Invited Talks

Beating The Odds

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For many, many years some people have invested considerable effort in trying to get the best of casinos and other entities running gambling operations. In this talk, I'll present a light-hearted coverage of some of the schemes that have been employed.

On Decomposing Regular Graphs and Multigraphs into Isomorphic Trees and Forests

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Let H and G be graphs or multigraphs such that G is a subgraph of H. A *G-decomposition* of H is a set $\Delta = \{G_1, G_2, \ldots, G_t\}$ of pairwise edge-disjoint subgraphs of H each of which is isomorphic to G and such that each edge of H occurs in exactly one G_i. Graham and Häggkvist have conjectured that every tree with n edges decomposes every $2n$-regular graph. This conjecture has been confirmed for a small number of cases. We believe the Graham and Häggkvist Conjecture extends to forests with n edges. We have also recently conjectured that every tree with n edges decomposes every $2n$-regular multigraph with edge multiplicity at most 2. In this talk, we report on some recent results related to variations of these conjectures.

On Covering Walks in Graphs

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One of the questions we often ask when a graph is studied is if it has a cycle that contains all of its vertices, that is, if the graph is Hamiltonian or not. A Hamiltonian cycle in a graph G is an example of a vertex-covering walk in G – a walk containing every vertex of G. In this talk, some concepts and results involving various covering walks in graphs will be presented.

An Introduction to Graph Labeling Methods

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A graph labeling is an assignment of integers to the vertices or edges, or both, subject to certain conditions. Graph labelings were first introduced in the 1960s. In the intervening 50 years more than 100 graph labelings techniques have been studied in over 1700 papers. In this talk I review some basic results about several popular graph labeling methods.

Euler Enumeration

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The flag vector contains all the face incidence data of a polytope, and in the poset setting, the chain enumerative data. It is a classical result that for face lattices of polytopes, and more generally, Eulerian graded posets, the flag vector can be written as a **cd**-index, a non-commutative polynomial which removes all the linear redundancies among the flag vector entries. This holds for regular CW complexes. We relax the regularity conditions to show the **cd**-index exists for manifolds whose boundary has a Whitney stratification. I will describe how the setting of Whitney stratifications expands the nature of questions in the area of flag enumeration. This is joint work with Mark Goresky and Richard Ehrenborg.

Chromatic Index of Latin Squares and Steiner Triple Systems

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The chromatic index of a hypergraph is the smallest number of colours with which the edges can be coloured in such a way that no two intersecting edges have the same colour. Latin squares (LSs) and Steiner Triple Systems (STSs) can be viewed as particularly nice 3-uniform hypergraphs. In this viewpoint, the chromatic index of a LS measures how close it is to having an orthogonal mate. Similarly, the chromatic index of an STS measures how close it is to being resolvable.

With these thoughts as motivation, we will investigate what is known about the chromatic index of LSs and STSs. Related questions are how few disjoint transversals a LS can have, and how few disjoint parallel classes a STS can have. These are questions that have recently seen some progress, though there is still much that we do not know. For details, enquire within!

Contributed Talks

A New Condition for the Optimum Value of a Function

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The problem of finding the global minimum of a vector function is very common in science, economics and engineering. One of the most notable approaches to find the global minimum of a function is based on interval analysis. In this area, the exclusion algorithms (EAs) are a well-known tool for finding the global minimum of a function over a compact domain.

There are several choices for the minimization condition In this paper, we introduce a new exclusion test and analyze the efficiency and computational complexity of exclusion algorithms based on this approach.We consider Lipschitz functions and give a new minimization condition for the exclusion algorithm. Then we study the convergence and complexity of the method.

Graph Truncations Using Clique Insertions

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Truncation is a standard method of converting graphs with large valency into graphs that are trivalent. The cube-connected cycle is a typical example. Frequently we want the truncated graph to capture special features of the original graph. This leads to non-trivial problems of inserting cycles into sets of vertices. One way to avoid some of these problems is to insert complete graphs instead of cycles. That is the topic of this talk.

Making A Dot Product Sandwich

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A *dot product graph* is a graph G such that there exists a function $f : V(G) \to I\!\!R^k$ such that for $x.y \in V(G)$ $xy \in E$ if and only if $f(x)^T f(y) \geq 1$. The minimum k such that there exists such a function f for G is the *dot product dimension of* G, denoted $\rho(G)$. We have applied the graph sandwich problem to dot product graphs. The *graph sandwich problem* asks if for given a graph G there exists a graph G' such that G' has a desired property and $E(G) \subset E(G')$.

In this talk, we will present how the graph sandwich problem can be applied by adding edges to a graph G to obtain a graph G' with $\rho(G') = k$. We will also explain how this problem addresses the conjecture on the maximum dot product dimension of any graph on n vertices.

Linear Operators on Graphs which Preserve the Dot-Product Dimension

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Let $\mathcal{G}_n$ be the set of all simple loopless undirected graphs on n vertices. Let T be a linear mapping, $T : \mathcal{G}_n \to \mathcal{G}_n$ for which the dot product dimension of $T(G)$ is the same as the dot product dimension for G for any $G \in \mathcal{G}_n$. We show that T is necessarily a vertex permutation. Similar results are obtained for mappings preserving sets of graphs with specified dot product dimension.

On k-Path Pancyclic Graphs

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The concepts of Hamiltonian paths, Hamiltonian cycles and Hamiltonian graphs have been studied extensively in the area of graph theory. The research in this area gave rise to a number of new concepts and properties involving paths and cycles in graphs, such as being Hamiltonian-connected, panconnected and pancyclic as well as the concept of path Hamiltonian graphs introduced in 2013. Inspired by these concepts, we introduce a related concept involving paths and cycles in graphs. Several results and open questions are presented in this area of research.

Problem Dependent Optimization

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A metaheuristic is generally a procedure designed to find a good solution to a difficult optimization problem. Known optimization search metaheuristics heavily rely on parameters, which are usually introduced so that the metaheuristic follows some supposedly related to the optimization problem natural process (simulated annealing, swarm optimization, genetic algorithms). Adjusting the parameters so that the metaheuristic performs successfully in the problem at hand could be quite tricky and time consuming task which often requires intimate knowledge of the problem and a lot of experimenting to achieve the needed level of performance. In this article I present a metaheuristic with parameters depending only on the problem at hand, which virtually eliminates the preliminary work on adjusting the parameters. Moreover, the parameters are frequently updated during the process, based on the increasing amount of information about the solution space collected during the run. The metaheuristic has been successfully applied in several different searches for discrete objects such as designs, packings, coverings and partitions.

Chordal Graphs aren't Cycle Extendable ... So What?

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A cycle in a graph is *extendable* if the cycle is contained in another of size one greater. A graph is *cycle extendable* if every non-Hamiltonian cycle is extendable. In 1980 G. R. T. Hendry conjectured that any Hamiltonian chordal graph (no induced cycle larger than a 4-cycle) is cycle extendable. This conjecture inspired many nice papers showing subclasses of chordal graphs such as interval graphs, split graphs, and spider intersection graphs are cycle extendable, and also nice results about the structure of chordal graphs writ large. But Hendry's conjecture has been disproved (Lafond, Seamone, 2014+). I'll give another conjecture to replace Hendry's (and *maybe, possibly*, prove it) which will hopefully inspire some more nice papers, and share some results on tournaments and their cycle extendability.

Vertex-transitive Graphs that Have no Hamilton Decomposition

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I will discuss recent work in which we show that there are infinitely many connected vertex-transitive graphs that have no Hamilton decomposition.

Conditional Diagnosability of Some Interconnection Networks

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Thanks to constant technological progress, multiprocessor systems with ever increasing number of interconnected computing nodes are becoming a reality. To address the reliability concern of such a system, it is ideal, and technically feasible, to have a self-diagnosable system where the computing nodes are able to detect faulty ones by themselves in the form of a diagnosis. Based on certain scheme of processor communications, the faulty status of the system may be detected. The number of detectable faulty nodes in such a multiprocessor system certainly depends on the topology of its associated interprocessor structure, as well as the modeling assumptions, and the maximum number of detectable faulty nodes in such a network is called its diagnosability. With the often made statistical assumption of independent and identical distribution of failures among processors, it is simply unlikely that all the neighbours of a certain processor will fail at the same time, hence the notion of conditional diagnosability.

The conditional diagnosability of interconnection networks has been studied by using a number of ad-hoc methods. Recently, gathering various ad-hoc methods developed in the last decade, an unified approach was developed, and this approach was used to find the conditional diagnosability of many interconnection networks. In this talk, we consider the conditional diagnosability of a number of additional interconnection networks.

Contributions to Strength Nine Balanced Arrays and Fractional Factorial Designs with Resolution Ten

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Balanced arrays (B-arrays) are generalizations of numerous combinatorial structures, and include (for example) orthogonal arrays (O-arrays) and balanced incomplete block designs (BIBDs), etc. as special cases. A balanced array T with m factors (rows, constraints), N treatment-combinations (columns, runs), and with s levels (elements, say $0, 1, 2, \ldots, s-1$) is merely a matrix T of size $(m \times N)$ with elements $0, 1, 2, \ldots, s-1$. In this paper, we restrict ourselves to the study of the existence of such matrices under a combinatorial constraint that each such array be of strength $t = 9$, and with $s = 2$ levels (i.e. each array T is made up of two elements 0 and 1). A B-array T is said to be of strength nine ($9 \leq m$) if in each $(9 \times N)$ sub-matrix T^* of T (clearly, there are $\binom{m}{9}$ such sub-matrices), every (9×1) column vector $\underline{\alpha}$ of weight i ($0 \leq i \leq 9$, the weight of a vector is the number of 1s in it) appears the same number μ_i (say) times. The elements of the vector $\underline{\mu}' = (\mu_0, \mu_1, \ldots, \mu_9)$ and m are called the parameters of T. In this paper, we obtain some necessary existence conditions in the form of inequalities involving m and elements of $\underline{\mu}'$. We use these new results to improve upon some of those earlier results found within the current literature. In some cases, we also obtain additional new results.

Spectra of Graphs and Closed Distance Magic Labelings

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Let $G = (V, E)$ be a graph of order n. A *closed distance magic labeling* of G is a bijection $\ell : V(G) \to \{1, \ldots, n\}$ for which there exists a positive integer μ such that $\sum_{x \in N[v]} \ell(x) = k$ for all $v \in V$, where $N[v]$ is the closed neighborhood of v.

In this talk we consider the closed distance magic graphs in the algebraic context. In particular we analyze the relations between the closed distance magic labelings and the spectra of graphs. These results are then applied to the strong product of graphs with complete graph or cycle and to the circulant graphs.

Fully Cordial Trees

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For a graph $G = (V, E)$ and a binary coloring $f : V(G) \to \mathbb{Z}_2$ let $v_f(i) = |f^{-1}(i)|$. f is said to be friendly if $|v_f(1) - v_f(0)| \leq 1$. The coloring $f : V(G) \to \mathbb{Z}_2$ induces an edge labeling $f_+ : E(G) \to \mathbb{Z}_2$ defined by $f_+(xy) = f(x) + f(y) \; \forall xy \in E(G)$, where the summation is in $\mathbb{Z}_2$. Let $e_f(i) = |f_+^{-1}(i)|$. The friendly index set of the graph G, denoted by $FI(G)$, is defined by

$$FI(G) = \{|e_f(1) - e_f(0)| : \; f \text{ is a friendly vertx labeling of } G \}.$$

The graph G is said to be fully cordial if $FI(G)$ contains all possible indices of G. In this talk we present certain classes of fully cordial trees and introduce some other classes that are not fully cordial.

Covering Small Alternating Groups with Proper Subgroups

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Any group with a finite noncyclic homomorphic image is a finite union of proper subgroups. Given such a group G, we define the covering number of G to be the least positive integer m such that G is the union of m proper subgroups. The aim of this talk is to present recent results on the determination of the covering numbers of the alternating groups on nine and eleven letters.

The Strong Admissibility of Finite Groups an Update

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For a finite group G, a bijection $\theta : G \to G$ is a *strong complete mapping* if the mappings $g \mapsto g\theta(g)$ and $g \mapsto g^{-1}\theta(g)$ are both bijections. A group is *strongly admissible* if it admits strong complete mappings.
Strong complete mappings have several combinatorial applications. There exists a latin square orthogonal to both the multiplication table of a finite group G and its normal multiplication table if and only if G is strongly admissible.
The problem of characterizing strongly admissible groups is far from settled. In this talk we will discuss progress towards its resolution.

Incomplete Round-robin Handicap Tournaments

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An *incomplete handicap round-robin tournament* of n teams ordered according to their rankings $1, 2, \ldots, n$ (where the strongest team is ranked 1 and the weakest team is ranked n) is an r-regular graph in which the *total opponents ranking* of team i (which is the i-th ranked team), $tor(i)$, is the sum of rankings of all opponents (i.e., the neighbors) of i and $tor(1), tor(2), \ldots, tor(n)$ is an increasing arithmetic progression with common difference 1. In other words, the strongest and highest ranked team 1 with the smallest $tor(i)$ has highest ranked (and therefore strongest) opponents and thus the most difficult schedule while the weakest team, ranked n-th, has the weakest opponents and hence the easiest schedule.

In 2013, Petr Kovar and Tereza Kovarova presented some results on the existence of incomplete handicap round-robin tournaments for a wide spectrum of r-regular graphs on n vertices for certain values of n. Their result was based on a recursive construction, relying on a computer search for small starting cases. We present a direct construction for $n \equiv 0 \pmod 4$ and all feasible values r.

Even-Degree Triangulation of Polygons and Point Sets

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The problem of triangulating polygons and point sets in two dimensions that satisfy certain structural properties have been considered by several investigators. In this presentation we consider the problem of triangulating polygons and point sets so that the number of even degree vertices is maximized. This problem has applications in determining the illumination properties of two dimensional shapes. We present efficient algorithms for triangulating polygons and point sets to substantially increase the number of even degree vertices. We also present experimental results of the performance of the proposed algorithms by triangulating randomly generated point sets.

WORM Colorings

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Given a coloring of the vertices of a graph, we say subgraph H is monochromatic if every vertex of H is assigned the same color, and rainbow if no pair of vertices of H are assigned the same color. Given a graph G and a forbidden graph F, we define an F-WORM coloring of G as a coloring of the vertices of G without a rainbow or monochromatic subgraph isomorphic to F. We explore such colorings especially as regards to the existence, complexity, and optimization within certain graph classes. Our focus is on the case that F is a path, cycle, or complete graph.

New Upper Bounds on the Distance Domination Numbers of Grids

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In 1992 Chang discovered an efficient way to dominate $m \times n$ grid graphs, and conjectured that his construction gives the most efficient dominating sets for relatively large grid graphs. In 2011 Gonçalves, Pinlou, Rao, and Thomassé proved Chang's conjecture, establishing a closed formula for the domination number of a grid. In March 2013, by Fata, Smith and Sundaram established upper bounds for the k-distance domination numbers of grid graphs by generalizing Chang's construction of dominating sets to k-distance dominating sets. In this paper we improve the upper bounds established by Fata, Smith, and Sundaram for the k-distance domination numbers of grids.

On Perfect Game

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In the game chess, draughts, go, etc., perfect play of one of the sides is such a play/move by that side which does not lead that side to losing whatever the other side would do - always will exist a resort; and perfect game of one of the sides is such a game of that side which consists of its perfect plays only. The perfect game problem is an example of more general problem when we have to rationally iterate a set of combinations subject to irregular constrains: the rationality is the perfect play, the combinations are the game positions, and the constrains are the game rules. In such a view, the (current, next) relation may be seen as a huge arc-colored multi-digraph with in/out-degrees higher than 1, where colors are the moves of pieces or some other actions. In general, to analyze such a graph on any significant depth directly is an infeasible task because of the irregularity. This talk presents an attempt to deal with that graph using the compatibility matrix method, i.e. to operate it with its blueprint of feasible size. The method shall many-one reduce the perfect game problem to a (even Horn) SAT instance of feasible size, where the satisfying true assignments will be in one-to-many relation with the perfect plays. The CNF will allow simple testing of the moves on the perfectness before being made. This talk is focused on the drafting and discuses a logarithmic-size presentation of the arc-colored multi-digraphs, logarithmic over the number of nodes/positions.

On Ovoids in Finite Orthogonal Spaces and Related Graphs

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Moorhouse and author* have shown that if the ovoids in finite orthogonal spaces of type $O_{2n+1}(q)$, q odd, exist then their two-graphs are regular. We explore the various graphs associated with these ovoids. The degree sequences associated with these graphs can be used as effective isomorphism invariants for ovoid classifications.

Spectrum of Excess Graphs for Trees With up to Five Edges

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For graphs G and H, a G-covering of H is a collection of subgraphs of H, all isomorphic to G, such that each edge of H is contained in at least one subgraph. Those edges used in more than one subgraph, form a graph called the excess graph. A minimum G-covering of H is a covering with the smallest number of edges in the excess graph. Depending on how we do the covering, we might obtain different excess graphs. For a graph G and an integer n, the spectrum of excess graphs for G is the set of all achievable excess graphs in G-coverings of the complete graph on n vertices. Here, we will find the spectrum of excess graphs for all trees with up to five edges.

Decompositions of λK_n into LEO and ELO Graphs

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The authors previously defined a *Stanton–type graph* $S(n,m)$. The authors also previously showed how to decompose λK_n (for the appropriate minimal values of λ) into Stanton–type graphs $S(4,3)$ of the LOE, OLE, LEO and ELO–types.
Sarvate and Zhang showed that for all possible values of λ, the necessary conditions are sufficient for LOE and OLE–decompositions. In this paper, we will show that for all possible values of λ, the necessary conditions are sufficient for LEO and ELO–decompositions.

Fully Product-Cordial Graphs

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A binary vertex coloring (labeling) $f : V(G) \to \mathbb{Z}_2$ of a graph G is said to be friendly if the number of vertices labeled 0 is almost the same as the number of vertices labeled 1. This friendly labeling induces an edge labeling $f^* : E(G) \to \mathbb{Z}_2$ defined by $f^*(uv) = f(u)f(v)$ for all $uv \in E(G)$. Let $e_f(i) = |\{uv \in E(G) : f^*(uv) = i\}|$ be the number of edges of G that are labeled i. Product-cordial index of the labeling f is the number $pc(f) = |e_f(0) - e_f(1)|$. The product-cordial set of the graph G, denoted by $PC(G)$, is defined by

$$PC(G) = \{pc(f) : \ f \text{ is a friendly labeling of } G \ \}.$$

In this talk, we determine the product-cordial sets of certain classes of trees and introduce the concept of fully product-cordial.

Permutation Symmetries Applied to Fair Division

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Certain problems of fair division can be formulated in terms of algebraic combinatorics. Consider two players faced with allocating n indivisible items. Requiring each player to have a strict ranking over the n items, their relative preferences can be encoded in a permutation on n letters.

We suppose that the players alternate selecting one item at a time. If both are ignorant of the other's preferences, then they proceed by a greedy algorithm, selecting their best available item at each turn. If both know the other's preferences, then they proceed by an optimal "bottom-up" strategy, which we will describe. (We do not here consider one-sided knowledge, in which case the player with knowledge (weakly) benefits, as expected.) Is one of these two equal knowledge options preferable for the first or second player?

The question is resolved using permutation diagrams and D_4 symmetries on those diagrams studied by Eric Egge. We show that, on average, neither situation benefits either player, no matter "how different" their preferences are (measured by permutation rank). We conclude with a short survey of other fair division questions where algebraic combinatorics might be helpful.

New LS[3][2,3,2^8] Geometric Large Sets

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Let V be an n-dimensional vector space over the field of q elements. By a *geometric* $t-[q^n, k, \lambda]$ design we mean a collection $\mathcal{D}$ of k-dimensional subspaces of V, called blocks, such that every t-dimensional subspace T of V appears in exactly λ blocks in $\mathcal{D}$. A large set LS[N][t,k,q^n] of geometric $t - [q^n, k, \lambda]$ designs is a decomposition of the collection of all k-dimensional subspaces ($k-$spaces) of V into N mutually-disjoint $t - [q^n, k, \lambda]$ geometric designs. In a recent paper Braun, Kohnert, Östergard, and Wasserman constructed the first ever known large set LS[N][2, k, q^n], namely an LS[3][2,3,2^8] under a cyclic group G of order 255. In this work we compute the Kramer-Mesner incidence matrices between the orbits of 2-spaces and 3-spaces under G, reconstruct the large set of the above authors, and construct an additional 8 large sets with the same parameters, using the L^3 algorithm for lattice basis-reduction. The full automorphism groups of the large sets are still unknown, and still unanswered is the question of isomorphism among them.

The Strong Rainbow Connection Number and Maximal Cliques

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A path (not necessarily a shortest one) between two vertices in a connected graph is *rainbow colored* if each edge of the path is labeled with a distinct color. A connected graph is *strongly rainbow connected* if the edges of the graph are assigned colors so that a rainbow colored geodesic (shortest path) exists between every pair of vertices, and the minimum number of colors needed to make a graph strongly rainbow connected is the *strong rainbow connection number.* In this talk, we provide an upper bound for the strong rainbow connection number based on maximal cliques and characterize all graphs for which the bound is sharp.

Another Look at Ramsey Numbers

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In a red-blue coloring of a graph G, every edge of G is colored red or blue. For two graphs F and H, the Ramsey number $R(F, H)$ of F and H is the smallest positive integer n such that for every red-blue coloring of the complete graph K_n of order n, there is either a red subgraph isomorphic to F or a blue subgraph isomorphic to H. In the case where F and H are bipartite, the bipartite Ramsey number $BR(F, H)$ has been defined as the smallest positive integer r such that every red-blue coloring of the r-regular complete bipartite graph $K_{r,r}$ results in a red F or a blue H. We provide another look at these two well-known Ramsey numbers. Several results and open questions are presented in this area of research.

Cyclic m-Cycle Systems of Complete Graphs minus a 1-factor

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In this talk, we give necessary and sufficient conditions for the existence of cyclic m-cycle systems of $K_n - I$ when m and n are even and $m \mid n$.

Gauss-Dickson-Jacobi Codes

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Cyclotomic numbers were defined by C. F. Gauss in 1801 and they were further studied by L. E. Dickson in 1935 using their relation with Jacobi sums. The cyclotomic numbers of order 3 and 4 were obtained by Gauss and those of order 5 by Dickson in terms of solutions of certain diophantine systems.

In this talk we show how to get p-ary [2,1,2]-codes for primes $p \equiv 1 \pmod 3$ and $p \equiv 1 \pmod 4$ in terms of solutions of the diophantine systems $4p = L^2 + 27M^2$ and $p = a^2 + b^2$ respectively. These will be called Gauss codes. We then propose p-ary [4,2,3]-codes for primes $p \equiv 1 \pmod 5$ in terms of solutions of the Diophantine system of Dickson. These will be called Dickson Codes.

We also explain how these results can be extended to get MDS codes over $\mathbb{F}_p$ for primes $p \equiv 1 \pmod l$, l odd prime. We call these codes as Jacobi codes. These are p-ary $[l-1, (l-1)/2, (l+1)/2]$-codes and they are obtained using arithmetic properties of Jacobi sums. We report some examples of these Jacobi codes.

(k, k', k'')-*Dominating Sets in Graphs*

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Let k, k' and k'' be nonnegative integers and let $G = (V, E)$ be a graph. A set $S \subseteq V$ is a (k, k', k'')-*dominating set* in G if every vertex in S has at least k neighbors in S and every vertex in $V \setminus S$ has at least k' neighbors in S and at least k'' neighbors in $V \setminus S$. The (k, k', k'')-*domination number* $\gamma_{(k,k',k'')}(G)$ is the minimum cardinality of a (k, k', k'')-dominating set.

Note that

$$\gamma_{(0,1,1)}(G) = \gamma_r(G) \quad \gamma_{(1,1,1)}(G) = \gamma_t^r(G)$$
$$\gamma_{(1,2,1)}(G) = \gamma_{2r}(G) \quad \gamma_{(k,k,k)}(G) = \gamma_{\times k,t}^r(G).$$

In this presentation, we calculate a lower bound on $\gamma_{(k,k',k'')}(G)$, which improves the existing lower bounds on parameters $\gamma_r(G), \gamma_t^r(G), \gamma_{2r}(G)$ and $\gamma_{\times k,t}^r(G)$.

On the connectivity of k-distance graphs

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Let G be a graph. For any $k \in \mathbb{N}$, the k-distance graph $D^k G$ has the same vertex set of G, and two vertices of $D^k G$ are adjacent if they are exactly distance k apart in the original graph G. In this talk, we consider the connectivity of $D^k G$ and state the results for graph G and integer k such that the graph $D^k G$ is connected.

Progress on 3-GDDs with Five Groups

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We study the edge decomposition of K_{g_0,g_1,g_2,g_3,g_4} into triangles. Such decompositions are also known as 3-GDDs with 5 groups. So far we have settled the existence of 3-GDDs with five groups when there are only one or two group sizes. (*Joint work with Charles J. Colbourn and Melissa S. Keranen.*)

Single Machine Scheduling under Availability Constraints

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We investigate the single machine scheduling problem with job release dates and due dates, and multiple planned unavailability time periods. This problem arises in the context of machine scheduling with planned preventive maintenance and might be viewed as a generalization of several fundamental single-machine problems. The contribution of this paper is two-fold. First, we propose a new lower bound that is based on the concept of semi-preemptive scheduling. Second, we propose an exact algorithm that requires solving a sequence of one-machine problems without availability constraints. We report the results of extensive computational experiments that provide evidence that the semi-preemptive lower bound is very tight and that the proposed algorithm consistently delivers optimal solution for instances with up to 1000 jobs while requiring short CPU times.

On Proper-Path Colorings in Graphs

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Let G be an edge-colored connected graph. A path P is a proper path in G if no two adjacent edges of P are colored the same. If P is a proper $u - v$ path of length $d(u, v)$, then P is a proper $u - v$ geodesic. An edge coloring c is a proper-path coloring of a connected graph G if every pair u, v of distinct vertices of G are connected by a proper $u - v$ path in G and c is a strong proper coloring if every two vertices u and v are connected by a proper $u - v$ geodesic in G. These concepts are inspired by the concepts of rainbow coloring and strong rainbow coloring of a connected graph G. We investigate the relationship among these four edge colorings as well as the well-studied proper edge colorings in graphs.

Chromaticity of Turán Graphs with at most Three Edges Deleted

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Let $P(G, \lambda)$ be the chromatic polynomial of a graph G. Two graphs G and H are said to be *chromatically equivalent* (simply χ-*equivalent*), denoted $G \sim H$ if $P(G) = P(H)$. A graph G is chromatically unique if for any graph H, $P(H, \lambda) = P(G, \lambda)$ implies H is isomorphic to G. For $t \geq 2$ and $1 \leq p_1 \leq p_2 \leq \cdots \leq p_t$, let $F = K(p_1, p_2, \ldots, p_t)$ be a complete t-partite graph with partition sets V_i such that $|V_i| = p_i$ for $i = 1, 2, \ldots, t$. The Turán graph, denoted $T = K(t_1 \times p, t_2 \times (p+1))$, is the unique complete t-partite graph having $t_1 \geq 1$ partite sets of size p and t_2 partite sets of size $p + 1$. In this paper, we determine the chromaticity of all Turán graphs with at most three edges deleted. As a by product, we found many families of chromatically unique graphs and chromatic equivalence classes of graphs.

On 2-steps-Hamiltonian Cubic Graphs

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Let G be a graph with vertex set $V(G)$ and edge set $E(G)$. A (p, q)-graph $G = (V, E)$ is said to be $AL(k)$-traversal if there exist a sequence of vertices $\{v_1, v_2, \ldots, v_p\}$ such that for each $i = 1, 2, \ldots, p - 1$, the distance for v_i and v_{i+1} is equal to k. We call a graph G a 2-steps Hamiltonian graph if it has a $AL(2)$-traversal in G and $d(v_p, v_1) = 2$. In this paper we characterize some cubic graphs which are 2-steps Hamiltonian. We show that no forbidden subgraphs characterization for non 2-steps Hamiltonian cubic graphs is available by showing every cubic graph is a homeomorphic subgraph of a non 2-steps Hamiltonian cubic graph.

New Adjacency Lemmas on Vizing's Edge Size Conjecture

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Let $\chi'(G)$ denote the edge chromatic number of graph G. G is called edge Δ-critical graph if $\chi'(G - e) < \chi'(G)$ for each edge e of G. Vizing , in 1968, conjectured that for any edge chromatic critical graph G with maximum degree Δ, $|E| \geq \frac{1}{2}(\Delta - 1)|V| + 3$. In order to verify the conjecture, the properties of adjacent vertices have been studied and numerous adjacency lemmas have been discovered. In this talk we present new adjacency lemmas on edge critical graphs.

A Bichromatic View of Matchings

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A red-blue coloring of a graph G is an edge coloring of G in which every edge is colored red or blue. For a connected graph H of size at least 2, a color frame F of H is obtained from a red-blue coloring of H having at least one edge of each color and in which a blue edge is designated as the root edge. For a color frame F, an F-coloring of a graph G is a red-blue coloring of G in which every blue edge is the root of some copy of F in G. We study F-colorings of some color frames F and show that F-colorings provide a different view of matchings in graphs.

The Local Eigenvalues of a Bipartite Distance-regular Graph

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We consider a bipartite distance-regular graph Γ with vertex set X, diameter $D \geq 4$, and valency $k \geq 3$. For $0 \leq i \leq D$, let $\Gamma_i(x)$ denote the set of vertices in X that are distance i from vertex x. We assume there exist scalars $r, s, t \in$, not all zero, such that

$$r|\Gamma_1(x) \cap \Gamma_1(y) \cap \Gamma_2(z)| + s|\Gamma_2(x) \cap \Gamma_2(y) \cap \Gamma_1(z)| + t = 0$$

for all $x, y, z \in X$ with path-length distances $\partial(x, y) = 2, \partial(x, z) = 3, \partial(y, z) = 3$. Fix $x \in X$, and let Γ_2^2 denote the graph with vertex set $\tilde{X} = \{y \in X \,|\, \partial(x, y) = 2\}$ and edge set $\tilde{R} = \{yz \,|\, y, z \in \tilde{X}, \partial(y, z) = 2\}$. We show that the adjacency matrix of the local graph Γ_2^2 has at most four distinct eigenvalues. We are motivated by the fact that our assumption above holds if Γ is Q-polynomial.

Collision Problem in $PSL(2, p)$

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A hash function is any function that can be used to map digital data of arbitrary size to digital data of small, fixed size. A cryptographic hash function is a hash function which is considered practically impossible to invert, that is, to recreate any preimages from the hash value alone. Collision resistance is one of few properties, a cryptographic hash function should possess, which means, it should be difficult to find two different elements m_1 and m_2 of the domain, such that $hash(m_1) = hash(m_2)$. Such a pair is said to constitute a cryptographic hash *collision*. Certain variants of cryptographic hash functions are based on finite groups. In particular, for prime p, let $G = PSL(2, p)$ be the projective special linear group, and suppose that G is generated by two elements a and b, i.e. $G = \langle a, b \rangle$. For any word $w(a, b)$, in a and b, let $\overline{w}$ denote the evaluation of $w(a, b)$ as an element of G. The collision problem in G is to find two different words $w_1(a, b)$ and $w_2(a, b)$ such that $\overline{w_1} = \overline{w_2}$. If the length $|w|$ of a word w is the total number of a's and b's appearing in w, the length of collision $\overline{w_1} = \overline{w_2}$ is the integer $\rho := |w_1| + |w_2|$. A collision is said to be *short* if $\rho = O(log|G|)$, otherwise, it is said to be *long*. To evaluate the possible utility of the hash functions for $PSL(2, p)$ described above, it is important to understand the distributional collision-length characteristics, over all possible pairs of generators (a, b). Our goal is to characterize the generating pairs in $PSL(2, p)$ having short and long collisions. We present some preliminary results.

Checking Hats with the Lopsided Lovász Local Lemma

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The famous Hatcheck Problem imagines n men checking their hats at a restaurant and each receiving a randomly chosen hat after dinner. What is the probability that no man receives his own hat? We will explore a new proof that this probability tends to $\frac{1}{e}$ with n. The proof makes use of the lopsided Lovász local lemma and is striking for two reasons. First, there is a precise sense in which the original local lemma is wholly unsuited for the task, yet the seemingly mild generalization found in the lopsided version allows it to fully circumvent this difficulty. Second, the probabilistic content of the proof is readily transformed into a simple injection argument. The proof therefore demonstrates how one may wield a more powerful version of the local lemma through elementary means.

Further Results on SD-Prime Labeling

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Let $G = (V(G), E(G))$ be a simple, finite and undirected graph with n vertices. Given a bijection $f : V(G) \to \{1, \ldots, n\}$, we associate two integers $S = f(u) + f(v)$ and $D = |f(u) - f(v)|$ with every edge $uv \in E(G)$. The labeling f induces an edge labeling $f' : E(G) \to \{0, 1\}$ such that for any edge uv in $E(G)$, $f'(uv) = 1$ if $gcd(S, D) = 1$, and $f'(uv) = 0$ otherwise. Such a labeling is called an SD-prime labeling if $f'(uv) = 1$ for all $uv \in E(G)$. We say that G is SD-prime if it admits an SD-prime labeling. A graph G is said to be a *strongly SD-prime graph* if for every vertex v of G there exists a SD-prime labeling f satisfying $f(v) = 1$. In this talk, we first give some sufficient conditions for a theta graph to be strongly SD-prime. We then give two constructions of new SD-prime graphs from known SD-prime graphs and investigate the SD-primality of some general graphs.

New Results on the Super Edge-magic Deficiency of Graphs

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A (p,q) graph G is called *super edge-magic* if there exists a bijective function f from $V(G) \cup E(G)$ to $\{1, 2, \ldots, p + q\}$ such that $f(x) + f(xy) + f(y)$ is a constant k for every edge xy of G and $f(V(G)) = \{1, 2, \ldots, p\}$. Furthermore, the *super edge-magic deficiency* of a graph G is either the minimum nonnegative integer n such that $G \cup nK_1$ is super edge-magic or $+\infty$ if there exists no such integer n.

In this talk, I present some new results on the super edge-magic deficiency of join product graphs and chain graphs.

On Hamilton Decomposition of Cayley Graphs on $\mathbb{Z}_p^3$

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Let G be a finite abelian group and consider a subset $0 \notin S \subseteq G$ that is inverse closed, i.e.. $x \in S$ whenever $-x \in S$. The *Cayley graph on G with connection set S* is the graph whose vertices are the elements of G, and where $\{x, y\}$ is an edge if and only if $x - y \in S$.

Let X be a regular graph of even valency d. If the edge set of X can be partitioned into $d/2$ Hamilton cycles, then we say that X *admits a Hamilton decomposition*.

In this talk we present some basic constructions and general ideas for study of Hamiltonian Decomposition of Cayley graphs on $\mathbb{Z}_p^3$. This work is part of the author's Ph.D. thesis under the supervision of Professor Donald L. Kreher.

Vertex Covers and an Application to Guarding Orthogonal Polygons

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Let $\mathcal{G} = (V, E)$ be a graph with no isolated vertices. A *vertex cover* for a graph $\mathcal{G}$ is a vertex subset S such that every edge of $\mathcal{G}$ is incident with at least one vertex in S. A vertex cover S is a *total vertex cover* provided every vertex in V (including those in S) is adjacent to at least one vertex in S. Thus a total vertex cover is simultaneously a vertex cover and a totally dominating set for $\mathcal{G}$. We prove that a connected graph $\mathcal{G} = (V, E)$ with at least three vertices has a vertex cover of cardinality at most $\left\lfloor \frac{|E|+1}{2} \right\rfloor$, and a total vertex cover of cardinality at most $\left\lfloor \frac{2|E|+2}{3} \right\rfloor$. If $\mathcal{G}$ has no 3-cycles, then $\mathcal{G}$ has a vertex cover of cardinality at most $\left\lfloor \frac{7|V|+|E|}{13} \right\rfloor$. Then we use these bounds to prove several art gallery theorems for orthogonal polygons.
This is joint work with T. S. Michael of U. S. Naval Academy.

Group Magic Labelings of the Delta Product of Graphs

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For a non-trivial abelian group A, a graph $G = (V, E)$ is A-magic if there exists an edge labeling $f : E(G) \to A\backslash\{0\}$ such that the induced vertex labeling $f^+ : V(G) \to A$, defined by $f^+(v) = \sum f(uv)$, where $uv \in E(G)$, is a constant map. Let G, H be two graphs and v be a vertex of H. Consider attaching one copy of H at each vertex of G by identifying each vertex of G with the vertex corresponding to v in a distinct copy of H. We denote the resulting graph by $G\Delta H$ and we call this construction the *delta product* of G and H. In this paper, we examine the group-magic property for the delta product of two graphs.

Fair Holey Hamiltonian Decompositions of Complete Multipartite Graphs

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A *k-factor* of a graph $G = (V(G), E(G))$ is a k-regular spanning subgraph of G. A *k-factorization* is a partition of $E(G)$ into k-factors. If $V_1, ..., V_p$ are the p parts of $V(K(n,p))$ (the complete multipartite graph with p parts, each of size n), then a *holey k-factor* of deficiency V_i of $K(n,p)$ is a k-factor of $K(n,p) - V_i$ for some i satisfying $1 \leq i \leq p$. Hence a *holey k-factorization* is a set of holey k-factors whose edges partition $E(K(n,p))$. A *holey hamiltonian decomposition* is a holey 2-factorization of $K(n,p)$ where each holey 2-factor is a connected subgraph of $K(n,p) - V_i$ for some i satisfying $1 \leq i \leq p$. A (holey) k-factorization of $K(n,p)$ is said to be *fair* if the edges between each pair of parts are shared as evenly as possible among the permitted (holey) factors. In this talk the existence of fair holey 1-factorizations and of fair holey hamiltonian decompositions of $K(n,p)$ will be discussed, along with a basic introduction to the amalgamation proof technique.

On Local Metric Dimension of $(n-3)$-Regular Graph

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A set of vertices W *locally resolves* a graph G if every two adjacent vertices is uniquely determined by its coordinate of distances to the vertices in W. The minimum cardinality of a local resolving set of G is called the *local metric dimension* of G. A graph G is called k-regular graph if every vertex of G is adjacent to k other vertices of G. In this talk, we present the local metric dimension of any $(n-3)$-regular graph of order n where $n \geq 5$.

Cyclically Indecomposable Cyclic λ-fold Triple Systems that are Decomposable for $\lambda = 2, 3, 4$.

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A $CTS_\lambda(v)$ is called *cyclically indecomposable* if its block set $\mathcal{B}$ cannot be partitioned into sets $\mathcal{B}_1, \mathcal{B}_2$ of blocks to form $CTS_{\lambda_1}(v)$ and $CTS_{\lambda_2}(v)$, where $\lambda_1 + \lambda_2 = \lambda$, $\lambda_1, \lambda_2 \geq 1$.
In this talk we show that a cyclic two-fold triple system is cyclically indecomposable if and only if it is indecomposable. Moreover, we construct cyclic three-fold triple systems of order v which are cyclically indecomposable but decomposable for all $v \equiv 3 \pmod 6$. We present a construction which yields infinitely many cyclically indecomposable but decomposable cyclic three-fold triple systems of order $v \equiv 1 \pmod 6$ and infinitely many cyclically indecomposable but decomposable cyclic four-fold triple systems of order $v \equiv 0$ or $1 \pmod 3$.

Directed Metric Dimension of Oriented Complete Bipartite Graphs

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Let D be an oriented graph. Let $S = \{s_1, s_2, ..., s_k\}$ be an ordered subset of $V(D)$ and v be a vertex of D. A representation of v with respect to S is a k-vector $r(v|S) = (d(v, s_1), d(v, s_2), ..., d(v, s_k))$, where $d(x, y)$ denotes the directed distance of x to y. If all vertices have representations and if two distinct vertices have distinct representation then S is a resolving set of D. The minimum cardinality of a resolving set in D is the directed metric dimension of D, $dim(D)$.

Necessary and sufficient conditions of 1-dimensional oriented graphs are known and in this talk we discuss some sufficient conditions for 2-dimensional oriented graphs. We shall conclude by presenting metric dimension of some oriented complete bipartite graphs.

On Cyclic and 1-Rotational G-Decompositions of 2-fold Complete Multigraphs

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Let ^2K_m denote the complete 2-fold multigraph of order m. Let G of size n be either a bipartite or an almost-bipartite subgraph of $^2K_{n+1}$. We discuss labelings of G that lead to cyclic G-decompositions of $^2K_{nx+1}$ for every positive integer x. If in addition, $|V(G)| \leq n$, we discuss a labeling of G that leads to 1-rotational G-decompositions of $^2K_{nx}$ for every positive integer x. We illustrate these results by finding such labelings for the graph $G(n)$ obtained from C_n by replacing one edge with two parallel edges.

On Partial Sums in Cyclic Groups

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Suppose that $A \subset \mathbb{Z}_n \setminus \{0\}$ is an arbitrary subset of the nonzero residues modulo n with $|A| = k$. Let $(a_1, a_2, \ldots, a_k)$ be an ordering of the elements in A. Define the *partial sums* to be

$$s_j = \sum_{i=1}^{j} a_i,$$

for $1 \leq j \leq n$, where the arithmetic is done modulo n. We conjecture that there always exists an ordering such that all the partial sums are distinct.

The purpose of this talk is to give some preliminary results on this problem, including some proofs of weaker results.

On Subdivision Graphs of Cycles with a Chord which are 2-steps Hamiltonian

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Let G be a graph with vertex set $V(G)$ and edge set $E(G)$. A (p,q)-graph $G = (V, E)$ is said to be $AL(k)$-traversal if there exist a sequence of vertices $\{v_1, v_2, \ldots, v_p\}$ such that for each $i = 1, 2, \ldots, p - 1$, the distance for v_i and v_{i+1} is equal to k. We call a graph G a k-steps Hamiltonian graph if it has a $AL(k)$-traversal in G and the distance between v_p and v_1 is k. In this paper, we give a construction of subdivision graphs of cycle with a chord to be 2-steps Hamiltonian.

A Study of Graphical Permutations

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A permutation π on a set of positive integers $\{a_1, a_2, ..., a_n\}$ is said to be graphical if there exists a graph containing exactly a_i vertices of degree $\pi(a_i)$. It has been shown that for positive integers with $a_1 < a_2 < ... < a_n$, if $\pi(a_n) = a_n$, then the permutation π is graphical if and only if the sum $\sum_{i=1}^{n} a_i \pi(a_i)$ is even and $a_n \leq \sum_{i=1}^{n-1} a_i \pi(a_i)$. This known result has been proved using a criterion of Fulkerson, Hoffman, and McAndrew which requires the verification of $\frac{1}{2} n(n+1)$ inequalities. In this talk, we use a criterion of Tripathi and Vijay to give a shorter proof of this result, requiring only the verification of n inequalities. We also use this criterion to provide a similar result for permutations π such that $\pi(a_{n-1}) = a_n$. We prove that such a permutation is graphical if and only if the sum $\sum_{i=1}^{n} a_i \pi(a_i)$ is even and $a_n a_{n-1} \leq a_{n-1}(a_{n-1} - 1) + \sum_{i \neq n-1} a_i \pi(a_i)$. We also consider permutations such that $\pi(a_n) = a_{n-1}$, and then more generally, permutations such that $\pi(a_n) = a_{n-j}$ for some $j < n$.

The Complexity of P_4-decomposition of Regular Graphs and Multigraphs

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Let G denote a multigraph with edge set $E(G)$, let $\mu(G)$ denote the maximum edge multiplicity in G, and let P_k denote the path on k vertices. Heinrich et al.(1999) showed that P_4 decomposes a connected 4-regular graph G if and only if $|E(G)|$ is divisible by 3. We show that P_4 decomposes a connected 4-regular multigraph G with $\mu(G) \leq 2$ if and only if no 3 vertices of G induce more than 4 edges and $|E(G)|$ is divisible by 3. Oksimets (2003) proved that for all integers $k \geq 2$, P_4 decomposes a connected $2k$-regular graph G if and only if $|E(G)|$ is divisible by 3. We prove that for all integers $k \geq 2$, the problem of determining if P_4 decomposes a $(2k+1)$-regular graph is NP-Complete. El-Zanati et al.(2014) showed that for all integers $k \geq 1$, every $6k$-regular multigraph with $\mu(G) \leq 2k$ has a P_4-decomposition. We show that unless P = NP, this result is best possible with respect to $\mu(G)$ by proving that for all integers $k \geq 3$ the problem of determining if P_4 decomposes a $2k$-regular multigraph with $\mu(G) \leq \lfloor \frac{2k}{3} \rfloor + 1$ is NP-Complete.

On Edge-Balance Index-Sets of n-wheels

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Let G be a simple graph with vertex set $V(G)$ and edge set $E(G)$, and let $\mathbb{Z}_2 = \{0, 1\}$. Any edge labeling $f : E(G) \to \mathbb{Z}_2$ induces a partial vertex labeling $f^+ : V(G) \to \mathbb{Z}_2$ assigning 0 or 1 to $f^+(v)$, depending on whether there are more 0-edges or 1-edges incident with v, and no label is given to $f^+(v)$ otherwise.
For each $i \in \mathbb{Z}_2$, let $v_f(i) = |\{v \in V(G) : f^+(v) = i\}|$ and $e_f(i) = |\{e \in E(G) : f(e) = i\}|$. An edge-labeling f of G is said to be edge-friendly if $|e_f(0) - e_f(1)| \leq 1$. The edge-balance index set of the graph G is defined as $EBI(G) = \{|v_f(0) - v_f(1)| : f$ is edge-friendly$\}$.
An n-wheel is a graph consisting of n cycles, with every vertex of each cycle also connected to a central hub vertex. In 2010, Chopra, Lee and Su discussed the EBI of wheel graphs (1-wheels). We present a different proof of their result and will generalize it to n-wheels.

Tropical Graphs: the Dot-product Representation's Ascent Into Paradise

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We review the concepts of dot-product representations (DPRs) of graphs. A DPR of dimension ρ of $G = (V, E)$ over the field F is a mapping $f : V \to F^\rho$ such that for $t > 0$, and $x, y \in V$, we have $xy \in E$ if and only if $f(x)^T f(y) \geq t$. Minimizing ρ, the dot-product dimension, is a typical focus, but we extend the concept of DPRs to the tropical semi-ring; that is, F is replaced by the tropical semiring. In this setting we prove graphs with (tropical) DPR of dimension 1 and threshold graphs are equivalent, that caterpillars have tropical DPR with dimension at most 2, and a few other results. Finally, extensions of results to other anti-negative semi-rings or to other representations of graphs is discussed, as are relationships between the DPR dimension and other graph parameters.

Mutually Orthogonal Latin Squares with Large Holes

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Euler's 36 Officers Problem looks for orthogonal Latin squares of order 6. Such squares do not exist; however, a pair of incomplete orthogonal Latin squares of order 6 does exist. Such squares result if we allow a common 2×2 subarray of each square to be empty, avoid using a common two symbols in any row or column with an empty cell, and can find each ordered pair in which both elements are not the common two symbols by taking a common cell of the two squares.

In general, we say a set of t incomplete mutually orthogonal Latin squares of order v and hole size n, denoted $t-IMOLS(v; n)$, is a set of t $v \times v$ arrays each with the same empty $n \times n$ subarray and with every row and every column containing each symbol at most once, no row or column with an empty cell containing one of the last n symbols, and every pair of squares containing every ordered pair of symbols except those in which each symbol in the pair is one of the last n. Such sets have been previously explored for small values of t.

In this talk we discuss an asymptotic result for the existence of $t-IMOLS(v; n)$ for general t requiring large holes, which we develop from our results on incomplete pairwise balanced designs.

Uniquely Bipancyclic Graphs on more than 30 Vertices

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A bipartite graph on n vertices, n even, is called uniquely bipancyclic (UBPC) if it contains precisely one cycle of length $2m$ for every $2 \leq m \leq n/2$. In this note, using computer programs, we show that if $32 \leq n \leq 56$, and $n \neq 44$, then there are no UBPC graphs of order n. We also present the six non-isomorphic UBPC graphs of order 44. This improves recent Wallis' results on UBPC graphs of order at most 30.

Small Uniquely Bipancyclic Graphs

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A *bipancyclic* graph on v vertices is a bipartite graph that contains, as subgraphs, cycles of length n for every even integer n such that $4 \leq n \leq v$. Such a graph is *uniquely bipancyclic* if it contains exactly one subgraph of each permissible length.

In this paper we find all uniquely bipancyclic graphs on 30 or fewer vertices.

The Game of Thrones

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The game of thrones is a two-player impartial combinatorial game played on an oriented complete graph (or tournament) named after the popular fantasy book and TV series. The game of thrones relies on two types of special vertices, kings and heirs. A king is a vertex, k, in a tournament, T, which for all x in T either k beats x or there exists a vertex y such that k beats y and y beats x. An heir is any vertex that is not a king but becomes a king when some vertex is removed from the tournament. Players take turns removing vertices from a given tournament until there is only one king left in the resulting tournament. The winning player is the one which makes the final move. We develop losing positions and a possible winning algorithm.

On the Spectrum Problem for Bipartite Digraphs of Small Order

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Let D be a directed graph and let K_n^* denote the complete digraph of order n. The *spectrum problem* for D is the problem of finding necessary and sufficient conditions for the existence of a D-decomposition of K_n^*. The spectrum problem has been settled for all subgraphs of K_3^*. We report on our investigation of the spectrum problem for bipartite subgraphs of K_4^*

Dimension of a Caterpillar

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k-labelling of a graph is a labelling of vertices of the graph by k-tuples of positive integers in such a way that two vertices of G are adjacent if and only if their label k-tuples differ in each coordinate. The dimension of a graph G is the least k such that G has a k-labelling.

Lovász et al showed that for $n \geq 3$ the dimension of a path of length n is $(\log_2 n)^+$. They also obtained the dimension of a cycle of length n for most n. In this talk we obtain the dimension of a caterpillar or close bounds for it.

A Ramsey Version of Graph Saturation

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In this talk, we describe an edge-colored variation of graph saturation. We show that it is equivalent to graph saturation of the appropriate Ramsey-minimal families, and discuss recent results on the topic.

Multilevel Encryption with Steganography and Lossless Wavelets

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The need for secure communication is greater than ever. In the news we hear every day file server and communication breach of one major corporation after another. We all have experienced a variety of attacks. Computer technology grows very rapidly creating large security gaps and a very insecure digital world affecting each and every one of us. In our work we use images to embed our message and manage the keys and the key distribution. First we transform an image with a lossless wavelet then we uses the bands of the image to embed the cryptographic message and keys, then we use inverse transform to recover the image and transmit the recovered image via the Internet. Intercepted images do not draw attention, and even if the adversary suspects that they contain a message is very difficult for the adversary to recover the message.

Hamiltonicity in Nearly Claw-Free Graphs

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Claw-free graphs have been a subject of interest of many authors in the recent years. It is also interesting to investigate classes of graphs containing claw-free graphs, and to generalize results on claw-free graphs to these superclasses.

In 1994, Ryjáček defined almost claw-free graphs. Let G be a graph and let A be the set of centers of claws of G. The graph G is called almost claw-free if A is independent, and for every vertex $v \in A$, there are two vertices $x, y \in N_G(v)$ such that $N_G(v) \subseteq N_G(x) \cup N_G(y) \cup \{x, y\}$. The graph G is called nearly claw-free if for every vertex $v \in A$, there are two vertices $x, y \in N_G(v)$ such that $x, y \notin A$ and $N_G(v) \subseteq N_G(x) \cup N_G(y) \cup \{x, y\}$. Obviously, an almost claw-free graph is nearly claw-free, and a nearly claw-free graph is almost claw-free if A is independent, i.e., the clique number of the subgraph induced by A is 1.

A graph G is triangularly connected if for every pair of edges $e_1, e_2 \in E(G)$, G has a sequence of 3-cycles $C_1, C_2, \cdots, C_l$ such that $e_1 \in C_1, e_2 \in C_l$ and $E(C_i) \cap E(C_{i+1}) \neq \emptyset$ for $1 \leq i \leq l-1$. In this paper, we show that

(i) every triangularly connected $K_{1,4}$-free nearly claw-free graph on at least three vertices is fully cycle extendable if the clique number of the subgraph induced by the set of centers of claws of G is at most 2, and

(ii) every 4-connected line graph of a nearly claw-free graph is hamiltonian connected.

Decomposition of a $\lambda K_{m,n}$ into Graphs of Four Vertices and Five Edges

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Recently the authors proposed a fundamental theorem for the decomposing of a complete bipartite graph. They applied the theorem to obtain complete results on the decomposition of a complete bipartite graph into connected subgraphs on four vertices and up to four edges. In this paper, we decompose a complete multi-bipartite graph into its subgraphs of four vertices and five edges. We show that necessary conditions are sufficient for the decompositions, with some exceptions where decompositions do not exist.