribution

We consider the problem of making accurate inferences about a complex distribution, in the regime in which the amount of data (i.e the sample size) is too small for the empirical distribution of the samples to be an accurate representation of the underlying distribution. Our first result is that given n samples drawn from an arbitrary distribution over a discrete support, one can accurately recover the unlabelled vector of probabilities of all domain elements whose true probability is greater than 1/(n log n). Stated differently, one can learn–up to relabelling–the portion of the distribution consisting of elements with probability greater than 1/(n log n). This result has several curious implications, including leading to an optimal algorithm for "de-noising" the empirical distribution of the samples, and implying that one can accurately estimate the number of new domain elements that would be seen given a new larger sample, of size up to n* log n. (Extrapolation beyond this sample size is provable information theoretically impossible, without additional assumptions on the distribution.) While these results are applicable generally, we highlight an adaptation of this general approach to some problems in genomics (e.g. quantifying the number of unobserved protein coding variants), and discuss some future directions. This talk is based on two joint works, one with Paul Valiant, and one with Paul Valiant and James Zou.

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MS12

A Story of Principal Component Analysis in the Distributed Model

We consider an illustrative problem in distributed machine learning - computing a low rank approximation in the arbitrary partition model. In this model each of s servers holds an n x d matrix A^i, where each entry is an $O(lognd)$-bit word, and we let $A = A^1 + ... + A^s$. We would like each server to output the same k x d matrix V, so that V is an approximation to the top k principal components of A, in the sense that projecting onto V provides a $(1+\epsilon)$-approximate low rank approximation. We give the first communication optimal protocol for this problem, namely a protocol with communication $O(skd)+poly(sk/\epsilon)$ words, improving upon several previous works, and show how to implement the protocol in input sparsity time up to low order terms. Importantly our results do not make any condition number assumptions, yet still achieve the desired bit complexity. Based on work with Christos Boutsidis and Peilin Zhong.

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MS13

Quantization for Uniform Distributions on Equilateral Triangles

We approximate the uniform measure on an equilateral triangle by a measure supported on n points. We find the optimal sets of points (n-means) and corresponding approximation (quantization) error for $n \leq 4$, give numerical optimization results for $n \leq 21$, and a bound on the quantization error for $n \to \infty$.

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MS13

Pseudometrically Constrained Centroidal Voronoi Tessellations and its Application to Acquisition Design in MRI

This talk will outline a new centroidal Voronoi tessellation that can be used to generate highly uniform and antipodally symmetric point set on the unit sphere and to show its application in acquisition design for MRI. This methodology includes a novel pseudometric and a new strategy for tessellating the sphere. The time complexity of the proposed tessellations is effectively linear, i.e., on the order of the number of generators (or points on the unit sphere).

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MS13

An Algorithm for Computing CVTs for Any Cantor Distribution

Abstract not available

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MS13

Fast Methods for Computing Centroidal Voronoi Tessellations

A Centroidal Voronoi tessellation (CVT) is a Voronoi tessellation in which the generators are the centroids for each Voronoi region. CVTs have many applications to computer graphics, image processing, data compression, mesh generation, and optimal quantization. Lloyds method, the most widely method used to generate CVTs, converges very slowly for larger scale problems. Recently quasi-Newton methods using the Hessian of the associated energy as a preconditioner are developed to speed up the rate of convergence. In this work a graph Laplacian preconditioner and a two-grid method are used to speed up quasi-Newton schemes. The proposed graph Laplacian is always symmetric, positive definite and easy to assemble, while the Hessian, in general, may not be positive definite nor easy to assemble. The two-grid method, in which an optimization method using a relaxed stopping criteria is applied on a coarse grid, and then the coarse grid is refined to generate a better initial guess in the fine grid, will further speed up the convergence and lower the energy. Numerical tests show that our preconditioned two-grid optimization methods converges fast and has nearly linear complexity.

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MS13

Application of Centroidal Voronoi Tessellation in Continuous Optimization

Abstract not available

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MS14

Stochastic Mean Payoff Games are Tropical Semidefinite Programs

Semidefinite programming consists in minimizing a linear form over a spectrahedron, i.e., over a set defined by a linear matrix inequality. Such optimization problems make sense over any real closed field, and in particular, over the field of Puiseux series with real coefficients. This leads to the notion of *tropical spectrahedron*, defined as the image by the nonarchimedean valuation (leading exponent) of a spectrahedron over the field of Puiseux series. We provide a combinatorial characterization of a class of tropical spectrahedra arising as images of nonarchimedean spectrahedra given by generic matrices that have a Metzler-type sign pattern. Moreover, we show that solving the tropical semidefinite feasibility problems associated to this class is equivalent to solving stochastic mean payoff games with perfect information, a well known unsettled problem in algorithmic game theory, belonging to NP $\cap$ coNP but not known to be polynomial.

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MS14

Tropical Polynomial System Solving via Combinatorial Homotopy Continuation

We report on progress on solving systems of n topical polynomials in n unknowns. Our method uses homotopy continuation, meaning that solutions are tracked as the coefficients of the system vary generically. Careful attention to the coefficients gives an algorithm which is memoryless and exact, while it at the same time has complexity bounds similar to those of a recent algorithm by Malajovich. As in the numerical algebraic geometry case, all isolated tropical solutions are obtained. Finally we explain why quick generation of circuits of point configurations is important for the practical performance of the algorithm.

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MS14

Computing Linear Systems on Metric Graphs

A linear system $|D|$ of a divisor D on metric graphs is a set of effective divisors. It has the structure of a cell complex. We introduce the anchor divisors in it - they serve as the landmarks for us to compute the f-vector of the complex and find all cells in the complex. A linear system can also be identified as a tropical convex hull of rational functions. We compute the extremal generators of the tropical convex hull using the landmarks. We apply these methods to some examples - namely the canonical linear systems on K_4 and $K_{3,3}$.

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MS14

The Membership Problem for Tropical Secant Varieties

Let V be a tropical variety; the kth secant set of V is the set of tropical sums of k-tuples of elements in V. Secant sets of different tropical varieties are known under different names and find their applications in different contexts of mathematics. For instance, the Barvinok rank arises from computer science and corresponds to the case when V is the set of rank-one matrices. When V is the set of tree metrics, we get a concept useful in phylogenetics and known as a mixture of trees. I am going to describe briefly some applications in which membership problems for tropical secant sets are important. I will present my results on the computational complexity of these problems, and I will present counterexamples to several conjectures on this topic.

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MS15

Towards an Excluded-Minor Characterization of the Hydra-5 Matroids

This talk will give an overview of excluded-minor characterizations of classes of representable matroids, and outline the progress made towards an excluded-minor characterization of the class of Hydra-5 matroids.

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MS15

Templates for Minor-Closed Classes of Binary Matroids

Matroids conforming to a frame template are obtained by altering a graphic matroid in a certain way. We introduce a partial order on binary frame templates and a list of minimal nontrivial templates in this partial order. An application of this result is that all sufficiently highly connected 1-flowing matroids are either graphic or cographic. Other applications can be made to growth rates of minor-closed classes of binary matroids.

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MS15

Bounding the Beta Invariants of 3-Connected Matroids

The beta invariant of a matroid M, denoted by $\beta(M)$, is defined as $\beta(M) = (-1)^{r(M)} \sum_{A \subseteq E(M)} (-1)^{|A|} r(A)$. Crapo showed that M is connected if and only if $\beta(M) > 0$. Oxley determined all matroids with beta invariants at most four. We study the bounds of the beta invariants for 3-connected matroids. We also study the binary matroids with small beta invariants.

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MS15

Unavoidable Minors for Disjoint Bases in a Matroid

I will discuss a Ramsey theorem that gives one of two unavoidable minors in a matroid with two disjoint bases, and the links that this result has to matroid structure theory. This is joint work with Jim Geelen.

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MS15

Enumerating Matroids of Fixed Rank

We give lower and upper bounds on the number of matroids of fixed rank. The upper bound relies heavily on the theory of matroid erections, developed by Crapo and Knuth, to encode each matroid as a stack of paving matroids. Our bound is obtained by relating this stack to an antichain that completely determines the matroid. Along the way, we obtain that the essential flats of a matroid give a concise description of matroids.

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MS16

Fast and Efficient High Order Sparse Matrix QR Factorization for FPGAs

A hardware and power efficient sparse matrix operation design system is presented for QR factorization for FPGA systems. Sparse matrices appear in many applications such as digital signal processing, digital image processing, power system analysis, and finite element systems. In this paper, a new memory storage system and resource reuse methodology are proposed to minimize hardware area and scale down system memory. System verification of the design is done using MATLAB and C++. The design system can perform any size QR factorization and verification.

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MS16

Connections Between Power Domination and Zero Forcing

Zero forcing is a process on a graph that starts with a 2-coloring of its vertices, traditionally black and white. Zero forcing continues as long as it is possible to change the color of a vertex by the application of the following rule: every black vertex with exactly one white neighbor changes the color of its white neighbor to black. If at the end of the process all vertices are black, the initial set of black vertices is called a zero forcing set. The zero forcing problem consists of finding zero forcing sets of minimum cardinality. Power domination is a graph process in which initially a set of vertices observe its closed neighborhood. The process continues as long as the following rule can be applied: an observed vertex with exactly one un-observed neighbor observes the un-observed vertex. If at the end of this process all vertices are observed, the initial set of vertices is a power dominating set. The power domination problem consists of finding power dominating sets of minimum cardinality. In this talk we will show the relation between these two processes and its contribution to the advancement of research in both problems. Some results are joint work with several co-authors.

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MS16

A Minimum Rank Interpretation for Power Domination

Using Kirchoff's Law, it is possible to accurately monitor an entire power network while only directly monitoring the current and voltage at selected locations. Ideally, one would like to be able to reliably observe the entire network using as few Phasor Measurement Units (PMUs) as possible. Power domination is a combinatorial interpretation of the PMU placement problem. Given a graph $G = (V, E)$, and a set $S \subset V$, the power domination process loosely works as follows. S and $N(S)$ can be "observed'. There after, any vertex u becomes observed if it has an observed neighbor v with $N(v) - u$ all observed. The power domination number, $\gamma_P(G)$, is the size of the minimum set S which allows all vertices of G to eventually be observed. Recent work on the minimum rank problem on graphs in linear algebra has introduced a similar iterative process known as zero-forcing. The main application of the zero-forcing process is to generate bounds on many variations of the minimum rank problem. In this work, an analogous rank minimization problem is presented which provides a bounds on power domination. Given a graph G, we describe a family of matrices, $\mathcal{P}(G)$ where $\max_{P\in\mathcal{P}(G)} \dim\ker P \leq \gamma_P(G)$. Examples and applications are also provided.

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MS16

Searching for a 3-Separation Formula: Where to Begin?

A 2-separation of a graph G is a pair of edge-disjoint subgraphs (G_1, G_2) such that $|V(G_1) \cap V(G_2)| = 2$ and whose union is G. In 2008 van der Holst gave a formula for the maximum nullity/minimum rank of a graph with a 2-separation. A graph with a vertex of degree 3 has a simple 3-separation. We will discuss the conditions under which a formula for the max nullity/min rank exists in this special case of a 3-separation.

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MS16

On the Northeast Property of Signed Graphs with Loops

A signed graph (G, Σ) satisfies the Northeast Property if for each real symmetric matrix A on (G, Σ), with p positive eigenvalues, q negative eigenvalues, and $p + q <$ maximum rank of (G, Σ), there exists a matrix on (G, Σ) with $p + 1$ positive and q negative eigenvalues, and a matrix on (G, Σ) with p positive and $q + 1$ negative eigenvalues. In this talk we discuss the Northeast Property of some classes of signed graphs.

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MS17

Minimum Number of Edges in Odd Cycles

Erdős, Faudree and Rousseau conjectured in 1992 that for every $k \geq 2$ every graph with n vertices and $\lfloor n^2/4 \rfloor + 1$ edges contains at least $2n^2/9$ edges that occur in C_{2k+1}. We disprove this conjecture for $k = 2$ by showing a graph with $(2 + \sqrt{2})n^2/16$ edges in pentagons. We prove that asymptotically this is the best possible constant in this case. For the remaining case of $k \geq 3$, we prove that asymptotically the conjecture is true. The main tool used in the proofs is the flag algebra method applied in a specific two-colored setting.

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MS17

Graph Limits - Finite Forcibility and Computability

A graphon is an analytic representation of a convergent sequence of dense graphs. Finitely forcible graphons, i.e. graphons that are defined uniquely by a finite number of density constraints, are important because of their close connection to extremal graph theory. We will present a unified framework for constructing finitely forcible graph limits that have a complex structure. Our framework includes several earlier constructions of such graphons using more specific methods.

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MS17

Are Short Cycles Fractalizers?

A graph G is a *fractalizer* if every graph maximizing the number of induced copies of G is a balanced iterated blow-up of G itself. Fox, Huang and Lee have shown that almost all graphs are fractalizers, but other than the trivial cases of complete and empty graphs, we know no small examples. In this talk, we will sketch a proof how to show that C_5 is the smallest non-trivial fractalizer, and further analyze the cases for other short cycles and paths.

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MS17

Forcibility Techniques in Flag Algebras

We describe a novel approach in flag algebras which is based on methods from finite forcibility. We use this approach to obtain structural results for a problem with recursive tight configuration, and also to extremal problems

with a large set of tight configurations.

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MS17
Some Progress on the Diamond Problem

For two posets $P = (P, \leq)$ and $P' = (P', \leq')$, we say P' is a *subposet* of P if there exists an injection $f : P' \to P$ that preserves the partial ordering, meaning that whenever $u \leq' v$, we have $f(u) \leq f(v)$ in P. For a poset P, define $\mathrm{La}(n, P)$ to be the size of the largest P-free family (i.e. no member of the family contains P as a subposet) of subsets of $[n]$. Define $\pi(P)$ to be the following limit:

$$\pi(P) := \lim_{n\to\infty} \frac{\mathrm{La}(n, P)}{\binom{n}{\lfloor n/2 \rfloor}}.$$

The *diamond*, denoted by D_2, is a poset of four elements a,b,c,d such that $a < b$,c and b,$c < d$. Determining $\pi(D_2)$ became one of the central problems in extremal poset theory over the recent years. It is clear that $\pi(D_2) \geq 2$, since the family that consists of the two middle layers of B_n is diamond-free. The famous Diamond Conjecture says that $\pi(D_2) = 2$. The current best bound available in the literature is $\pi(D_2) \leq 2.25$ by Kramer, Martin and Young. We improve this bound using flag algebras.

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MS18
Inclusion Matrices and the MDS Conjecture

An arc is an ordered family of vectors in $\mathbb{F}_q^k$ in which every subfamily of size k is a basis. The MDS conjecture (Segre, 1955) states that if $k \leq q$, then an arc in $\mathbb{F}_q^k$ has size at most $q + 1$, unless q is even and $k = 3$ or $k = q - 1$, in which case it has size at most $q + 2$. Using inclusion matrices, we propose a conjecture which would imply that the MDS conjecture is true for almost all values of k when q is odd.

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MS18
Rate-Distance Tradeoff for Codes Above Graph Capacity

The capacity of a graph is defined as the rate of exponential growth of independent sets in the strong powers of the graph. In the strong power an edge connects two sequences if at each position their letters are equal or adjacent. We consider a variation of the problem where edges in the power graphs are removed between sequences which differ in more than a fraction δ of coordinates. The proposed generalization can be interpreted as the problem of determining the highest rate of zero undetected-error communication over a link with adversarial noise, where only a fraction δ of symbols can be perturbed and only some substitutions are allowed. We derive lower bounds on achievable rates with a graph-theoretic generalization of the Gilbert-Varshamov bound. We relate optimal rates for different graphs using graph homomorphisms.

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MS18
Estimating the Capacity of the 2-D Hard Square Constraint Using Generalized Belief Propagation - Part II

A binary $m \times n$ array is said to satisfy the hard square constraint if no row or column of the array contains ones in consecutive positions. Let $N(m, n)$ denote the number of such arrays. The capacity of the hard square constraint is the limit, as $m, n \to \infty$, of the quantity $\frac{1}{mn} \log N(m, n)$. Determining this capacity exactly is a long-standing open problem; its numerical value is known up to ten decimal places. Sabato and Molkaraie (2012) empirically demonstrated that the capacity of the hard square constraint can be approximated extremely well using the generalized belief propagation (GBP) algorithm. They did not, however, give an analytical explanation for their observations. In this talk, we outline an approach for analyzing GBP with a view to giving guarantees for the accuracy of the GBP estimate of the capacity of the hard square constraint. More generally, our approach provides a means of analyzing the performance of GBP in estimating the partition function of any Ising model on the 2-D lattice. This is joint work with Eric Chan, Sidharth Jaggi and Pascal Vontobel at the Chinese University of Hong Kong.

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MS18
Estimating the Capacity of the 2-D Hard Square Constraint Using Generalized Belief Propagation - Part I

A binary $m \times n$ array is said to satisfy the hard square constraint if no row or column of the array contains ones in consecutive positions. Let $N(m, n)$ denote the number of such arrays. The capacity of the hard square constraint is the limit, as $m, n \to \infty$, of the quantity $\frac{1}{mn} \log N(m, n)$. Determining this capacity exactly is a long-standing open problem; its numerical value is known up to ten decimal places. Sabato and Molkaraie (2012) empirically demonstrated that the capacity of the hard square constraint can be approximated extremely well using the generalized belief propagation (GBP) algorithm. They did not, however, give an analytical explanation for their observations. In this talk, we outline an approach for analyzing GBP with a view to giving guarantees for the accuracy of the GBP estimate of the capacity of the hard square constraint. More generally, our approach provides a means of analyzing the performance of GBP in estimating the partition function of any Ising model on the 2-D lattice. This is joint work with Eric Chan, Sidharth Jaggi and Pascal Vontobel at the Chinese University of Hong Kong.

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MS18

Uncertainty Principle and Stronger Hypercontractivity on the Hypercube

We show a sharp form of uncertainty principle for the hypercube. Namely, if there is a function with $(1-\epsilon_1)$ fraction of its energy contained in a Hamming ball of relative radius ρ_1 and $(1-\epsilon_2)$ fraction of its Fourier transform's energy contained in a ball of radius ρ_2, then

$$(1-2\rho_1)^2 + (1-2\rho_2)^2 < 1 + o(1)$$

as $n \to \infty$ regardless of $\epsilon_1, \epsilon_2 > 0$. In fact, the same holds true if one of the balls is replaced with any subset of equal cardinality. Conversely, when this inequality does not hold, there are functions satisfying (ρ_1, ρ_2) conditions with arbitrary small ϵ_1, ϵ_2 and $n \to \infty$. The key step of our proof relies on sharpening the standard hypercontractive inequality on the hypercube. It is noticed that the latter is only tight for functions close to a constant and thus could be sharpened for functions with small support. Sharpening is made possible by leveraging the strengthening of the Gross's log-Sobolev inequality by Samorodnitsky'2008 (arXiv:0807.1679).

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MS19

Analysis of Breast Cancer Genome Data Using Discrete Computational Topology

Cancer genomes are characterized by their genomic instability and the presence of chromosome aberrations (i.e. morphological alterations of the genome). In our previous work we have shown that the β_0 number can be used to identify copy number chromosome aberrations, such as amplifications and deletions, associated with the different molecular subtypes of breast cancer. In this work I will discuss the applications and interpretation of β_1 in the identification of copy number changes in breast cancer with emphasis in aberrations found in the Her2 amplified subtype.

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MS19

Using Inequality-Based Gene Tree Invariants in Phylogenomic Inference

Phylogenetic invariants were introduced in 1987 by biologists as polynomial equalities relating the probabilities of the different outcomes of an evolutionary process. This led to many beautiful and interesting links between algebraic geometry, statistics, and discrete optimization problems for phylogenetic inference. We analyze methods for *phylogenomic* inference-the inference of a phylogeny using data from multiple loci in a collection of genomes-by emphasizing the role of algebraic inequalities between gene probabilities instead of equalities. We also discuss current obstacles to the use of invariant-based approaches on real and simulated phylogenomic data.

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MS19

Strings, Trees, and RNA Folding

Under a suitable abstraction, complex biological problems can reveal surprising mathematical structure. Modeling RNA folding by plane trees, we prove combinatorial theorems yielding insight into the structure and function of large RNA molecules. We also obtain new insights into the meander enumeration problem, building on results for plane trees and noncrossing partitions motivated by the biology of RNA folding. These results illustrate the fruitful interaction between discrete mathematics and molecular biology.

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MS19

Branching Polytopes for Parametric Analysis of RNA Secondary Structure Prediction

To perform the necessary function, the RNA nucleotide chain must fold into a specific three-dimensional functional shape. The energy function in the Nearest Neighbor Thermodynamic Model, the prevalent model for RNA secondary structure prediction, depends on hundreds of parameters. Three of these are used to score multibranch loops, which are often incorrectly predicted by the model. We construct branching polytopes for RNA sequences which via their normal fan allow for a full parametric analysis of the branching part of the model and give insights into the robustness of the secondary structure prediction.

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MS19

Convexity in Tree Spaces

We study the geometry of metrics and convexity structures on the space of phylogenetic trees, here realized as the tropical linear space of all ultrametrics. The CAT(0)-metric of Billera-Holmes-Vogtman arises from the theory of orthant spaces. While its geodesics can be computed by the Owen-Provan algorithm, geodesic triangles are complicated and can have arbitrarily high dimension. Tropical convexity and the tropical metric are better behaved, as they exhibit properties that are desirable for geometric statistics.

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MS20

Kempe Equivalence of Colourings of Graphs

Let G be a graph with colouring α. Let a and b be two colours. Then a connected component of the subgraph induced by those vertices coloured either a or b is known as a Kempe chain. A colouring of G obtained from α by swapping the colours on the vertices of a Kempe chain is said to have been obtained by a Kempe change. Two colourings of G are Kempe equivalent if one can be obtained from the other by a sequence of Kempe changes. In this talk, I will survey some of the existing results, cover common proof techniques and mention some open problems in this area.

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MS20

Invitation to Combinatorial Reconfiguration

Reconfiguration problems arise when we wish to find a step-by-step transformation between two feasible solutions of a combinatorial problem such that all intermediate results are also feasible. They are PSPACE-complete for most NP-complete underlying problems, and in P for several polynomial-time solvable underlying problems, although there are exceptions to both general patterns. In this talk, I will give a broad introduction and invite you to this exciting new topic.

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MS20

Shortest Reconfiguration Paths in the Solution Space of Boolean Formulas

Given a Boolean formula and a satisfying assignment, a flip is an operation that changes the value of a variable in the assignment so that the resulting assignment remains satisfying. We study the problem of computing the shortest sequence of flips (if one exists) that transforms a given satisfying assignment s to another satisfying assignment t of an input Boolean formula. Earlier work characterized the complexity of deciding the existence of a sequence of flips between two given satisfying assignments using Schaefer's framework for classification of Boolean formulas. We build on it to provide a trichotomy for the complexity of finding the shortest sequence of flips and show that it is either in P, NP-complete, or PSPACE-complete. Our result adds to the growing set of complexity results known for shortest reconfiguration sequence problems by providing an example where the shortest sequence can be found in polynomial time even though the sequence flips variables that have the same value in both s and t. This is in contrast to most reconfiguration problems studied so far, where polynomial-time algorithms for computing the shortest path were known only for cases where the path modified no more than the symmetric difference of s and t. Our proof uses Birkhoff's representation theorem on a set system that we show to be a distributive lattice. The technique provides insights and can perhaps be used for other reconfiguration problems as well.

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MS20

Reconfiguring Graph Homomorphisms and Colourings

The starting point for this talk is the following question: given two proper k-colourings of a graph G, is it possible to transform one colouring into the other by changing the colour of one vertex at a time so that every intermediate colouring is proper k-colouring? The computational complexity for this problem exhibits a rather surprising dichotomy: it is polynomial if $k \leq 3$ and PSPACE-complete if $k \geq 4$. We consider the analogous problem for *graph homomorphisms*, which generalize graph colourings. Here, the complexity is only known for some restricted families of 'target graphs' H including (1) C_4-free graphs, (2) 'circular cliques' and (3) odd wheels. We discuss some of the ideas behind the proofs of these results and propose several avenues for future research.

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MS20

Kempe Reconfiguration and Potts Antiferromagnets

The Potts model plays an important role in Statistical Mechanics: it is very simple to formulate, but highly nontrivial. Many unusual features occur in its antiferromagnetic regime; in particular, the existence of critical points at zero temperature. Monte Carlo Markov chains have been very often used to study the properties of this model. The Wang–Swendsen–Kotecký (WSK) cluster algorithm is the most popular to simulate Potts antiferromagnets. Moreover, at zero temperature, this algorithm is equivalent to Kempe reconfiguration. We shall review whether the zero-temperature WSK algorithm is irreducible or not on several regular graphs embedded on a torus. Non-bipartite graphs are the most challenging ones: in some physically important cases, the algorithm fails to be irreducible.

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MS21

Perfect Matchings in Hypergraphs

The problem of determining the minimum d-degree threshold for finding a perfect matching in k-uniform hypergraphs has attracted much attention in the last decade. It is also closely related to the Erdős Matching Conjecture. We will introduce the problem, survey the existing results, and mention some recent progress.

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MS21

Turan Problems for Sparse Hypergraphs

Given an r-graph H, the Turan number $ex(n, H)$ of H is the maximum size of an r-graph on n vertices that does not contain H as a subgraph. We focus on r-graphs H with $ex(n, H)$ on the order of $O(n^{r-1})$. One class of such r-graphs are hypertrees. But there are also non-tree hypergraphs H for which $ex(n, H)$ falls in this range. Turan problems for such hypergraphs are often extensions of some classic problems from extremal set theory and therefore tools from extremal set theory have proven to be quite effective. One theme of study that is sometimes key to the corresponding Turan problem is to understand how the size of a hypergraph is related to the size of its shadow at the absence of a given subhypergraph. We discuss some recent results and pose some problems.

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MS21

Fractional Clique Decompositions of Dense Graphs and Hypergraphs

For any hypergraph F, a hypergraph G has a fractional F-decomposition if the copies of F in G can be non-negatively weighted so that every edge in G is contained in copies of F with total weight 1. We will show that if G has a large minimum codegree then it has a fractional F-decomposition, and discuss improvements to these techniques. This is joint work with Barber, Kühn, Lo and Osthus.

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MS21

Exact Minimum Codegree Threshold for K_4^--Factors

Given hypergraphs F and H, an F-factor in H is a set of vertex-disjoint copies of F which cover all the vertices in H. Let K_4^- denote the 3-uniform hypergraph with 4 vertices and 3 edges. We show that for sufficiently large $n \in 4N$, every 3-uniform hypergraph H on n vertices with minimum codegree at least $n/2 - 1$ contains a K_4^--factor. This bound is sharp and our result resolves a conjecture of Lo and Markström.

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MS21

Codegree Thresholds for Hypergraph Covering

Given two 3-uniform hypergraphs (3-graphs) F and G, we say that G has an *F-covering* if we can cover $V(G)$ by copies of F. The *minimum codegree* of G is the largest integer d such that every pair of vertices from $V(G)$ is contained in at least d triples from $E(G)$. Define $c_2(n, F)$ to be the largest minimum codegree among all n-vertex 3-graphs G that contain no F-covering. Determining $c_2(n, F)$ is a natural problem intermediate (but distinct) from the well-studied Turán problems and tiling problems. In this talk we determine $c_2(n, K_4)$ exactly and the associated extremal configurations for sufficiently large n, where K_4 denotes the complete 3-graph on 4 vertices. We also obtain bounds on $c_2(n, F)$ which are apart by at most 2 in the cases where F is K_4^- (K_4 with one edge removed), K_5^-, and the tight cycle C_5 on 5 vertices.

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MS22

Inducibility in Binary Trees and Tanglegram Crossing Numbers

We study the distribution of rooted k-leaf induced binary subtrees of n-leaf rooted binary trees; in particular the inducibility of a fixed rooted k-leaf binary tree, which is the limit superior of the proportion of such trees amongst all k-leaf binary trees, as n incresases. We apply these results to estimate the tanglegram crossing number of a random tanglegram. Biologists connected tanglegram crossing numbers to horizontal gene transfers and to parasites switching hosts.

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MS22

Efficient Quartet Systems in Phylogenetic Applications

Sets of quartet trees displayed by larger phylogenetic trees are often the inputs for species tree and supertree reconstruction methods. Our Efficient Quartet System (EQS) represents a tree by a subset of its displayed quartets. We prove that the EQS encoding of a tree T contains all of the combinatorial information of T, and test EQS-dependent pipelines on simulated datasets to show EQS is a promising tool for fast, accurate species tree and supertree estimation.

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MS22

On Local Profiles of Trees

We discuss the local profiles of trees. The k-profile of a tree T is the probability distribution $p_k(T)$ over its subtrees on k vertices. That is, if a k-subtree is drawn at random from T it is isomorphic to each k-tree with probability prescribed by $p_k(T)$. Bubeck and Linial studied the limit set of k-profiles as the number of vertices in T goes to infinity and showed that it is convex for each k, and so can be described by defining inequalities. This differs from the setting of general graphs and their induced subgraphs on k vertices, where the set of limit profiles is nonconvex and difficult to understand. We discuss what's known about k-profiles of trees, and some open problems in the area. In particular, we give a partial characterization of the set of 5-profiles.

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MS22

The Maximum Quartet Distance Between Phylogenetic Trees

A conjecture of Bandelt and Dress states that the maximum quartet distance between any two phylogenetic trees on n leaves is at most $(\frac{2}{3}+o(1))\binom{n}{4}$. Using the machinery of flag algebras we improve the currently known bounds regarding this conjecture, in particular we show that the maximum is at most $(0.69+o(1))\binom{n}{4}$. We also give further evidence that the conjecture is true by proving that the maximum distance between caterpillar trees is at most $(\frac{2}{3}+o(1))\binom{n}{4}$.

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MS22

The Shape of Treespace

Trees are a canonical structure for representing evolutionary histories. Many popular criteria for optimal trees are computationally hard. The underlying structure of the spaces of trees yields rich insights that can improve the search for optimal trees, both in accuracy and running time, and the analysis and visualization of results. We review the past work on analyzing and comparing trees by their shape as well as recent work that incorporates trees with weighted branch lengths.

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MS23

Finding Planted Graphs with Few Eigenvalues Using the Schur Horn Relaxation

Extracting structured planted subgraphs inside large graphs is a fundamental question that arises in a range of domains. We describe a tractable approach based on convex optimization to recover certain families of graphs embedded in larger graphs containing spurious edges. Our method relies on tractable semidefinite descriptions of the spectrum of a matrix, and we give conditions on the eigenstructure of a planted graph in relation to the noise level under which our algorithm succeeds.

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MS23

Chordal Structure in Computational Algebra

Chordal structure and bounded treewidth allow for efficient computation in linear algebra, graphical models, constraint satisfaction, and many other areas. It is natural to analyze to what extent chordality might help in computational algebra. To this end, we propose new techniques to approach two important problems: solving polynomial equations and computing permanents. Besides the theoretical developments, we illustrate the suitability of our methods in examples arising from graph colorings, sensor localization and cryptography.

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MS23

Graph Profiles: Algorithms and Approximation Guarantees

We present a novel distributed algorithm for computing graph profiles, vectors that describe a big graphs connectivity properties by counting all of its 3-node and 4-node induced subgraphs. Our algorithm is a local message passing scheme in which each vertex computes its 4-profile in parallel using primarily local information. We also establish novel concentration results showing that global graph profiles retain good approximation quality even when the graph is sparsified substantially.

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MS23

Convex Optimization for Clustering: Theoretical Guarantees and Practical Applications

We consider the problem of finding clusters in an unweighted graph when it is partially observed. We analyze two convex programs based on low-rank matrix recovery using nuclear norm minimization. For the commonly used Stochastic Block Model, we obtain explicit bounds on the problem parameters that are sufficient to guarantee the exact recovery of the clusters. We corroborate our theoretical findings through extensive simulations. We also apply our algorithms to the problem of crowdsourcing inference using real data.

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MS24

A Lattice Point Counting Generalisation of the Tutte Polynomial

The Tutte polynomial for matroids is not directly applicable to polymatroids. For instance, deletion-contraction properties do not hold. We construct a polynomial for polymatroids which behaves similarly to the Tutte polynomial of a matroid, and in fact contains the same information as the Tutte polynomial when we restrict to matroids. We also show that, in the matroid case, our polynomial has coefficients of alternating sign, with a combinatorial interpretation closely tied to the Dawson partition.

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MS24

On Representations of Frame Matroids Over Fields

We show that everything one wishes to know about matrix representations of frame matroids is provided by *gain functions* (or, *group-labellings*) on graphs. We show that for every field K, every matrix representation over K of a frame matroid M is projectively equivalent to a representation arising from a gain function on a graph, and that the projective equivalence classes of its matrix representations are essentially in one-to-one correspondence with the switching equivalence classes of gain functions.

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MS24

Bicircular Matroids Representable Over $GF(4)$ or $GF(5)$

Given a graph G, the bicircular matroid $B(G)$ is a matroid on the edge set of G whose circuits are the edge sets of minimal subgraphs of G that are connected and contain two cycles. Given a bicircular matroid $B(G)$ and $q \in \{4, 5\}$, we characterize when the bicircular matroid $B(G)$ is $GF(q)$-representable by precisely describing the structure of G. These descriptions yield polynomial-time algorithms with input G to certify if $B(G)$ is or is not $GF(q)$-representable.

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MS24

Matroids with Many Small Circuits and Many Small Cocircuits

A consequence of Tuttes Wheels-and-Whirls Theorem is that the only 3-connected matroids in which every element is in both a 3-element circuit and a 3-element cocircuit are the well-known wheels and whirls. Miller showed that a sufficiently large 3-connected matroid in which every pair of elements is contained in a 4-element circuit and a 4-element cocircuit must be spikes. Here we investigate a similar family of graphs and matroids, those having each element in a 4-cocircuit and each pair in a 4-circuit, and give a complete characterization of their members.

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MS24

The Binary Matroids Whose Only Odd Circuits are Small

This talk generalizes a graph-theoretical result of Maffray to binary matroids. In particular, we prove that a connected simple binary matroid M has no odd circuits other than triangles if and only if M is affine, M is $M(K_4)$ or F_7, or M is the cycle matroid of a graph consisting of a collection of triangles all of which share a common edge. We then show similar results for larger odd circuits on binary matroids.

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MS25

Reed's Conjecture and Strong Edge Coloring

The chromatic number of a graph is trivially bounded from above by the maximum degree plus one, and from below by the size of a largest clique. Reed proved in 1998 that compared to the trivial upper bound, we can always save a number of colors proportional to the gap between the maximum degree and the size of a largest clique. A key step in the proof deals with how to spare colors in a graph whose every vertex "sees few edges" in its neighborhood. We improve the existing approach, and discuss its applications to Reed's theorem and strong edge coloring.

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MS25

Colorings of Plane Graphs

One of the oldest topics studied in graph theory concerns coloring vertices of graphs drawn in the plane. In this talk, we will survey open problems and results on several classical types of vertex colorings of plane graphs, i.e., graphs embedded in the plane. In particular, we will focus on cyclic colorings and report about our recent results obtained on this type of coloring.

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MS25

Generalizations of Reed's Conjecture

In 1998, Reed conjectured that the chromatic number is at most halfway between its trivial lower bound, the clique number, and its trivial upper bound, the maximum degree plus one. In this talk, we discuss results on various generalizations of this conjecture to list coloring, correspondence coloring, local versions and maximum average degree.

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MS25

Maximal k-Edge-Colorable Subgraphs, Vizing's Theorem, and Tuza's Conjecture

If M is a maximal matching in a graph G and F is the set of vertices not covered by M, then F is an independent set. We generalize this observation to maximal k-edge-colorable subgraphs M: if F is the set of vertices having degree less than k in M, then each vertex $v \in F$ satisfies $d_F(v) \leq$

$d_M(v)$. This implies Vizing's Theorem on edge-coloring and a special case of Tuza's Conjecture about triangles.

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MS25

A Topological Approach Related to Hedetniemi's Conjecture

Hedetniemi's conjecture says that $\chi(G \times H) = \min(\chi(G), \chi(H))$. More generally, we can look for graphs K (called *multiplicative* graphs) such that $G \times H$ has a homomorphism to K iff G or H has. We generalize a topological approach to the conjecture, showing in particular that all graphs K with no C_4 subgraph are multiplicative, providing the first high-chromatic examples.

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MS26

Degenerate Hypergraphs

A hypergraph $H = (V, E)$ consists of a vertex set V and an edge set $E \subseteq 2^V$; the edges in E are not required to all have the same cardinality. The set of all cardinalities of edges in H is denoted by $R(H)$, the set of edge types. For a fixed hypergraph H of edge type R, the Turán density $\pi(H)$ is defined to be $\lim_{n\to\infty} \max_{G_n} \sum_{F\in E(G_n)} \frac{1}{\binom{n}{|F|}}$, where the maximum is taken over all H-free hypergraphs G_n on n vertices satisfying $R(G_n) \subseteq R$. A hypergraph H is called *degenerate* if $\pi(H) = |R(H)| - 1$. For the special case of r-uniform hypergraphs, it is well-known that H is degenerate if and only if H is r-partited. However, it is an intrigue question to classify degenerate non-uniform hypergraphs. This is a preliminary report on what we know and what we don't know on this problem.

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MS26

Exploring with Flag Algebras

We will discuss progress on two conjectures in extremal graph theory: the first one due to Grossman, Harary and Klawe on Ramsey numbers of double stars, and the second one due to Erdős, Gallai and Tuza on triangle-independent sets. In both cases computer assisted computations, employing Razborov's flag algebras, were used to explore the problem. However, the proofs of the main results are computer-free.

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MS26

A Sparse Regular Approximation Lemma

We introduce a new variant of Szemerédi's regularity lemma which we call the *sparse regular approximation lemma* (SRAL). The input to this lemma is a graph G of edge density p and parameters $\epsilon \ll \delta$. The goal is to construct an ϵ-regular partition of G while having the freedom to add/remove up to $\delta|E(G)|$ edges. As we show here, this weaker variant of the regularity lemma already suffices for proving the graph removal lemma and the hypergraph regularity lemma, which are two of the main applications of the (standard) regularity lemma. This of course raises the following question: can one obtain quantitative bounds for SRAL that are significantly better than those associated with the regularity lemma? Our first result answers the above question affirmatively by proving an upper bound for SRAL given by a tower of height $O_\delta(\log 1/p)$. This allows us to reprove Fox's upper bound for the graph removal lemma. Our second result is a matching lower bound for SRAL showing that a tower of height $\Omega(\log 1/p)$ is unavoidable. We in fact prove a more general multi-colored lower bound which is essential for proving lower bounds for the hypergraph regularity lemma.

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MS26

Off-Diagonal Hypergraph Ramsey Numbers

In this talk, we present several new results in hypergraph Ramsey theory. In particular, we give lower bounds on the classical Ramsey number $r_k(s, n)$, for k, s fixed and n tending to infinity, which nearly settles a question of Erdős and Hajnal from 1972. We also show, using different methods, a super-exponential lower bound for the Ramsey number $r_4(5, n)$, which represents the first significant progress on this problem since it was considered by Erdős and Hajnal. Several other results may be presented if time permits. This is joint work with Dhruv Mubayi.

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MS26

On a Conjecture of Erdős on Triangle-Free Graphs

Erdős conjectured that a triangle-free graph G of chromatic number $k \geq k_0(\varepsilon)$ contains cycles of at least $k^{2-\varepsilon}$ different lengths as $k \to \infty$. In this talk I outline a proof of a stronger statement, namely: every triangle-free graph G of chromatic number $k \geq k_0(\varepsilon)$ contains cycles of $\frac{1}{64}(1-\varepsilon)k^2 \log k$ consecutive lengths, and a cycle of length at least $\frac{1}{4}(1-\varepsilon)k^2 \log k$. As there exist triangle-free graphs of chromatic number k with at most roughly $4k^2 \log k$ vertices for large k, these results are tight up to a constant factor.

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MS27

Anticanonical Tropical del Pezzo Cubic Surfaces Contain Exactly 27 Lines

Since the beginning of tropical geometry, a persistent challenge has been to emulate tropical versions of classical results in algebraic geometry. The well-know statement "any smooth surface of degree 3 in P^3 contains exactly 27 lines" is known to be false tropically. Work of Vigeland from 2007 provides examples of cubic surfaces with infinitely many lines and gives a classification of tropical lines on general smooth tropical surfaces in TP^3. In this talk we explain how to correct this pathology. The novel idea is to consider the embedding of a smooth cubic surface in P^{44} via its anticanonical bundle. The tropicalization induced by this embedding contains exactly 27 lines under a mild genericity assumption. More precisely, smooth cubic surfaces in P^3 are del Pezzo's, and can be obtained by blowing up P^2 at six points in general position, which we identify with six parameters over a field with nontrivial valuation. Our genericity assumption requires the valuations of these six parameters not to vanish identically.

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MS27

A Versatile Technique for the Construction of Spectra

The construction of the spectrum of a commutative ring via lattice theory goes back to at least 1969, in a paper of D. Kirby, and Johnstone had developed this perspective into his theory of coverages by the early '80s. Nevertheless, the full strength of this viewpoint is still under-appreciated outside of point-free topology and universal algebra. I will briefly explain the tools involved in presenting a uniform construction of a wide variety of spectra, including prime ideal spectra of monoids and semirings, and the adic spectrum of an affinoid.

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MS27

Scheme Theoretic Tropicalization

Recent work of Jeff and Noah Giansiracusa exhibits a scheme theoretic structure for tropicalizations of classical varieties in terms of so-called semiring schemes. This works well in the framework of closed subvarieties of toric varieties, and Maclagan and Rincon recover the structure of a polyhedral complex from the scheme theoretic tropicalization of a variety embedded into a torus. In this talk, I will review these ideas and show how these results can be extended by using blue schemes. This leads to an intrinsic notion of a tropicalization, independent from an embedding into an ambient space, and generalizes the above mentioned results to the broader context of log-schemes.

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MS27

Bitangents of Tropical Plane Quartic Curves

A smooth plane quartic curve over an algebraically closed field has 28 bitangent lines. In this talk, I will prove the corresponding result for the tropical world: a tropical smooth place quartic curve has 7 tropical bitangent lines, up to a natural equivalence. The proof of this result will consider plane tropical curves both as embedded piecewise linear subsets of the Euclidean plane, and as abstract graphs with lengths on the edges.

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MS27

Tropical Skeletons and the Section of Tropicalization

Given a subvariety X of a torus T over a nonarchimedean field K, a basic question is to relate Trop(X) to some kind of skeleton of the Berkovich analytification X^an of X. One way to formulate this problem is to ask if there exists a continuous section of the tropicalization map s: $Trop(X)- > X^an$, and if this section is unique. I will discuss a result which asserts the answer is yes, on the multiplicity-1 locus. I'll also discuss an extension of this result to subvarieties of toric varieties, which turns out to be surprisingly subtle.

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MS28

Unavoidable Patterns in Words

Define the n^{th} Zimin word Z_n by $Z_1 = x_1$ and $Z_n = Z_{n-1}x_nZ_{n-1}$. A theorem of Zimin says that for any n there exists $\ell(n)$ such that any word of length $\ell(n)$ contains a copy of Z_n, where one word W is said to contain another word $V = v_1 \dots v_t$ if there are non-empty words $W_1, \dots, W_t$ such that $W_i = W_j$ if $v_i = v_j$ and $W_1 \dots W_t$ is a subword of W. We study the quantitative aspects of this theorem, proving surprisingly tight bounds on $\ell(n)$.

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MS28

Monochromatic Cycle Partitioning of 2-Edge-Colored Graphs with Minimum Degree 2n/3

It is conjectured the vertex set of any 2-edge-colored graph G with minimum degree at least $2|V(G)|/3$ can be partitioned into 3 monochromatic cycles. This is sharp, since there are graphs of lower minimum degree for which this is not true. We prove that apart from $o(|V(G)|)$ vertices, the vertex set of any 2-edge-colored graph G with minimum degree at least $(2/3 + \epsilon)|V(G)|$ can be partitioned into 3 such cycles.

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MS28

Monochromatic Cycle Partitions

Erdős, Pyber and Gyárfás conjectured that if K_n is r-edge-coloured, then its vertices may be partitioned into r monochromatic cycles. For $r = 2$, much more is true: we prove that if G is a 2-coloured graph on n vertices with minimum degree $3n/4$, then its vertices may be partitioned into two monochromatic cycles. This settles a conjecture by Balogh et al. Pokrovskiy showed that the above conjecture is false for $r \geq 3$. Nevertheless, we prove a slight weakening of it for $r = 3$.

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MS28

Ramsey Numbers of Sparse Graphs and Monochromatic Partitions

Abstract not available

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MS28

Decompositions of Edge-Colored Infinite Graphs into Monochromatic Connected Pieces

The aim of this presentation is to survey results and open problems on vertex decompositions of edge-colored infinite complete graphs into monochromatic trees or paths. In particular, we focus on a solution to a question of R. Rado: the vertex set of every r-edge colored infinite complete graph can be partitioned into r monochromatic paths of different colors (with r finite). The corresponding problem for finite graphs is still wide open.

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MS29

Fully-Active Cops and Robbers

We discuss *fully-active Cops and Robbers*, a variant of Cops and Robbers in which players can't sit still: on their respective turns, every cop and the robber must move to an adjacent vertex. In this talk, we determine how many cops it takes to win this game on products of trees, products of cycles, and outerplanar graphs. We also explore the relationship between the fully-active game and classic Cops and Robbers.

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MS29

Fundamental Conjectures on Eternal Domination

Eternal domination concerns the perpetual, dynamic maintenance of a dominating set while an adversary attempts to destroy it. Stated another way, it concerns the minimum number of mobile guards needed to defend a graph from any sequence of attacks at vertices. Three fundamental conjectures and partial results are discussed: one relating

the eternal domination number to the clique covering number, one related to criticality, and one regarding an upper bound in terms of order.

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MS29

The Firefighter Problem for All Orientations of the Cubic Grid

Let G be a directed graph in which, at time $t = 0$, a fire breaks out at vertex r. At each subsequent time, $t = 1, 2, \ldots$, the firefighter *defends* $d \geq 1$ undefended vertices which have not yet been reached by the fire, and then the fire spreads from all vertices it has reached to all of their undefended out-neighbours. We show that, if G is an orientation of the infinite cubic grid, then, by defending one vertex per time step, in a finite number of steps it is possible for the firefighter to stop the fire from spreading beyond the vertices it has already reached.

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MS29

The Robot Crawler Graph Process

Information gathering by crawlers on the web is of practical interest. We consider a simplified model for crawling complex networks such as the web graph, which is a variation of the robot vacuum edge-cleaning process of Messinger and Nowakowski. In our model, a crawler visits nodes via a deterministic walk determined by their weightings which change during the process deterministically. The minimum, maximum, and average time for the robot crawler to visit all the nodes of a graph is considered on various graph classes such as trees, multi-partite graphs, binomial random graphs, and graphs generated by the preferential attachment model.

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MS29

On the Zero-Visibility Cops and Robber Game

The zero-visibility cops-and-robber game is a variant of the classical cops-and-robber game, in which the robber is invisible. We show that the zero-visibility cop-number of a graph is bounded above by its pathwidth and cannot be bounded below by any nontrivial function of the pathwidth. We give an algorithm that computes the zero-visibility cop-number of a tree in linear time. We also show that the corresponding decision problem is NP-complete even for starlike graphs.

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MS30

Quadrangular Embeddings of Complete Graphs

A quadrangular embedding of a complete graph is a minimal quadrangulation of a surface. Divisibility conditions based on Euler's formula give necessary conditions for such embeddings to exist. In 1989 Hartsfield and Ringel showed that the embeddings exist in half of the possible cases. We show existence in the remaining cases.

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MS30

3-Flows with Large Support

Tutte's 3-Flow Conjecture says that every 4-edge-connected graph should have a nowhere-zero 3-flow. The 4-edge-connectivity assumption cannot be weakened – K_4 is an example of a 3-edge-connected graph that does not have a nowhere-zero 3-flow. However, K_4 is minimal in the sense that K_4^- has a nowhere zero 3-flow. Since K_4 has 6 edges in total, this means that we are able to give

K_4 a 3-flow in which 5/6 of the edges are nonzero. With DeVos, Pivotto, Rollová and Šámal, we can show that this is the worst case in general – that is, if G is any 3-edge-connected graph, then G has a 3-flow with support size at least $\frac{5}{6}|E(G)|$. As a corollary, this implies that every planar graph has an assignment of three colours to its vertices so that at most a sixth of its edges join vertices of the same colour.

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MS30

Minimum Degree and Dominating Paths

A *dominating path* is a path P such that every vertex outside P has a neighbor on P. From a result of Broersma [1988], an n-vertex connected graph G with $\delta(G) > (n-4)/3$ contains a dominating path. We seek short dominating paths. For $\delta(G) > an$, where $a > 1/3$ and n is sufficiently large, G has a dominating path with length at most logarithmic in n (the base depends on a). For constant s and $c' < 1$, an s-vertex dominating path is guaranteed by $\delta(G) \geq n - 1 - c'n^{1-1/s}$ when n is sufficiently large but not by $\delta(G) \geq n - c(s \ln n)^{1/s} n^{1-1/s}$ (where $c > 1$).

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MS30

Packing Cycles in Doubly Group Labeled Graphs

A classic result says that every graph either contains k disjoint cycles or there exists a set of at most $ck \log k$ vertices intersecting every cycle in the graph(for some fixed constant c). This result has been generalized to numerous other problems where we want the cycles to satisfy some additional property: for example, the cycles all have odd length, or the cycles intersect a specified set of vertices, or the cycles have both odd length and intersect a specified set of vertices, etc. We consider a model of group labeled graphs with two group labels on every edge. A doubly non-zero cycle is one which has non-zero weight for each of the two group labels. We look at the problem of finding many disjoint doubly non-zero cycles. We show that there exists a function f such that every such group labeled graph either has k doubly non-zero cycles such that each vertex is in at most two of them (a half integral packing of doubly non-zero cycles) or alternatively, there exists a set of at most $f(k)$ vertices intersecting every such cycle. We also give a sufficient condition on the group labels which allows us to conclude that the doubly non-zero cycles are pairwise disjoint. Our theorem implies the all the aforementioned packing results on cycles as well as several new results. This is joint work with Felix Joos and Tony Huynh.

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MS30

A Polyhedral Description of Kernels

Let G be a digraph and let $\pi(G)$ be the linear system consisting of nonnegativity, stability, and domination inequalities. We call G kernel ideal (resp. kernel Mengerian) if $\pi(H)$ defines an integral polytope (resp. $\pi(H)$ is totally dual integral) for each induced subgraph H of G. The purpose of this talk is to show that G is kernel ideal iff it is kernel Mengerian iff it contains none of three forbidden structures. (Joint work with Qin Chen and Xujin Chen)

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MS31

Reparametrization Covariant Invariants of Time Series and Cyclicities

Recovering the causal structure of processes evolving in time (such as gene expressions or protein interactions or trophic networks or business cycles in an economy) is an important component of their analysis. Often the network interaction patterns cannot be directly discerned from the models, and need to be inferred from (often, noisy) measurements. We introduce a novel invariant (cyclicity) of time series of observed activities in networks of interacting entities. Cyclicity is the first of a hierarchy of invariants stable with respect to the time reparametrizations. We prove several convergence theorems, and illustrate with real life examples.

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MS31

Network-Based Personalization at Twitter

Personalization is at the core of a variety of Twitter products — timeline ranking, user recommendations, tweet notifications/emails, and search to name a few — and many of these are powered by personalized computations on the Twitter network (or graph). This network-based personalization is challenging to scale since it involves running personalized graph algorithms such as personalized pagerank for hundreds of millions of users. In this talk, we'll give an overview of Twitter's graph processing systems that enable these applications.

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MS31

Network Meso-Structure – Behind the Complexity Curtain

One particularly challenging problem in "Big Data Analysis" has been understanding and analyzing complex networks, which naturally model relationships in many types of data (e.g. friendships in a social network or protein/gene interactions in a biological one). Although efficient graph algorithms with guaranteed performance and solution quality are impossible in general networks (according to computational complexity), recent work has identified a multitude of parameterized algorithms that exploit specific forms of sparse graph meso-structure to drastically reduce running time. On the other hand, much of the work on real-world networks as "big data" has focused on either coarse, global properties (e.g., diameter) or very localized measurements (e.g., clustering coefficient) – metrics which are insufficient for ensuring efficient algorithms. We discuss recent work on bridging the gap between network science and structural graph algorithms, answering questions like: Do real-world networks exhibit meso-structure that enables efficient algorithms? Is it observable empirically? Can this sparse structure be proven for popular random graph models? How does such a framework help?

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MS32

The Ramsey-Turán Problem with Small Independence Number

Let s be an integer, $f = f(n)$ a function, and H a graph. Define the *Ramsey-Turán number* $\mathbf{RT}_s(n, H, f)$ as the maximum number of edges in an H-free graph G of order n with $\alpha_s(G) < f$, where $\alpha_s(G)$ is the maximum number of vertices in a K_s-free induced subgraph of G. In this talk we consider $\mathbf{RT}_s(n, K_t, n^\delta)$ for fixed $\delta < 1$. We show that for an arbitrarily small $\varepsilon > 0$ and $1/2 < \delta < 1$, $\mathbf{RT}_s(n, K_{s+1}, n^\delta) = \Omega(n^{1+\delta-\varepsilon})$ for all sufficiently large s. This is nearly optimal, since a trivial upper bound yields $\mathbf{RT}_s(n, K_{s+1}, n^\delta) = O(n^{1+\delta})$. Furthermore, the range of δ is as large as possible.

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MS32

Universality and Resilience in Pseudorandom Graphs

There has recently been much progress on universality and resilience results concerning spanning or almost spanning substructures in random graphs. For pseudorandom graphs much less was known. The (new) blow-up lemma for pseudorandom graphs leads to very general new results in this direction. In this talk I will present these results, describe how their proofs use the blow-up lemma, and discuss some of the many problems that remain open. (Joint with Allen, Ehrenmüller, Taraz.)

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MS32

Towards Disproving the Erdős-Hajnal Conjecture...

The celebrated Erdős-Hajnal conjecture formulated in 1989 states that for every undirected graph H there exists $\epsilon(H) > 0$ such that every H-free n-vertex graph contains either a clique or a stable set of order at least $n^{\epsilon(H)}$. In its equivalent directed version undirected graphs are replaced by tournaments and cliques/stable sets by transitive subtournaments. The conjecture is still open. It turns out that random graph theory is a useful tool for finding strong upper bounds on the so-called Erdős-Hajnal coefficients that may lead to the counterexample of the conjecture. In this talk I will explain random graph theory techniques that recently provided mathematicians with the strongest known upper bounds on the aforementioned Erdős-Hajnal coefficients. I will also explain how these techniques combined with some recent positive results give tight asymptotics of the Erdős-Hajnal coefficients for infinite classes of prime tournaments for which the conjecture was proven just very recently.

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MS32

Looking for Vertex Number One

iven an instance of the preferential attachment graph $G_n = ([n], E_n)$, we would like to find vertex 1, using only 'local' information about the graph; that is, by exploring the neighborhoods of small sets of vertices. Borgs et. al gave an $O(\log^4 n)$ algorithm, which is local in the sense that at each step, it needs only to search the neighborhood of a set of vertices of size $O(\log^4 n)$. We give an algorithm to find vertex 1, which w.h.p. runs in time $O(\omega \log n)$ and which is local in the strongest sense of operating only on neighborhoods of single vertices. Here $\omega = \omega(n)$ is any function that goes to infinity with n.

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MS32

An Occupancy Method for Bounding Partition Functions and Counting Matchings

We consider the monomer-dimer model of a random matching in a d-regular graph. By solving a local optimization problem, we prove a tight bound on the occupancy fraction: the expected fraction of edges in the random matching. This is turn shows that over all d-regular graphs on the same number of vertices, a union of $K_{d,d}$'s maximizes the partition function of the model and the total number of matchings. As a corollary we prove the 'Asymptotic Upper Matching Conjecture' of Friedland, Krop, Lundow, and Markstrom.

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MS33

Deletions, Contractions, and Connectivity

Let M be a 3-connected matroid. Some theorems regard the cardinality and structure of the set of elements e such that M/e (resp. $M\backslash e$, si(M/e), co$(M\backslash e)$) is 3-connected. In other hand, some of the so-called splitter theorems, in the form: for 3-connected matroids $M > N$ satisfying certain hypothesis, there exists e in $E(M)$ such that M/e or $M\backslash e$ (resp...) is 3-connected with an N-minor. We propose an unification of both types of theorems.

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MS33

Matroids, Antimatroids and Groups

Given a finite group, does there exist a matroid, resp. antimatroid, whose group of automorphisms is isomorphic to the given group? The answer is positive for matroids, even for projective planes (Mendelsohn, 1972; Babai, 1977). For antimatroids and even for really represented ones, we derive a positive answer from our recent, simple proof of a result of Schulte and Williams (2015) stating the existence of a convex polytope with preassigned group.

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MS33

Strong Splitter Theorem and its Applications

The Splitter Theorem is a central result in matroid theory since it provides a useful induction tool for characterizing excluded minor classes. In this talk I will present a strengthening of the Splitter Theorem called the Strong Splitter Theorem. The Strong Splitter Theorem is joint work with Manoel Lemos. Building on Seymour's characterization of regular matroids, I used the Strong Splitter Theorem to characterize a class of binary matroids that properly contains the regular matroids.

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MS33

A Class of Infinite Convex Geometries

Various characterizations of finite convex geometries are well known. This note provides similar characterizations for possibly infinite convex geometries whose lattice of closed sets is strongly coatomic and spatial. Some classes of examples of such convex geometries are given.

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MS34

Constructive Algorithm for Path-Width of Matroids

We present a fixed parameter tractable algorithm to construct a linear layout of width at most k, if it exists, for input subspaces of a finite-dimensional vector space over $\mathbb{F}$. As corollaries, we obtain a fixed parameter tractable algorithm to produce a path-decomposition of width at most k for an input $\mathbb{F}$-represented matroid of path-width at most k, and a fixed-parameter tractable algorithm to find a linear rank-decomposition of width at most k for an input graph of linear rank-width at most k. In both corollaries, no such algorithms were known previously. Also, as corollaries, we give an algorithm that computes the linear rank-width for an input graph of bounded rank-width, and an algorithm that computes the path-width for an input $\mathbb{F}$-representable matroid of bounded branch-width. Our approach is based on dynamic programming combined with the idea developed by Bodlaender and Kloks (1996) for their work on path-width and tree-width of graphs.

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MS34

The Directed Grid Theorem

The grid theorem, originally proved by Robertson and Seymour in Graph Minors V in 1986, is one of the fundamental results in the study of graph minors. It it is the basis for several other structure theorems developed in the graph minors project and has found numerous applications in algorithmic graph structure theory, for instance in bidimensionality theory. In the mid-90s, Reed and Johnson, Robertson, Seymour and Thomas, independently, conjectured an analogous theorem for directed graphs, i.e. the existence of a function $f : \mathbb{N} \to \mathbb{N}$ such that every digraph of directed tree-width at least $f(k)$ contains a directed grid of order k. In an unpublished manuscript from 2001, Johnson, Robertson, Seymour and Thomas give a proof of this conjecture for planar digraphs. In 2014, the conjecture was confirmed in full generality by Kawarabayashi and Kreutzer. In this talk we will give an introduction to directed tree width and present the main ideas of the proof of the directed grid theorem. We will also present some applications of this result to Erds-Psa problems for directed graphs. This is joint work with Ken-ichi Kawarabayashi, National Institute of Informatics, Tokyo.

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MS34

Fixed-Parameter Tractable Canonization and Isomorphism Test for Graphs of Bounded Treewidth

We give a fixed-parameter tractable algorithm that, given a parameter k and two graphs G_1, G_2, either concludes that one of these graphs has treewidth at least k, or determines whether G_1 and G_2 are isomorphic. The running time of the algorithm on an n-vertex graph is $2^{O(k^5 \log k)} \cdot n^5$, and this is the first fixed-parameter algorithm for Graph Isomorphism parameterized by treewidth. Our algorithm in fact solves the more general canonization problem. We namely design a procedure working in $2^{O(k^5 \log k)} \cdot n^5$ time that, for a given graph G on n vertices, either concludes that the treewidth of G is at least k, or: (i) finds in an isomorphic-invariant way a graph $\mathfrak{c}(G)$ that is isomorphic to G; (ii) finds an isomorphism-invariant construction term — an algebraic expression that encodes G together with a tree decomposition of G of width less than k. Hence, the isomorphism test reduces to verifying whether the computed isomorphic copies or the construction terms for G_1 and G_2 are equal.

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MS34

Canonical Decompositions and Isomorphism Testing

Decompositions play a central role in graph theory in particular in the structural theory of graphs with a forbidden minor. In order for decompositions to be applicable to graph isomorphism testing, it is necessary that the decompositions are canonical. To obtain such canonical decompositions one can first canonically decompose a graph into parts corresponding to its maximal tangles. These tangles may be viewed as describing objects resembling "k-connected components". Using the notion of treelike decompositions, it is then sometimes possible to further decompose said parts in a canonical fashion. We describe how they can be constructed and used to test isomorphism of graphs of bounded rank width (or equivalently of bounded clique width) in polynomial time. (This is joint work with Martin Grohe)

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MS34

The Splitter Game on Nowhere Dense Classes of Graphs

Nowhere dense classes of graphs were introduced by Neetril and Ossona de Mendez as a very general model of uniform sparseness in graphs. All familiar classes of sparse graphs such as planar graphs, bounded degree graphs and classes that exclude minors or topological minors are nowhere dense. The concept of nowhere denseness turns out to be very robust and seems to capture a natural property of graphs, as witnessed by the fact that nowhere dense classes can equivalently be characterized in several completely different ways arising independently in diverse contexts. The Splitter game offers a very intuitive characterisation of nowhere dense classes of graphs. The game was introduced by Grohe et al. to efficiently solve the first-order model-checking problem of first-order logic on nowhere dense classes of graphs. In the game, two players recursively decompose local neighbourhoods of a graph. A winning strategy for one of the players can then be translated into a structural decomposition of local neighbourhoods. In this talk, we will survey algorithmic applications of the Splitter game. We will furthermore discuss a connection between the Splitter game and generalized colouring numbers that provides strong new bounds on the length of the game on restricted classes of graphs.

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MS35

Hypergraph Embeddings

Trying to generalise a 2-graph proof using the Regularity Method to k-graphs usually fails. A reason is that 'regularity inheritance' is guaranteed for 2-graphs, but not for k-graphs with $k \geq 3$. We prove a 'regularity inheritance lemma' which roughly says that this failure is a rare occurrence. This makes the natural generalisations work, and also allows us to handle sparse hypergraphs. In this talk, I will explain what the above means, what it is good for, and why it is true.

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MS35

Spectra of Random Symmetric Hypermatrices and

Random Hypergraphs

We discuss progress on the problem of asymptotically describing the complex homogeneous adjacency eigenvalues of random and complete uniform hypergraphs. There is a natural conjecture arising from analogy to random matrix theory that connects these spectra to that of the all-ones hypermatrix. To approach the question, we provide a bound on the spectral radius of the symmetric Bernoulli hyperensemble.

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MS35

The Codegree Threshold of {abc, abd, abe, cde}

Let F be a fixed 3-uniform hypergraph (3-graph). The *codegree threshold* of F is the smallest d such that every n-vertex 3-graph G with minimum codegree at least $d+1$ must contain a copy of F as a subgraph. In this talk I will discuss our determination of the codegree threshold of $\{abc, abd, abe, cde\}$ and characterization of the associated extremal configurations.

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MS35

Hamilton Cycles in Hypergraphs

For large n, we give a precise characterisation of all 4-graphs H on n vertices with minimum codegree $\delta(H) \geq n/2 - \epsilon n$ (i.e. a little below the existence threshold) which do not admit a Hamilton 2-cycle. This gives the exact Dirac-type threshold for such a cycle. Moreover, we may use this characterisation to find a Hamilton 2-cycle in H (or output that no such cycle exists) in polynomial time. By contrast, we show that the analogous problem for tight Hamilton cycles is NP-hard.

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MS35

Universal Hypergraphs

An $\mathcal{F}(n, \Delta)$-universal hypergraph H contains a copy of any hypergraph on at most n vertices with maximum vertex degree bounded by Δ. We study universality of random hypergraphs and also provide almost optimal constructions of universal hypergraphs.

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MS36

Techniques for Solving the Sudoku Puzzle

Solving Sudoku puzzles is one of the most popular pastimes in the world. Puzzles range in difficulty from easy to very challenging; the hardest puzzles tend to have the most empty cells. The current work explains and compares three algorithms for solving Sudoku puzzles: backtracking, simulated annealing, and alternating projections. All three are generic methods for attacking combinatorial optimization problems. We use Sudoku as a plot device to discuss the pros and cons of each.

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MS36

A Comparison of Approaches for Solving Hard Graph-Theoretic Problems

To formulate conjectures likely to be true, a number of base cases must be determined. However, computational complexity often makes this approach difficult. To work around computational issues, a variety of methods are explored. These are a parallelized approach using Matlab, a quantum annealing approach using the D-Wave computer, and using SMT solvers. We address the challenges of computing solutions to an NP-hard problem with respect to each of these methods.

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MS36

Using the D-Wave Machine for Combinatorial Problems

D-Wave Systems manufactures quantum annealing processors that physically seek minimum-energy spin configurations in the Ising model – an NP-hard problem – using superconducting processors operating near absolute zero. To solve other NP-hard problems with this system, we need to avoid a variety of pitfalls that appear when "polynomial reduction" becomes more than a pencil-and-paper exercise. I will talk about graph minors, constraint satisfaction, and how to get the most out of this computer.

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MS36

Algorithms for Combinatorial Generation

Abstract not available

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MS36

The Graph Isomorphism Problem and Adiabatic Algorithms

The graph isomorphism problem is a long standing unsolved problem both in classical and quantum computing theory. In this talk we give a brief introduction about the reasons behind known hardnesses of the general and special classes of graph isomorphism both in classical and quantum paradigms. Finally, we introduce a new quantum approach to attempt the problem and report the progress.

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MS37

Bounds on Equiangular Lines and on Related Spherical Codes

We will prove that every set of lines in $\mathbf{R}^d$ whose pairwise angles are all equal to some fixed α has at most $c_\alpha d$ lines. We will explain connection of this result to problems on multiplicity of graph eigenvalues, and to constructions of strongly regular graphs.

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MS37

Geometric Discrepancy and its Applications

Discrepancy theory has been developed into a diverse and fascinating field, with numerous closely related areas and applications. We present a size-sensitive and near-optimal discrepancy bound for geometric set systems. Our analysis exploits the so-called "entropy method" and "partial coloring", combined with the existence of small packing numbers. As a main application, we define the notion of "Epsilon-approximations", initially introduced in learning theory, their construction using discrepancy, and their role in "approximate range search".

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MS37

Quantitative Helly-Type Results

Helly-type results describe how local properties affect the intersection structure of a family of convex sets in R^d. During this talk we will discuss variations of these results if we also incorporate quantitative information about the intersection (such as its volume or diameter).

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MS38

Online Sprinkling

In this talk I present a new perspective due to Vu and myself of generating random structures, referred to as "online sprinkling". Using this method, with several coauthors we solve few packing problems in random graphs and hypergraphs for almost optimal probabilities, such as: Packing perfect matchings in hypergraphs (with Vu), packing loose cycles (with Luh, Nguyen and Montealegre), packing arbitrarily oriented Ham cycles in directed graphs (with Long), packing given spanning trees in Gnp (with Samotij), and more.

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MS38

Independence of Random Sets in Hypergraphs

The independence density of a countable graph, introduced by Bonato, Brown, Kemkes, and Prałat, is the probability that a subset of vertices is independent when each vertex is included independently with probability 1/2. The independence density of a countable hypergraph is defined similarly. In this talk, I will present new results on some generalizations and on the sets of real numbers that are independence densities of some countably infinite hypergraph. Joint work with P. Balister and B. Bollobás.

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MS38

Using Pólya Urns to Show Normal Limit Laws for Fringe Subtrees in m-ary Search Trees and Preferential Attachment Trees

We study fringe subtrees in m-ary search trees and in preferential attachment trees, by putting them in the context of generalised Pólya urns. We show that for both of these random tree models, the number of fringe subtrees that are isomorphic to an arbitrary fixed tree T converges to a normal distribution; more generally, we also prove multivariate normal distribution results for random vectors of such numbers for different fringe subtrees.

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MS38

Unsatisfiability Proofs of Random (2,3)-SAT Require Much Space

Random boolean formulas appear to be intractible. When the density is a little below the satisfiability threshold, it may be impossible to find a satisfying solution in polynomial time. When the density is above the satisfiability threshold, even far above, it may be impossible to provide an efficient proof that a formula is unsatisfiable. There has been extensive research showing that there are no short proofs using certain proof systems, most commonly resolution. Recently, a new line of study has focused on the amount of space required for a proof: w.h.p. every resolution proof that a random k-SAT formula is unsatisfiable requires $\Theta(n^2)$ space, for $k \geq 3$. This is considered large since every unsatisfiable k-SAT formula has a proof using $O(n^2)$ space. In this talk, we extend the result to a random mixture of 2-clauses and 3-clauses.

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MS38

How to Determine if a Random Graph with a Fixed Degree Sequence has a Giant Component

For a fixed degree sequence $\mathcal{D} = (d_1, ..., d_n)$, let $G(\mathcal{D})$ be a uniformly chosen (simple) graph on $\{1, ..., n\}$ where the vertex i has degree d_i. We determine whether $G(\mathcal{D})$ has a giant component, essentially imposing no conditions on $\mathcal{D}$. We simply insist that the sum of the degrees in $\mathcal{D}$ which are not 2 is at least $\lambda(n)$ for some function λ going to infinity with n. This is a relatively minor technical condition, and the typical structure of $G(\mathcal{D})$ when $\mathcal{D}$ does not satisfy this condition, is simple and also discussed.

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MS39

Predict, Prevent and Manage Antimicrobial Drug Resistance: Discrete and Algebraic Approaches

Antibiotic resistance and HIV drug resistance depend on mutations which accumulate in drug environments. There are usually constrains for the order in which mutations accumulate. Some resistance mutations are only selected for in the presence of other mutations, and some mutations never co-occur. The patterns can be represented by a directed graph where the nodes are labeled by digital genotypes. Finding optimal treatment plans translate to discrete optimization problems.

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MS39

Emergent Dynamics from Network Connectivity: A Minimal Model

Many networks in the brain exhibit *internally-generated* patterns of activity – that is, emergent dynamics that are shaped by intrinsic properties of the network rather than inherited from an external input. While a common feature of these networks is an abundance of inhibition, the general mechanisms underlying pattern generation remain unclear. In this talk I will introduce a new model, Toy Recurrent Networks (TRNs), consisting of simple threshold-linear neurons with binary inhibitory interactions. The dynamics of TRNs are thus controlled solely by the structure of an underlying directed graph. By varying the graph, we observe a rich variety of emergent patterns including: multistability, neuronal sequences, and complex rhythms. These patterns are reminiscent of population activity in cortex, hippocampus, and various central pattern generators for locomotion. I will then explain how our new mathematical results allow us to predict many features of the dynamics by examining properties of the underlying graph. Finally, I'll show examples illustrating how these theorems enable us to engineer complex networks with prescribed dynamic patterns.

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MS39

A Topological Language of Rna Structures

We introduce a novel, context-free grammar (CFG) for the analysis of RNA structures including pseudoknots (pk-structures). RNA structures are considered in a fatgraph model and classified by their topological genus, in particular, secondary structures have exactly genus zero. The grammar acts on an arc-labeled RNA secondary structures, called λ-structures, that correspond one-to-one to pk-structures together with additional information (blueprint) about its construction from a secondary structure. The blueprint can be interpreted as a specific sequence of transpositions of the backbone by which a pk-structure can be made cross-free. Based on the grammar, we design an $O(n \log(n))$ runtime algorithm which samples pk-structures having fixed genus according to the probability distribution implied by an RNA dataset.

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MS39

Convex Hulls in Phylogenetic Tree Space

The space of metric phylogenetic trees, as constructed by Billera, Holmes, and Vogtmann, is a polyhedral cone complex. This space is non-positively curved, so the geodesic (shortest path) between two trees is unique. We give a polynomial-time algorithm for computing convex hulls in the space of trees with 5 leaves. This algorithm extends to any 2D CAT(0) polyhedral complex with a single vertex. We also discuss some unexpected properties of these convex hulls.

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MS39

Complexity of the Single Cut-Or-Join Model for Genome Rearrangement

Represent a genome with an edge-labelled, directed graph having maximum total degree two. Perhaps the simplest model, computationally, for genome rearrangement is the single cut-or-join model. Here, a genome can mutate via a cut, which divides a degree two vertex into two degree one vertices, or a join, which merges two degree one vertices into one degree two vertex. Despite the simplicity, determining the number of most parsimonious median scenarios remains #P-complete. We will discuss this and other complexity results that arise from an abstraction of this problem.

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MS40

Cops, Robbers, and Infinite Graphs

This talk will be a short survey of our work on the cops-and-robber game on infinite graphs, with emphasis on the infinite rather than cops-and-robber. The results come from collaboration with Bonato, Gordinowicz,, Laviolette Sauer, Woodrow as well as from work of Polat, Chastand and Lehner.

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MS40

The Prisoner's Dilemma Game on Graphs

One of the oldest scenarios studied in economic game theory is the Prisoners Dilemma: a simple game where two participants have the option to cooperate, with a modest pay-off for both, or cheat, with a large advantage for the cheater. Unless, of course, both parties cheat, in which case their pay-off is zero. Now imagine that this game is played among a large group of participants, and over a sustained period of time. In particular, imagine that the group is connected via a friendship network. Participants can change their strategy (cooperate or cheat) based on what they observe from their friends (neighbours in the network). If a participant has a friend who got a larger pay-off, then they will change their strategy to that of the friend. We study the spread of strategies through a graph under this model, and its limiting configuration. In particular, for some specific graphs and parameter choices, we show how the final proportion of the different strategies depends on the initial configuration, the cheating advantage, and the topology of the graph. This is joint work with Christopher Duffy and with Santiago Guzman Pro.

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MS40

Cops and Robbers and Barricades

We investigate a variant of the familiar game of Cops and Robbers where the robber is allowed to place barricades. A barricade blocks a vertex so that neither player is able to enter it. We consider various rules for the placements of barricades, and consider examples in trees and other graph families. In addition, we present a structural and algorithmic characterization of barricade-cop-win graphs, which is analogous to the cop-win characterization of Nowakowski and Winkler.

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MS40

Searching Graph Products

We consider the traditional graph searching model in which there exists an infinitely fast, hidden intruder. To search a graph, it is necessary to formulate and execute a search strategy; a sequence of actions designed so that, upon their completion, all edges of the graph have been cleared of the invisible intruder. We provide the first nontrivial lower bound for the search number of the Cartesian product of graphs, by considering the pathwidth of graph products.

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MS40

To Catch a Falling Robber

We consider a Cops-and-Robber game played on the subsets of an n-set. The robber starts at the full set; the cops start at the empty set. In each round, each cop moves up one level by gaining an element, and the robber moves down one level by discarding an element. The question is how many cops are needed to ensure catching the robber when the robber reaches the middle level. Alan Hill posed the problem and provided a lower bound of $2^{n/2}$ for even n and $\binom{n}{\lceil n/2\rceil}2^{-\lfloor n/2\rfloor}$ (which is asymptotic to $2^{\lceil n/2\rceil}/\sqrt{\pi n/2}$) for odd n. Until now, no nontrivial upper bound was known. In this paper, we prove an upper bound that is within a factor of $O(\ln n)$ of this lower bound.

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MS41

On Box-Perfect Graphs

A graph G is called `box-perfect` if the polytope of stable sets of G is box-TDI (totally dual integral). All box-perfect graphs are perfect but not the other way around. The study of box-perfect graphs was initiated by Edmonds and Cameron. In this talk we survey known results on box-perfect graphs and we also present a few new ones.

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MS41

Degree Sum and Dominating Paths

A *vertex dominating path* in a graph is a path P such that every vertex outside P has a neighbor on P. In 1988 H. Broersma stated a result implying that every n-vertex k-connected graph G such that $\sigma_{(k+2)}(G) \geq n - 2k - 1$ contains a dominating path. We show that every n-vertex k-connected graph with $\sigma_2(G) \geq \frac{2n}{k+2} + f(k)$ contains a dominating path of length at most $O(|T|)$, where T is a minimum dominating set of vertices. The main result is that every n-vertex k-connected graph such that $\sigma_2(G) \geq \frac{2n}{k+2} + f(k)$ contains a path of length at most $O(|T|)$ through any set of T vertices where $|T| = o(n)$.

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MS41

Packing and Covering Immersions in 4-Edge-Connected Graphs

A graph G immerses another graph H if H can be obtained from a subgraph of G by splitting off edges and removing isolated vertices. In this talk, we will sketch a proof of an edge-variant of the Erdős-Pósa property with respect to the immersion containment in 4-edge-connected graphs. More precisely, we prove that for every graph H, there exists a function f such that for every 4-edge-connected graph G, either G contains k pairwise edge-disjoint subgraphs each immersing H, or there exist a set of at most $f(k)$ edges of G intersecting all such subgraphs. The theorem is best possible in the sense that the 4-edge-connectivity cannot be replaced by the 3-edge-connectivity.

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MS41

Tiling Directed Graphs with Tournaments

The Hajnal–Szemerédi theorem is a celebrated theorem in extremal graph theory. It states that for any integer $r \geq 1$ and any multiple n of r, if G is a graph on n vertices and $\delta(G) \geq (1 - 1/r)n$, then G can be partitioned into n/r vertex-disjoint copies of the complete graph on r vertices. We will discuss a very general analogue of this result for large directed graphs.

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MS41

Clique Degrees in Random Graphs

One of the first theorems one may learn in graph theory is that every graph on at least two vertices contains two vertices of equal degrees. One can define the K_r-degree of a vertex as the number of K_rs that vertex lies in. Inspired by the previous theorem, we ask if a similar statement is true for K_r-degrees. The answer is no, finding a graph with all different K_r-degrees is an interesting exercise. But is this outcome typical? To this end, we study the question for random graphs.

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MS42

On Sampling Crossing-Free Geometric Structures

We initiate a study of sampling and approximate counting algorithms for graph structures with geometric constraints. We consider geometric graphs where the vertices are given by points in the plane and edges connect pairs of vertices by straight line segments. Wettstein [SoCG 2014] gave an $O^*(2^n)$ algorithm counting crossing-free perfect matchings in complete geometric graphs. We design polynomial-time randomized approximation counting algorithms for several types of instances and show rapid mixing of the corresponding Markov chains.

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MS42

Sampling Integer Partitions Using Biased Markov Chains

We present the first provably efficient Markov chain for generating random integer partitions of n. While there are other methods for generating random partitions, these require knowledge of the exact number of partitions and cannot be adapted to restricted families of partitions. Our algorithm runs in expected time $O(n^{9/4})$ with optimal space $O(n^{1/2}\log n)$ and generates samples exactly from the uniform distribution. We use a correspondence between partitions and Ferrers diagrams, which are staircase walks in the plane, and sample from the set of Ferrers diagrams within a fixed region. In addition, our algorithm can be adapted to sample from other classes of integer partitions, such as those with bounded numbers of pieces, maximal size, or bounded Durfee square. In these cases the Markov chain is always guaranteed to converge in time $\widetilde{O}(n^{2.5})$ and space $\widetilde{O}(n^{1/2})$, allowing us to generate samples of varying size efficiently. The expected time to produce a partition of n depends on well-believed conjectures that the partition numbers are log-concave (for sufficiently large n) for these restricted settings. We test this conjecture as we run the algorithm, so we generate partitions of n efficiently, or gain evidence that this conjecture is not true, an idea used previously in the context of self-avoiding walks.

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MS42

Sampling on Lattices with Free Boundary Conditions Using Randomized Extensions

Many statistical physics models are defined on an infinite lattice by taking appropriate limits of finite lattice regions, where a key consideration is how the boundaries are defined. For several models on planar lattices, such as 3-colorings and lozenge tilings, efficient sampling algorithms are known for regions with *fixed boundary conditions*, where the colors or tiles at the boundary are pre-specified [Luby, Randall, and Sinclair, 2001], but much less is known about sampling when these regions have *free boundaries*, where we want to include all configurations one could see within a finite window. We introduce a method using *randomized extensions* to relate sampling problems on lattice regions with free boundaries to a constant number of sampling problems on larger regions with fixed boundaries. We demonstrate this principled approach to sample 3-colorings of regions of Z^2 and lozenge tilings of regions of the triangular lattice, building on arguments for the fixed boundary cases. Our approach also yields an efficient algorithm for sampling 3-colorings with free boundary conditions on regions with one reflex corner, the first such result for a nonconvex region. This approach generalizes to a broad class of mixed boundary conditions, significant because it allows us to establish self-reducibility. As a consequence, we give the first algorithm to approximately count the total number of 3-colorings of rectangular lattice regions.

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MS42

Reverse Cycle Walking and its Applications

We study the problem of constructing a block-cipher on a "possibly-strange" set S using a block-cipher on a larger set T. Such constructions are useful in format-preserving encryption. Previous work has solved this problem using a technique called cycle walking, first formally analyzed by Black and Rogaway. We introduce an alternative to cycle walking that we call reverse cycle walking, which lowers the worst-case number of times we must apply the block-cipher on T from $\Theta(N)$ to $\Theta(\log N)$. Our analysis of reverse cycle walking relies heavily on Markov chain analysis techniques.

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MS42

Cycle Basis Markov Chain for the Ising Model

Studying the ferromagnetic Ising model with zero applied field reduces to sampling even subgraphs X of G with probability proportional to $\lambda^{|E(X)|}$. In this paper we present a class of Markov chains for sampling even subgraphs, which contains the classical single-site dynamics M_G and generalizes it to nonlocal chains. The idea is based on the fact that even subgraphs form a vector space over F_2 generated by a cycle basis of G. Given any cycle basis C of a graph G, we define a Markov chain $M(C)$ whose transitions are defined by symmetric difference with an element of C. We characterize cycle bases into two types: long and short. We show that for any long cycle basis C of any graph G, $M(C)$ requires exponential time to mix when λ is small. All fundamental cycle bases of the grid in 2 and 3 dimensions are of this type. Moreover, on the 2-dimensional grid, short bases appear to behave like M_G. In particular, if G has periodic boundary conditions, all short bases yield Markov chains that require exponential time to mix for small enough λ.

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MS43

On a Phase Transition of the Random Intersection Graph: Supercritical Region

When each vertex is assigned a set, the intersection graph generated by the sets is the graph in which two distinct vertices are joined by an edge if and only if their assigned sets have a nonempty intersection. In 1999, Karoński, Scheinerman and Singer-Cohen introduced a random intersection graph by taking random assigned sets. The random intersection graph $G(n, m; p)$ has n vertices and their assigned sets are chosen to be i.i.d. random subsets of a fixed set M of size m where each element of M belongs to each random subset with probability p, independently of all other elements in M. Fill, Scheinerman and Singer-Cohen showed that the total variation between the random graph $G(n, m; p)$ and the Erdös-Rényi graph $G(n, \hat{p})$ tends to 0 if $m = n^\alpha$, $\alpha > 6$, where ph is chosen so that the expected numbers of edges in the two graphs are the same. Recently we proved that the total variation still tends to 0 whenever $m \gg n^4$. We believe that this is the best possible.

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MS43

Multicolour Ramsey Properties of Random Graphs

First we focus on the size-Ramsey number of a path P_n on n vertices. In particular, we show that $5n/2 - 15/2 \leq \hat{R}(P_n) \leq 74n$ for n sufficiently large. This improves the previous lower bound due to Bollobás, and the upper bound due to Letzter. Next we study long monochromatic paths in edge-coloured random graph $G(n, p)$ with $pn \to \infty$. Recently, Letzter showed that a.a.s. any 2-edge colouring of $G(n, p)$ yields a monochromatic path of length $(2/3 - o(1))n$, which is optimal. Extending this result, we show that a.a.s. any 3-edge colouring of $G(n, p)$ yields a monochromatic path of length $(1/2 - o(1))n$, which is also optimal. In general, we prove that for $r \geq 4$ a.a.s. any r-edge colouring of $G(n, p)$ yields a monochromatic path of length $(1/r - o(1))n$. We also consider a related problem and show that for any $r \geq 2$, a.a.s. any r-edge colouring of $G(n, p)$ yields a monochromatic connected subgraph on $(1/(r-1) - o(1))n$ vertices, which is also tight.

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MS43

Folkman Numbers and Hypergraph Containers

For an integer k, the Folkman number $f(k)$ is the least integer n for which there exists a graph G on n vertices that does not contain a clique of size $k+1$ and has the property that every two coloring of $E(G)$ yields a monochromatic clique of size of size k. That is, it is the least number of vertices in a K_{k+1}-free graph that is Ramsey to K_k. A recent result of Rodl, Rucinski, and Schacht gives an upper bound on the Folkman numbers $f(k)$ which is exponential in k. A fundamental tool in their proof is a theorem of Saxton and Thomason on hypergraph containers. This talk will give a brief history of the Folkman numbers, introduce the hypergraph container theorem, and sketch the proof of the Rodl, Rucinski, and Schacht result. Recent joint work with Hiep Han, Vojtech Rodl, and Mathias Schacht on two related problems concerning cycles in graphs and arithmetic progressions in subsets of the integers will also be presented.

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MS43

Concentration of Extension Counts in $G(n, p)$

Given a graph H, let X_R be the number of extensions of a fixed vertex subset $R \subset [n]$ to a copy of H in the random graph $G(n, p)$. In 1990 Spencer showed that with high probability for every $R \subset [n]$ random variables X_R are concentrated in a small interval, if $EX_R > C \log n$, for sufficiently large C. We study the relation between C and the size of the interval.

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MS43

Finding Structures in Random Graphs Economically

We discuss a new setting of algorithmic problems in random graphs, studying the minimum number of queries one needs to ask about adjacency between pairs of vertices of $G(n,p)$ in order to typically find a subgraph possessing a certain property. In this talk we focus specifically on the properties of containing a Hamilton cycle and containing paths of linear size.

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MS44

Effective Implicational Bases of Convex Geometries

The problem of finding an optimum implicational basis of a general closure system is known to be NP-complete (D.Maier, 1980). For the closure systems with the anti-exchange axiom, or convex geometries, it remains to be an open problem whether the optimum basis can be found from any given basis in polynomial time of the size of the basis. In our presentation we will tell about several subclasses of convex geometries where optimum basis is tractable, and discuss further directions of attacking the problem.

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MS44

Clones in Matroids

We give a survey on results on clones in matroids and their relationship to matroid representability. Two elements in a matroid are clones if the map that interchanges the elements and fixes all other elements is an automorphism. Results on the cardinality of a set of clones in a non-uniform matroid are given as well as connections between the sets and arcs in projective geometries are given.

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MS44

Coefficients of the Tutte Polynomial

The Tutte polynomial is an important invariant associated with a matroid. It encodes lot of structural information about the matroid, and is important because of its universality property. What can we say about the coefficients of the Tutte polynomial? We will first address this question and then we will restrict our attention to special classes of matroids where we hope a lot more can be said.

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MS44

Clones in Matroids Representable Over a Prime Field

Two elements of a matroid are clones if the map that interchanges the two and fixes all other elements is an automorphism of the matroid. Jakayla Robbins conjectured that a clonal class in a 3-connected non-uniform GF(q)-matroid can have size at most q-1. We confirm this conjecture for all prime fields. This is joint work with James Reid and Adam Gray.

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MS45

Modular Decomposition and its Algorithmic Applications

Birds of a Feather Flock Together. A similar observation in graphs is that some vertices are “alike’: A set of vertices is a module if they have the same neighborhood outside this set, and they can be treated as a whole for many problems. A nice theory has been built on the properties of modules, and in particular, all the modules of a graph can be represented by a hierarchical tree structure. This provides a very handy, and sometimes indispensable, tool for solving a large family of graph problems. We survey the use of modules in algorithm design, including both classic results and our recent ones.

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MS45

Structural Sparseness and Complex Networks

Even by careful estimates, humanity as amassed more data in the recent decade than in its entire historymuch of it in the form of online social interactions. Algorithmic tools to extract useful information from these heaps of data will be a mayor focus in the near future. Motivated by this development, we asses how structural graph theory can be applied to network data occurring in the real world. We identify a notion of sparseness (so-called ’bounded expansion’) that is general and robust enough to be present in such data. To substantiate our claim, we 1) prove that well-established random graph models used in network theory have indeed bounded expansion and 2) use empirical measurements to gauge the applicability of our result. We further show that problems related to complex networks can be solved more efficiently if one assumes that they have bounded expansion.

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MS45

Parameterized Algorithms Using Matroids

The Two-Families Theorem of Bollobas for extremal set systems and its generalization to subspaces of a vector space of Lovasz are the corner-stones in extremal set theory with numerous applications in graph and hypergraph theory, combinatorial geometry and theoretical computer science. In this talk we will survey these two results and show its recent algorithmic applications in the domain of parameterized and exact algorithms.

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MS45

Optimization Problems via Minimal Triangulations and Potential Maximal Cliques

Let G be an arbitrary graph. A vertex subset K is called a potential maximal clique of G if there is some minimal triangulation (i.e., minimal chordal super-graph) H of G such that K induces a maximal clique in H. Assume that we have as input the graph G together with the list of all its potential maximal cliques. Not very surprisingly, based on this information one can compute the treewidth of G. More surprisingly, one can also compute maximum induced subgraphs of bounded treewidth satisfying some CMSO property (e.g., maximum independent sets, maximum induced forests or paths) in running time linear in the number of potential maximal cliques and polynomial in the size of the graph. In this talk we survey applications of potential maximal cliques for solving this type of problems in different contexts: polynomial algorithms for some graph classes, exact (moderately exponential) algorithms, parameterized algorithms

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MS45

Color Coding-Related Techniques

Narrow sieves, representative sets and divide-and-color are three breakthrough techniques related to color coding, which led to the design of extremely fast parameterized algorithms. In this talk, I will discuss the power and limitations of these techniques. I will also briefly address some recent developments related to these techniques, including general schemes for mixing them.

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MS46

Saturation in Random Graphs

A graph H is K_s-saturated if it is a maximal K_s-free graph. The minimum number of edges in a K_s-saturated graph was determined over 50 years ago by Zykov and independently by Erdős, Hajnal and Moon. In this talk, we consider the analog of this problem in the Erdős-Rényi random graph $G(n, p)$. We give asymptotically tight estimates on the minimum, and also provide exact bounds for the related notion of weak saturation in random graphs.

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MS46

The Matching-Number Process

The k-matching process starts with n vertices, and has each of the $n(n-1)/2$ potential edges sequentially offered according to a uniformly random permutation. When an edge is offered, if its addition would keep the maximum matching size in the graph at less than or equal to k edges, then it is added. We prove that for $k = o(n)$, a.a.s. this terminates with the extremal construction in the classical Erdős-Gallai bound: k dominating vertices.

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MS46

Problems and Results on Bisections

A bisection of a graph or digraph is a bipartition where the sizes of two parts differ by at most one. Motivated by the classical Max-Cut problem and applications in industry such as VLSI chip design, various problems on bisections have been investigated. We will mention some of the problems and then focus on some results recently obtained, including a tight bound on bisections of digraphs and a strengthening of a partitioning theorem of Kuhn-Osthus into bisections. Joint work with Hehui Wu

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MS46

On Some Turán and Dirac-Type Questions for

Triple Systems

In my talk I will report on some recent results, obtained with various co-authors, about the Turán numbers and Dirac-type thresholds for matchings, short paths, as well as for Hamilton cycles in 3-uniform hypergraphs. Among others, I intend to discuss the concept of the k-th order Turán numbers, as well as a new bound on the minimum degree guaranteeing a Hamilton cycle.

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MS46

Extremal Problems for Uniformly Dense Hypergraphs

Extremal problems for hypergraphs concern the maximum density of large hypergraphs H that do not contain a copy of a given hypergraph F. Estimating the so-called Turán-densities is a central problem in combinatorics. However, despite a lot of effort precise estimates are only known for very few hypergraphs F. We consider a variation of the problem, where the large hypergraphs H satisfy additional hereditary density conditions. We present recent progress based on joint work with Reiher and Rödl.

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PP1

Fast and Efficient High Order Sparse Matrix Qr Factorization for Fpgas

A hardware and power efficient sparse matrix operation design system is presented for QR factorization for FPGA systems. Sparse matrices appear in many applications such as digital signal processing, digital image processing, power system analysis, and finite element systems. In this paper, a new memory storage system and resource reuse methodology are proposed to minimize hardware area and scale down system memory. System verification of the design is done using MATLAB and C++. The design system can perform any size QR factorization and verification.

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PP1

Linear Sequential Dynamical Systems and the Moebius Functions of Partially Ordered Sets

A sequential dynamical system (SDS) consists of a graph, a set of local functions and an update schedule. A linear sequential dynamical system is an SDS whose local functions are linear. In this paper, we obtain a closed formula for the composition of linear local functions according to a given permutation update schedule as well as updating schedules that are words. We connect linear SDS to the Moebius functions of partially ordered sets and prove a cut theorem for the Moebius functions of certain posets based on a decomposition of their chains.

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PP1

Method for Finding the Maximum Region Disjoint Paths in a Network

In INFOCOM 2006, Region Based Connectivity was introduced as a metric for determining network robustness. In this work, at first I show that determining if there exist k region node disjoint paths between two nodes is NP-complete. I have also implemented this in a Java program and analyzed real networks in civilian and military domain to test for their robustness.

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PP1

Linear Feedback State Registers Fool Finite Automata

Linear feedback state registers (LFSRs) are popular pseudorandomness generators. We demonstrate experimentally that they produce output of maximal automatic complexity, and investigate various possible explanations for this phenomenon. Automatic complexity was introduced by Shallit and Wang in 2001.

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PP1

Enumeration of Chord Diagrams

In this talk we present some results on enumerating different classes of chord diagrams. We enumerate labelled and unlabelled chord diagrams without loops and show that they are in bijection with Hamiltonian paths in n-dimensional octahedrons. We also enumerate diagrams without loops and parallel chords that represent shapes, a special class of maps.

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PP1

Analyzing RNA Secondary Structures with Fixed Percentage of Bases

We study unlabeled and labeled RNA secondary structures, by marking vertices as purines and pyrimidines. For labeled case, we derive an asymptotic formula $c_p \rho_p^n \Big(n^{-2} + O(n^{-3})\Big)$ for the number of structures for fixed purine percentage p using multivariate singularity analysis, and prove central limit theorem for the distribution of arc numbers for fixed p. For unlabeled case, we show limit theorem on arc numbers and phase transition for the number of structures allowing purine percentage p.

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PP1

Moments and Cycle Structures for Random Permutations with Restricted Positions

In a paper by Diaconis, Graham and Holmes, permutations with restricted positions are introduced and used as tools for permutations tests. There are several ways to define these restrictions, each with a different use. We consider restriction matrices, specified 0-1 matrices, to see how the properties of these matrices affect the cycle structure of restricted permutations. We also consider restriction vectors and calculate expected number of fixed points of a randomly selected restricted permutation.

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PP1

A Combinatorial Approach to Deep Learning and Compression

We introduce Dracula, a deep learning framework that utilizes dictionary-based compression to perform unsupervised feature selection for text. Dracula equates the problem of finding a useful feature representation with that of compressing data under a suitable storage cost model. The resulting optimization problem is a binary linear program, and we will discuss its problem structure and polyhedral interpretations in view of designing efficient combinatorial algorithms.

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