Invited Talks

Combinatorial t-Restrictions

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Many fundamental combinatorial problems can be expressed in the following framework. Let Σ be a set of symbols, which may be finite or infinite. Let $t > 0$ be an integer. Let A be an $m \times t$ matrix with symbols from Σ. For $X \subseteq \Sigma^t$, the integer variable $\rho(A, X)$ counts the rows of A that appear in X. A *basic t-restriction* on A is a requirement that $\rho(A, X)$ be at least, or at most, or exactly, a specified constant. Then a *t-restriction* P on A is a logical formula whose terms are basic t-restrictions. For a matrix M that is $m \times k$ for $k \geq t$, M *satisfies* P when for every way to select t columns of M (in order), the $m \times t$ submatrix so formed satisfies P.

A typical combinatorial example is a *pairwise balanced design*; take $\Sigma = \{0, 1\}$, and treat the $b \times v$ incidence matrix of blocks against points. Then the 2-restriction satisfied is that there is an integer λ so that $\rho(A, (1, 1)) = \lambda$ for every $b \times 2$ submatrix A of the incidence matrix. Standard combinatorial designs, such as balanced incomplete block designs, t-designs, packings, and coverings all fit into this framework. When the alphabet is larger, we encounter orthogonal arrays, covering arrays, and error-correcting codes ($\equiv$ packing arrays). Moreover, many different types of so-called hash families are obtained by considering larger subsets for X in the basic restrictions.

In this talk, we use the framework of t-restrictions to discuss a general recursive construction for combinatorial matrices.

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Constructions for Retransmission Permutation Arrays

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Recently, Li, Liu, Tan, Viswanathan, and Yang introduced a technique for resolving overlapping channel transmissions that used an interesting new type of combinatorial structure. In connection with this problem, they provided an example of a 4 x 4 array having certain desirable properties. We define a class of combinatorial structures, which we term "Retransmission Permutation Arrays" (or RPA's), that generalize the example that Li et. al. provided. These RPA's turn out to be arrays that are row latin and satisfy an additional property in each of the top two corners. We show that these arrays exist for all possible orders. We also define some extensions having additional properties, for which we provide some partial results.

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Spherical and Toroidal Latin Bitrades

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Latin bitrades can be viewed both as sets of triples and as 3-colourable eulerian triangulations. The talk will address questions of their construction, generation and enumeration, and also the connections to group theory. A special attention will be paid to constructions via dissections of equilateral triangles and to homogeneous and nearly homogeneous bitrades.

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On Some Recent Progress on Rosa-Type Labelings

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A *labeling* (or *valuation*) of a graph G is an assignment of integers to the vertices of G subject to certain conditions. A hierarchy of graph labelings was introduced by Rosa in the late 1960s. Rosa showed that certain basic labelings of a graph G with n edges yielded cyclic G-decompositions of K_{2n+1} while other stricter labelings yielded cyclic G-decompositions of K_{2nx+1} for all natural numbers x. Until recently, labelings of the latter type were defined only for bipartite and almost-bipartite graphs. We report on two new labelings for tripartite graphs and show that if a graph G with n edges admits either of these labelings, then there exists a cyclic G-decomposition of K_{2nx+1} for every positive integer x. We also discuss the multigraph extensions of the labelings.

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Asymptotic Existence of Combinatorial Designs

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Over the last 40 years, various works have been done on the asymptotic results in combinatorial design theory. In particular, balanced incomplete block designs, pairwise balanced designs, group divisible designs, resolvable balanced incomplete block designs, edge-colored graph designs, resolvable graph designs and various other problems have been considered by various authors. In this talk, we give a survey of the recent results and also discuss new results, and open problems in this challenging area.

Resolutions of t-designs, orthogonality, and group-theoretic constructions

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Resolutions of $t-$designs were studied as early as 1847 by Reverend T. P. Kirkman [**?**, **?**] who proposed the famous 15 schoolgirls problem (see also [**?**]). Kirkman's problem is equivalent to finding a *resolvable* 2-$(15, 3, 1)$ design with $r = 7$, and $b = 35$. We define and discuss τ*-resolutions* of t-designs, *large sets* of t-designs, *orthogonal resolutions* of t-designs, *Room rectangles* [**?**, **?**], and *Steiner tableaux.* We briefly discuss recursive constructions of large sets, but spend more time on techniques for constructing *starter* large sets which can then be used in the recursive techniques to obtain infinite families of large sets. We pay particular attention to *coherence* techniques, i.e. construction methods which assume particular automorphism groups under which the above combinatorial objects are invariant. We give examples of large sets and *super-large* sets constructed by means of groups. We discuss infinite families of *semiregular* large sets arising from 3-homogeneous actions of the groups $PSL_2(q)$ on the projective line, and time permitting, we discuss the construction of certain sporadic, as well as infinite families of Room rectangles arising from block-transitive but imprimitive group actions. Finally, we present some tantalizing open problems.

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The Weak 3-Flow Conjecture and Graph Decomposition

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Tutte's 3-flow conjecture says that every 4-edge-connected graph has an orientation such that, for each vertex x, the indegree of x equals the outdegree of x modulo 3. In 1988 Jaeger suggested to replace 4 by a larger (universal) number and called that the weak 3-flow conjecture. In this talk we present a proof of the weak 3-flow conjecture and discuss its applications to graph decomposition.

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Contributed Talks

Graphs determined by their Laplacian spectra

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(joint work with S. Akbari and N. Shajari)

In this talk, we give some results on the Laplacian spectral characterization of some families of graphs, specially those graphs with at most two cycles. The banana tree $B(n, k)$ is a tree obtained by joining a vertex to one of arbitrary pendant vertices of each copy of n-copies of $K_{1,k}$. Also, $H_n(p, q)$ is a tree obtained by joining p pendant vertices to an end vertex of a path of order n and then joining q pendant vertices to another end of the path. Here, we present some conditions under which two trees $B_{n,k}$ and the double star like tree $H_n(p, q)$ are determined by their Laplacian spectra.

MSC2000: 05A20, 05C05, 05C50, 05C75.

Keywords: Laplacian spectrum, Tree.

VE Algorithm for Dual LI(2) Systems via an Example

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Vertex Enumeration (VE) algorithms attempt to explore and list all extreme points that lie at corners of convex polyhedron formed by systems of linear equations or inequalities. For general polyhedra, these problems are known to be NP-hard. Concentrations are now given to some special classes of polyhedra. We review a Basis Oriented Pivoting (BOP) algorithm for enumerating the vertices of polyhedra associated with dual LI(2) systems. We present an example and discuss some real life practical applications of the algorithm.

MSC2000: 05B07, 05B40.

Keywords: Vertex Enumeration, Computational Geometry, Mathematical Programming, Graph Theory.

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Size condition for cycles in bipartite digraphs

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Let D be a bipartite digraph with color classes X and Y such that $|X| = a \leq b = |Y|$. We are interested in finding a sufficient condition on the size of D to contain a directed cycle of even length m ($4 \leq m \leq 2a$). First, we present a counterexample to a result of M. Manoussakis and Y. Manoussakis ("Some cyclic properties in bipartite digraphs with a given number of arcs", *Ars Combinatoria* 32 (1991) 301-310). Next we formulate a conjecture and prove it in a special case. We give a correct size condition for D to contain every orientation of a cycle of length $2a - 2p$ ($a \geq \frac{1}{2}p^2 + \frac{5}{2}p + 6$). The bound on the size is best possible. We characterize all extremal digraphs for this problem.

MSC2000: 05C20, 05C38, 05C35.

Keywords: DIGRAPH, BIPARTITE DIGRAPH, CYCLE, CYCLE ORIENTATION, SIZE CONDITION.

Zero-Sum Flows in Designs

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(joint work with G.B. Khosrovshahi, A. Mofidi)

Let D be a t-(v, k, λ) design and let $N_i(D)$, for $1 \le i \le t$, be the higher incidence matrix of D, a $(0, 1)$-matrix of size $\binom{v}{i} \times b$, where b is the number of blocks of D. A *zero-sum flow* of D is a nowhere-zero real vector in the null space of $N_1(D)$. A *zero-sum k-flow* of D is a zero-sum flow with values in $\{\pm1, \ldots, \pm(k-1)\}$. In this paper we show that every non-symmetric design admits an integral zero-sum flow, and consequently we conjecture that every non-symmetric design admits a zero-sum 5-flow. Similarly, the definition of zero-sum flow can be extended to $N_i(D)$, $1 \le i \le t$. Let $D = t$-$(v, k, \binom{v-t}{k-t})$ be the complete design. We conjecture that $N_t(D)$ admits a zero-sum 3-flow and prove this conjecture for $t = 2$.

MSC2000: 05B05, 05B20, 05C21, 05C22.

Keywords: Nowhere-zero flow, zero-sum flow, incidence matrix, t-designs.

Chromatic Polynomials Of Certain Polyphenylene Dendrimers

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Let G be a simple graph and $\chi(G, \lambda)$ denotes the number of proper vertex colourings of G with at most λ colours, which is for a fixed graph G, a polynomial in λ, which is well known the chromatic polynomial of G. A dendrimer is an artificially manufactured or synthesized molecule built up from branched units called monomers. In this talk, using the chromatic polynomial of some specific graphs, we compute the chromatic polynomials for certain polyphenylene dendrimers.

MSC2000: 05C15,82D80.

Keywords: Chromatic polynomial, Dendrimer, Graph.

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On the Cozero-Divisor Graph of a Commutative Ring

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(joint work with S. Akbari and S. Khojasteh)

Let R be a commutative ring with identity. The Cozero-divisor graph of R denoted by $\Gamma'(R)$, is a graph whose vertex set is the set of all non-zero and non-unit elements of R, and two distinct vertices a and b are adjacent if and only if $a \notin bR$ and $b \notin aR$. In this talk we determine the diameter of $R[x]$. Also, we classify all non-local rings whose cozero-divisor graph is a tree. Finally, we obtain some results on graph theoretical parameters of the cozero-divisor graph, for instance clique and chromatic number.

MSC2000: 05C69, 05C75, 13A15.

Keywords: Cozero-divisor graph, Connected, Forest.

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Complete sets of metamorphoses of twofold 4-cycle systems into twofold 6-cycle systems

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(joint work with Nicholas J. Cavenagh and Abdollah Khodkar)

Let (X, C) denote a twofold k-cycle system with an even number of cycles. If these k-cycles can be paired together so that: (i) each pair contains a common edge; (ii) removal of the repeated common edge from each pair leaves a $(2k-2)$-cycle; and (iii) all the repeated edges, once removed, can be rearranged exactly into a collection of further $(2k-2)$-cycles; then this is a *metamorphosis* of a twofold k-cycle system into a twofold $(2k-2)$-cycle system. The existence of such metamorphoses has been dealt with for the case of 3-cycles (Gionfriddo and Lindner, 2003) and 4-cycles (Yazıcı, 2005).

If a twofold k-cycle system (X, C) of order n exists, which has not just one but has k different metamorphoses, from k different pairings of its cycles, into twofold $(2k-2)$-cycle systems, such that the collection of all removed double edges from all k metamorphoses precisely covers $2K_n$, we call this a *complete set* of twofold paired k-cycle metamorphoses into twofold $(2k-2)$-cycle systems.

Here we deal with $k = 4$ and show that there exists a twofold 4-cycle system (X, C) of order n with a *complete set* of metamorphoses into twofold 6-cycle systems if and only if $n \equiv 0, 1, 9, 16 \pmod{24}$, $n \neq 9$.

I shall include lots of pictures to explain the above!

MSC2000: 05B30, 05C38.

Keywords: cycle system; metamorphosis; complete set of metamorphoses.

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Integer Programming Formulations for the Minimum Weighted Maximal Matching Problem

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(joint work with Z. Caner Taşkın and Tınaz Ekim)

Given a graph, a matching is a set of edges that are pairwise non-adjacent. A matching is said to be maximal if no other edge can be added to it while keeping the property of being a matching. The problem of finding a maximal matching having minimum cardinality is called Minimum Maximal Matching (MMM). This problem, which is NP-hard, has been studied extensively from a graph theoretical point of view due to its various applications. Mostly, polynomial time exact algorithms are developed for some restricted classes of graphs or approximation algorithms are produced. However, we took general graphs into consideration from an optimization point of view. We developed a new integer programming formulation for the problem by using a decomposition approach and compared the results against the results obtained by our previous integer programming formulations. With this new approach, we are able to solve larger and denser instances to the optimality.

MSC2000: 90C11.

Keywords: minimum maximal matching, integer programming.

New Heuristic Methods for Unit Disk Graph Vertex Coloring and Its Reoptimization

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(joint work with Tinaz Ekim)

A reoptimization problem can be formally defined as follows: for a given instance I of a problem π, an optimal solution S of I and a locally modified instance I', find an optimal solution of the instance I'. Local modifications in graph theoretical problems can be stated as follows: inserting or deleting vertices or edges, modifying edge costs etc.

Motivated by frequency assignment problem in telecommunication, we consider the minimum vertex coloring in unit disk graphs and related vertex adding / removing reoptimization problems.

In this talk, we describe some construction heuristics and an improvement heuristic based on Kempe's exchange method. While most of the studies in the literature are focused on the worst-case analysis of the algorithms, we reveal the practical performance of the suggested methods through a series of systematic computational experiments. Results show that simple heuristic methods followed by our improvement heuristic method find almost all the time the optimal value, especially on sparse unit disk graphs.

MSC2000: 05C15, 05C85, 05C90.

Keywords: vertex coloring, heuristic methods, reoptimization.

Dihedral Hamiltonian cycle systems of $K_{2n} - I$ (a case of serendipity in combinatorics)

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(joint work with Francesca Merola)

A cycle system of a graph K is a set of subcycles of K partitioning $E(K)$. It is cyclic, abelian, dihedral ... if it is invariant under a cyclic, abelian, dihedral ... automorphism group of K acting sharply transitively on $V(K)$.
The existence problem for cyclic Hamiltonian cycle systems of the complete graph K_{2n+1} or the complete graph minus a 1-factor $K_{2n} - I$ (the so *called cocktail party graph*) have been completely settled in [**?**] and [**?**], respectively.
In this talk I will speak about the existence problem of dihedral Hamiltonian cycle systems of $K_{2n}-I$. This problem generated an interesting case of serendipity; some years ago I realized that I would had been able to solve it if a certain conjecture of mine [**?**] about the Hamiltonian paths of a complete graph of prime order were true. Though my conjecture is still open despite the efforts of some mathematicians [**?**, **?**, **?**], we have been able to find a complete solution to our dihedral problem.

MSC2000: 05C38, 05C70.

Keywords: Hamiltonian cycle system; Buratti's conjecture.

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Odd order $2(n+1)$ regular connected Cayley graphs on elementary abelian groups are Hamilton decomposable

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(joint work with Donald L. Kreher)

First it is shown that every odd order $2(n+1)$-regular connected Cayley graph on an elementary abelian group is Hamilton decomposable. We apply this result to Paley graphs and show that when given a prime power $q = p^n$, and even order rank n multiplicative subgroup S of the finite field $\mathbb{F}_q$, that the Cayley graph with connection set S is Hamilton decomposable, whenever $|S| \geq 2n^2$. This extends the recent result of Alspach, Bryant and Dyer on Paley graphs.

MSC2000: 05E99.

Keywords: Cayley graph, Hamilton decomposition.

New spectral upper bounds on the size of k-regular induced subgraphs

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(joint work with Sofia Jorge Pinheiro)

In [W. Haemers, Interlacing eigenvalues and graphs, *Linear Algebra Appl.* 226/228 (1995): 593-616] a spectral upper bound (based on the least and greatest adjacency eigenvalues) on the independence number of arbitrary graphs was introduced. Later, in [M. Lu, H. Liu and F. Tian, Laplacian spectral upper bounds for clique and independence numbers of graphs, *J. Combin. Theory* Ser. B 97 (2007): 726-732], spectral upper bounds (using the greatest Laplacian eigenvalue) on the independence number was deduced by a similar technic to the one adopted by Haemers. In the case of regular graphs, in [D.M. Cardoso, M. Kaminsky and V. Lozin, Maximum k-regular induced subgraphs, *J. Comb. Optim.* 14 (2007): 455-463] a spectral upper bound on the order of k-regular induced subgraphs (based on adjacency eigenvalues) was obtained, using convex quadratic programming techniques. Now, using again a technic similar to the one of Haemers, we extend this upper bound to arbitrary graphs, introducing three new upper bounds on the order of k-regular induced subgraphs. These upper bounds are based on adjacency, Laplacian and signless Laplacian eigenvalues, respectively.

MSC2000: 5C50, 05C69, 90C27, 90C35.

Keywords: Graph spectra, graph invariants, combinatorial optimization.

On the Menger number of graphs

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(joint work with Ana Diánez Martínez and Pedro García Vázquez)

Given any two vertices x, y of a connected graph G, the xy-Menger number, denoted by $\zeta_l(x, y)$, is the maximum number of internally disjoint xy-paths whose lengths are at most l in G. The Menger number of G with respect to l is defined as $\zeta_l(G) = \min\{\zeta_l(x, y) : x, y \in V(G)\}$.
In this work we study the Menger number of the composition and the strong product of two connected graphs. For these two families of graphs we obtain a lower bound of $\zeta_l(G)$ and derive a bound for the case $l = d(G)$. Furthermore, we show that these bounds are best possible.

MSC2000: 05C35, 05C40.

Keywords: Menger number, strong product, edge-fault-tolerant diameter, edge-deletion problem.

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Enumeration of RNA Secondary Structures

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(joint work with Siang-Ning Zeng)

RNA (Ribonucleic acid) is one of major molecules in cells, which participates in a lot of basic biological functions. Unlike DNA (deoxyribonucleic acid) molecules in the shape of a double-helix, RNA bases have unpaired and paired forms so that they compose various RNA secondary structures. Based on our definitions of structural elements, RNA secondary structures can be classified into (h, m)-classes, where h and m denote the numbers of hairpin loops and multiloops, respectively. In this paper, we will equally partition each (h, m)-class into subclasses and enumerate RNA secondary structures with n bases in each subclass. We also point out some incorrect results in literature.

(This work was supported in part by the National Science Council under grant NSC 96-2215-M-036-001-MY3.)

MSC2000: 05A15, 92B05.

Keywords: RNA (Ribonucleic acid) secondary structure, enumeration.

A Study on the Radio Colourings of Graphs

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(joint work with Yu-Ying Hsiung)

Let $G = (V, E)$ be a simple graph of order n. We denote the diameter of G by $diam(G)$ and the distance between u and v by $dist(u, v)$. A function f from V to $\{1, 2, \cdots, k\}$ is called a radio colouring of G with span k if for each pair of vertices u and v the inequality

$$|f(u) - f(v)| \geq diam(G) - dist(u, v) + 1$$

holds. The radio number of G is the minimum span over all radio colourings of G.

In this talk, we propose the results that we have gotten. (This work was supported in part by the National Science Council under grant NSC 99-2115-M-036-001.)

MSC2000: 05B07, 05B40.

Keywords: diameter, radio colouring, radio number.

On $(C_n; k)$ stable graphs

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(joint work with Agnieszka Görlich, Małgorzata Zwonek, Andrzej Żak)

A graph G is called $(H; k)$-*vertex stable* if G contains a subgraph isomorphic to H ever after removing any of its k vertices. $\mathrm{Stab}(H; k)$ denotes the minimum size among the sizes of all $(H; k)$-vertex stable graphs. In this paper we deal with $(C_n; k)$-vertex stable graphs with minimum size. For each n we prove that $\mathrm{stab}(C_n; 1)$ is one of only two possible and we give the exact value for infinitely many n's. Furthermore we establish an upper and lower bound for $\mathrm{stab}(C_n; k)$ for $k \geq 2$.

MSC2000: 05B07, 05B40.

Keywords: stable graphs, cycle, extremal graphs.

Factorizations of the complete graph into bipartite 2-factors

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(joint work with Darryn Bryant)

The Oberwolfach problem was first introduced by Ringel in the 1960's, the problem requires one to find a factorization of K_n (K_n minus a $1-$factor if n is even) into a specified $2-$factor F. An obvious generalization requires the factorization into t specified $2-$factors $F_1, \ldots, F_t$. When $t = 2$, this is known as the Hamilton-Waterloo problem. Both of these problems have received some attention of late and I will present some recent results.

In particular, I will present a Theorem that solves a large number of cases when n is even and the $2-$factors F_i are bipartite. This result completes the solution of the Oberwolfach problem for any collection of even sized cycles and in addition, it settles the Hamilton-Waterloo problem for bipartite 2-factors of order $n \equiv 0 \bmod 4$, except in the case where all but one of the 2-factors are isomorphic. This is joint work with Darryn Bryant.

Enumeration of Orthogonal Arrays

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(joint work with Ben Burton and Diane Donovan)

In this talk, a new and efficient combinatorial algorithm for the enumeration and classification of orthogonal arrays will be presented. This algorithm generates all non-isomorphic orthogonal arrays with a given parameter set and it is easy to implement it for parallel processing. Also, we will describe how to use this algorithm for isomorphism checking of orthogonal arrays.

MSC2000: 05B15.

Keywords: Orthogonal arrays, isomorphism.

Forbidden Minor Characterizations for Edge Searching

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Edge Searching is a combinatorial game in which there are two opponents: An intruder and a group of searchers. The intruder is aware of searchers' actions and he is trying to avoid them. Hence he is invisible and he has unbounded speed. On the other hand, the searchers have no information about the location of the intruder. The game consists of constructing a search plan which will finalize with the situation that all edges of the graph secured. The allowed actions are placing a searcher on a vertex, sliding a searcher along an edge and removing a searcher from the graph. We aim to find the optimal search strategy that will use as few searchers as possible to search the whole graph. This minimum number for a graph G is the edge search number of G, and it is denoted as $s(G)$.

One of the major problems of edge searching is to characterize the k-searchable graphs, those graphs G such that $s(G)$ is at most k, for a fixed positive integer k. This problem is solved only for $k = 1, 2$ and 3. Since 1976 this has been an open problem for $k \geq 4$. In this talk we will consider the characterization of 4-searchable graphs. We will give the complete characterization of forbidden minors for 4-searchable outerplanar graphs. This is a constructive characterization that gives us hints to extend this result to the whole family of 4-searchable graphs.

MSC2000: 05C83.

Keywords: Edge Searching, Forbidden Minors.

Latin squares and determinants

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In the talk I will define the concept of a determinant of a latin square, and then present known results for latin squares of small order. In particular, it is known that for latin squares of order less than eight, isotopic latin squares have similar determinants. However Ford and Johnson have shown this is not the case for latin squares of order 8, and they have exhibit examples of isotopic latin squares for which the determinants are not similar. Ford and Johnsons examples are interesting in that in each case the latin squares can be partitioned into subsquares of order 4. Building on this work I will present new arguments which provide theoretical justifications for these computational results.

Defective Ramsey Numbers

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(joint work with A. Akdemir and J. Gimbel)

The classical *Ramsey Number* $R(a;b)$ is defined as the smallest number n such that all n-graphs contain either a clique of size a or a stable set of size b. It is extremely difficult to compute Ramsey Numbers; despite extensive work, only a few Ramsey Numbers (for small a and b) are known to date. Defective Ramsey Numbers are recently introduced by Ekim and Gimbel where the notion of cliques and stable sets are generalized to respectively k-dense sets and k-sparse sets. Given a graph G and an integer k, a set S of vertices in G is k-sparse if S induces a graph with maximum degree of at most k. Similarly, S is k-dense if S induces a k-sparse graph in the complement of G. We will present some known Defective Ramsey Numbers. Then, we show how these numbers can be used to compute some parameters related to the so-called defective cocoloring problem where one's objective is to minimize the total number of k-dense or k-sparse sets partitioning the vertex set of the given graph. We will also discuss some ongoing research on Defective Ramsey Numbers in some restricted classes of graphs and the related cochromatic parameters.

MSC2000: 05B07,05B40 .

Keywords: Ramsey Numbers, defective sets, cocoloring.

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A short proof that geodetic number is NP-hard in cobipartite graphs

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A subset of vertices D of a graph G is called a *geodetic set* if every vertex of G lies on a shortest path between two vertices of D. The cardinality of a minimum geodetic set is called the *geodetic number of G*. In this talk, after giving a brief overview of some computational complexity results of the geodetic number problem in certain graph classes, I will give a short proof that this problem is NP-hard even in cobipartite graphs.

MSC2000: 05B07, 05B40.

Keywords: shortest path, geodetic set, geodetic number, cobipartite graph.

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Generalization of the outer-connected domination in graphs

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(joint work with M. H. Akhbari, N. Jafari Rad and R. Hasni)

Let $k \geq 1$ be an integer. For a given graph $G = (V, E)$ a set $D \subseteq V$ is outer-k-connected component dominating set if D is a dominating and the graph $G - D$ has exactly k connected component. The outer-k-connected component domination number of G, denoted by $\widetilde{\gamma}_c^k(G)$, is the minimum cardinality of a outer-k-connected component dominating set of G. In this paper we generalize the outer-connected domination and study outer-k-connected component domination in a graph G.

MSC2000: 05C69.

Keywords: Domination; Connected; Outer-connected.

Covering arrays with row limit $w = 4$

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(joint work with P. Danziger and E. Mendelsohn)

Covering arrays with row limit ($CARL$s) are a generalization of the covering arrays, the combinatorial objects modeling a test suite. $CARL$s have one extra parameter, the *weight* w, representing the number of components tested at once. Hence, they are applicable as testing suites in pharmaceutical, medical, agricultural, and similar studies. We give a lower bound on the size of a $CARL$, which is a generalization of the Schönheim bound for covering designs. We also present several construction methods for $CARL$s with $w = 4$ testing pairwise interactions. In this way, we get an optimal solution for any $CARL$ with $w = 4$ having a regular excess graph, with some exceptions. In order to complete the study, we need the optimal solutions for finitely many $CARL$s with irregular excess graph having small parameters, which are the ingredients in the constructions. Moreover, even a close to optimal solution to these ingredient $CARL$s would produce a close to optimal solution for the respective families of $CARL$s.

MSC2000: 05B40, 05B15, 05B05.

Keywords: covering arrays with row limit, covering arrays, group divisible covering designs, graph covering.

Simple signed Steiner triple systems

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(joint work with G.B. Khosrovshahi)

Let X be a v-set, $\mathcal{B}$ a set of 3-subsets (triples) of X, and $\mathcal{B}^+ \cup \mathcal{B}^-$ a partition of $\mathcal{B}$ with $|\mathcal{B}^-| = s$. The pair $(X, \mathcal{B})$ is called a simple signed Steiner triple system, denoted by $\mathrm{ST}(v,s)$, if the number of occurrences of every 2-subset of X in triples $B \in \mathcal{B}^+$ is one more than the number of occurrences in triples $B \in \mathcal{B}^-$. In this paper we prove that $\mathrm{ST}(v,s)$ exists if and only if $v \equiv 1, 3 \pmod 6$, $v \neq 7$, and $s \in \{0, 1, \ldots, s_v - 6, s_v - 4, s_v\}$ where $s_v = v(v-1)(v-3)/12$ or $v = 7$ and $s \in \{0, 2, 3, 5, 6, 8, 14\}$.

MSC2000: 05B07, 05B05.

Keywords: Simple Signed Steiner Triple System, Trade.

On connectedness of the suborbital graphs of the Picard group

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(joint work with Ali Hikmet Değer and Murat Beşenk)

We consider the action of a permutation group on a set in the spirit of the theory of permutation groups, and graph arising from this action in hyperbolic geometric terms. In this paper, we examine some properties of suborbital graphs for the Picard group.

MSC2000: 05C25, 05C40.

Keywords: Picard group, transitive and imprimitive action, suborbital graph.

The Picard group is denoted by $\mathbf{P}$ and contains all linear fractional transformations

$$T : z \to \frac{az+b}{cz+d}\text{ , where } a, b, c, d \in \mathbb{Z}(i) \text{ and } ad - bc = 1.$$

Let's define $\mathbb{Q}(i) := \{\frac{\alpha}{\beta} \mid \beta \neq 0 \text{ and } \alpha, \beta \in \mathbb{Z}[i]\}$. The action of $\mathbf{P}$ on $\hat{\mathbb{Q}}(i) := \mathbb{Q}(i) \cup \{\infty\}$ now becomes $\begin{pmatrix} a & b \\ c & d \end{pmatrix} : \frac{x}{y} \to \frac{ax+by}{cx+dy}$. We show that this action is transitive and imprimitive by the relation $\mathbf{P}_\infty < \mathbf{P_1}(N) < \mathbf{P}$ where $\mathbf{P}_\infty$ is the stabilizer of ∞ in $\hat{\mathbb{Q}}(i)$ and $\mathbf{P_1}(N) := \{T \in \mathbf{P} \mid a \equiv d \equiv 1(modN),\ c \equiv 0(modN)\}$ is a congruence subgroup of $\mathbf{P}$.

Let (G, Δ) be transitive permutation group. Then G acts on $\Delta \times \Delta$ by $g(\alpha, \beta) = (g(\alpha), g(\beta))(g \in G, \alpha, \beta \in \Delta)$. The orbits of this action are called *suborbitals* of G. The orbit containing (α, β) is denoted by $O(\alpha, \beta)$. From $O(\alpha, \beta)$ we can form a *suborbital graph* $G(\alpha, \beta)$: its vertices are the elements of Δ, and there is a directed edge from γ to δ denoted by $\gamma \to \delta$ if $(\gamma, \delta) \in O(\alpha, \beta)$. By a directed circuit, we mean that a sequence $v_1, v_2, \ldots, v_m$ of different vertices such that $v_1 \longrightarrow v_2 \longrightarrow \ldots \longrightarrow v_m \longrightarrow v_1$. Applying these ideas to our case, we obtain edge and circuit conditions, then examine the connectedness of the graph.

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Optimizing Quasi-Locally Quasi-Line graphs

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(joint work with AIT HADDADENE HACENE)

In this paper, we introduce a class of graphs named Quasi-Locally Quasi-Line graphs, denoted by QLQL graphs (i.e. graphs such that each induced subgraph has a vertex whose neighbourhood can be partitioned into at most two maximal cliques). First, we give polynomial combinatorial algorithms of recognizing and also of determining the maximum clique in QLQL graphs. Then, we give a polynomial combinatorial algorithm for ω-coloring any perfect Quasi-Line graph. Finally, we give another polynomial combinatorial algorithm for ω-coloring any perfect QLQL graph. These algorithms use the technique of the bi-chromatic exchange.

Keywords: Maximum clique; Perfect Graph; Recognizing; Algorithm; Coloring; Bi-chromatic exchange.

The Bollobás-Eldridge Packing Theorem for Hypergraphs

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(joint work with Alexandr Kostochka and Christopher Stocker
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In this talk we give a brief history of graph and hypergraph packing and we outline a new result on non-uniform hypergraph packing. We will show how this result generalizes some of the known graph and hypergraph packing theorems.

MSC2000: 05C65, 05C35.

Keywords: Graph Packing, Hypergraph Packing.

Two possible approaches to solving a conjecture about embedding partial Steiner triple systems

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(joint work with S. Ozkan)

We discuss an old conjecture about embedding Steiner triple systems. A number of analogues of this conjecture are known to be true (these analogues include a theorem of Cruse about embedding partial latin squares, and a theorem of Johansson about embedding triple systems of even index). We sketch two possible approaches to proving the conjecture, one via an edge colouring conjecture, and one via a possible analogue of Ryser's theorem about embedding partial latin squares involving a Hall-type condition.

MSC2000: 05B07.

Keywords: Steiner triple systems, Embedding, Ryser's theorem, Hall Conditions, Edge-colourings.

Group Divisible 2-Perfect Hexagon Systems

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(joint work with E.J. Billington)

We determine the spectrum for uniform, group divisible, 2-perfect 6-cycle systems of arbitrary index.

On the Hamiltonian coloring of graphs

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Let G be a connected graph of order n. For two vertices u and v in G, let $D(u,v)$ denote the length of a longest $u-v$ path in G. A hamiltonian coloring of G is an assignment c of positive integers to the vertices of G for which

$$D(u,v) + |c(u) - c(v)| \geq n - 1$$

for all distinct vertices u and v of G. The *value* of hamiltonian coloring c of G is the maximum color assigned by c to the vertices of G. The hamiltonian chromatic number of G is the minimum value of a hamiltonian coloring of G. In this talk we present a survey and also our recent results on hamiltonian colorings of graphs.

Joint Work: H.R.Maimani

MSC2000: 05xx.

Keywords: Hamiltonian coloring, longest path.

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Fixed Block Configuration GDDs with Block Size Six

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(joint work with Melissa Keranen)

A group divisible design GDD$(n, m, k; \lambda_1, \lambda_2)$ is a collection of k element subsets of a set of $v = nm$ points called blocks. These points are partioned into m groups of size n, and the blocks have the property that each pair of points from the same group appears in exactly λ_1 blocks and each pair from different groups is in exactly λ_2 blocks. If we require that each block contains s points from one group and t points from the other group, then it is called a (s, t) fixed block configuration. We present necessary conditions and sufficient conditions about the existence of group divisible designs with 2 groups and block size 6 for all fixed block configurations.

MSC2000: 05B05, 05B30.

Keywords: fixed block configuration, first and second associates, group divisible designs.

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Triple metamorphosis of twofold triple systems

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(joint work with M. Mezska and A. Rosa)

In a simple twofold triple system $(X, \mathcal{B})$, any two distinct triples T_1, T_2 with $|T_1 \cap T_2| = 2$ form a matched pair. Let $\mathcal{F}$ be a pairing of the triples of $\mathcal{B}$ into matched pairs (if possible). Let $\mathcal{D}$ be the collection of double edges belonging to the matched pairs in $\mathcal{F}$, and leet $\mathcal{F}^*$ be the collection of 4-cycles obtained by removing the double edges from the matched pairs in $\mathcal{F}$. If the edges belonging to $\mathcal{D}$ can be assembled into a collection of 4-cycles $\mathcal{D}^*$, then $(X, \mathcal{F}^* \cup \mathcal{D}^*)$ is a twofold 4-cycle system called a metamorphosis of the twofold triple system $(X, \mathcal{B})$. Previous work [1] has shown that the spectrum for twofold triple systems having a metamorphosis into a twofold 4-cycle system if precisely the set of all $n \equiv 0, 1, 4$ or 9 (mod 12), $n \geq 9$. In this paper, we extend this result as follows. We construct for each $n \equiv 0, 2, 4$ or 9 (mod 12), $n \neq 9$ or 12, a twofold triple system $(X, \mathcal{B})$ with the property that the triples in $\mathcal{B}$ can be arranged into three sets of matched pairs $\mathcal{F}_1, \mathcal{F}_2, \mathcal{F}_3$ having metamorphises into twofold 4-cycle systems $(X, \mathcal{F}_1^* \cup \mathcal{D}_1^*)$, $(X, \mathcal{F}_2^* \cup \mathcal{D}_2^*)$, and $(X, \mathcal{F}_3^* \cup \mathcal{D}_3^*)$, respectively, with the property that $\mathcal{D}_1 \cup \mathcal{D}_2 \cup \mathcal{D}_3 = 2K_n$. In this case we say that $(X, \mathcal{B})$ has a triple metamorphosis. Such a twofold triple system does notexist for $n = 9$, and its existence for $n = 12$ remains an open and apparently a very difficult problem.

Dynamical 2-Domination of Graphs

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(joint work with Ch. Eslahchi, R. Torabi, and R. Tusserkani)

Let $G = (V, E)$ be a graph and $D \subseteq V$. D is called a 2-dominating set of G if every vertex in $V \setminus D$ is dominated by at least two vertices in D. If $D = V_0 \subseteq V_1 \subseteq V_2 \cdots \subseteq V_k = V$ and for each i, V_{i-1} is a 2-dominating set of $G[V_i]$, then D is called a dynamical 2-dominating set, $d2d$ set, in G. In this talk we introduce and study $d2d$ sets and $d2d$ number, the minimum cardinality of $d2d$ sets, in a graph G.

MSC2000: 05C69,05C05 .

Keywords: Nearly perfect sets, Domination, 2-dominating number..

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Hamiltonian Cycles in Directed Toeplitz Graphs

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An $(n \times n)$ matrix $A = (a_{ij})$ 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.

Notation: The main diagonal of an $(n \times n)$ Toeplitz adjacency matrix will be labeled 0 and it contains only zeros. The $n-1$ distinct diagonals above the main diagonal will be labeled $1, 2, \ldots, n-1$ and those under the main diagonal will also be labeled $1, 2, \ldots, n-1$. Let $s_1, s_2, \ldots, s_k$ be the upper diagonals containing ones and $t_1, t_2, \ldots, t_l$ be the lower diagonals containing ones, such that $0 < s_1 < s_2 < \cdots < s_k < n$ and $0 < t_1 < t_2 < \cdots < t_l < n$. Then, the corresponding Toeplitz graph will be denoted by $T_n\langle s_1, s_2, \ldots, s_k; t_1, t_2, \ldots, t_l\rangle$. That is, $T_n\langle s_1, s_2, \ldots, s_k; t_1, t_2, \ldots, t_l\rangle$ is the graph with vertices $1, 2, \ldots, n$, in which the edge (i, j) occurs if and only if $j - i = s_p$ or $i - j = t_q$ for some p and q $(1 \leq p \leq k,\ 1 \leq q \leq l)$.

MSC2000: 05-XX, 05Cxx.

Keywords: Hamiltonian cycle, Hamiltonian graph, Adjacency matrix, Treatable Graph.

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Bounds for the signless Laplacian energy

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(joint work with Nair Abreu, Domingos M. Cardoso, Ivan Gutman and Maria Robbiano)

The energy of a graph G is the sum of the absolute values of the eigenvalues of the adjacency matrix of G. The Laplacian (respectively, the signless Laplacian) energy of G is the sum of the absolute values of the differences between the eigenvalues of the Laplacian (respectively, signless Laplacian) matrix and the arithmetic mean of the vertex degrees of the graph. In this talk, we present some results which relate these energies and we point out some bounds to them using the energy of the line graph of G. Most of these bounds are valid for both energies, Laplacian and singless Laplacian. However, we present two new upper bounds on the signless Laplacian which are not upper bounds for the Laplacian energy.

MSC2000: 5C50, 15A48.

Keywords: Laplacian graph spectrum, signless Laplacian spectrum, Laplacian energy, signless Laplacian energy.

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Integral Trees

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(joint work with E. Ghorbani and B. Tayfeh-Rezaie)

A graph is called integral if all eigenvalues of its adjacency matrix consist entirely of integers. Integral graphs are extremely rare and very difficult to find. For a long time, it has been an open question whether there exist integral trees of any diameter. Last year, the existence of integral trees of any even diameter has been confirmed. In the odd case, integral trees have been constructed with diameter at most seven. In this talk, we show that there are infinitely many integral trees of any odd diameter.

MSC2000: 05C05, 05C50.

Keywords: adjacency eigenvalue, diameter, integral tree.

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Restricted arc-connectivity of digraphs

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(joint work with C. Balbuena, P. García-Vázquez and A. Hansberg)

For a strongly connected digraph D, the restricted arc-connectivity $\lambda'(D)$ is defined as the minimum cardinality of an arc-cut over all arc-cuts S satisfying that $D-S$ has a non trivial strong component D_1 such that $D-V(D_1)$ contains an arc. A strongly connected digraph D is called λ'-connected if $\lambda'(D)$ exists. In this work we prove that every digraph on at least 4 vertices and of minimum degree at least 2 is λ'-connected and $\lambda'(D) \leq \xi'(D)$, where $\xi'(D)$ is the minimum arc-degree of D. Also we introduce the concept of super-λ' digraphs and provide a sufficient condition for a s-geodetic digraph to be super-λ'. Further, we show that the h-iterated line digraph $L^h(D)$ of a s-geodetic digraph is super-λ' for certain iteration h. Finally, we guarantee λ'-optimality in generalized p-cycles in terms the semigirth ℓ.

MSC2000: 05B07, 05B40.

Keywords: Restricted arc-connectivity, s-geodetic digraph, generalized p-cycle, semigirth, line digraph.

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Primitive rank 3 linear spaces

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(joint work with Mauro Biliotti and Eliana Francot)

A linear space $\mathcal{D} = (\mathcal{P}, \mathcal{L})$ is a non-empty set $\mathcal{P}$ of *points*, provided with a collection $\mathcal{L}$ of subsets of $\mathcal{P}$ called *lines*, such that any pair of points is contained in exactly one line and the lines contain the same number of points. The linear spaces with an automorphism group G satisfying some transitivity properties has been investigated by a fairly wide number of authors. The first important result in this direction is the classification of the linear spaces $\mathcal{D}$ admitting an automorphism group with a 2-transitive action on its points obtained by Kantor in 1985. Some years later, Buekenhout, Delantsheer, Doyen, Kleidman, Liebeck and Saxl announced the classification of the finite linear spaces $\mathcal{D}$ admitting a flag-transitive automorphism group G not isomorphic to an affine semilinear 1-dimensional group.

A natural generalization of the flag-transitive linear spaces, and ultimately of those with a point 2-transitive automorphism group is represented by the linear spaces $\mathcal{D}$ admitting a primitive rank 3 automorphism group G. There are three families of primitive rank 3 groups of degree n: G is almost simple; or $S \times S \lhd G \leq S_0 wr Z_2$, where S_0 is an almost simple 2-transitive group of degree n_0, and $n = n_0^2$ (Grid type); or $G = TG_0$, where T is an elementary abelian p-group acting regularly on a vector space V, and G_0 is an irreducible subgroup of $GL_d(p)$ with two orbits on the non-zero vectors of V (Affine type).

The linear spaces admitting a group G of almost simple type or grid type are essentially determined by Devillers in 2005 and 2008. In the present talk we present further results and new examples on the linear spaces admitting a primitive rank 3 automorphism group of affine type by using the classification of these groups by Foulser-Liebeck, and properties of Segre varieties.

Designs and Codes from $PSL_2(q)$

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We have developed two methods for constructing codes and designs from finite groups (mostly simple finite groups), see [?]. In this paper we first discuss background material and results required from finite groups, permutation groups and representation theory. Then we aim to describe our **second method** of constructing codes and designs from finite groups. The second method introduced a new technique from which a large number of non-symmetric 1-designs could be constructed. Let G be a finite group, M be a maximal subgroup of G and $C_g = [g] = nX$ be the conjugacy class of G containing g. We construct $1-(v,k,\lambda)$ designs $\mathcal{D} = (\mathcal{P}, \mathcal{B})$, where $\mathcal{P} = nX$ and $\mathcal{B} = \{(M \cap nX)^y | y \in G\}$. The parameters v, k, λ and further properties of $mathcalD$ are determined. We also study codes associated with these designs. In this paper we apply the second method to the group $PSL_2(q)$. The main aim of is to develop a general approach to $G = PSL_2(q)$, where M is the maximal subgroup that is the stabilizer of a point in the natural action of degree $q+1$ on the set Ω.

References

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MSC2000: 05B05, 20D05.

Keywords: Designs, codes, simple groups, maximal subgroups, conjugacy classes..

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Diameter and some finiteness conditions on the intersection graph of ideals of a ring

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(joint work with S. Akbari and M.J. Nikmehr)

Let R be a ring with unity and $I(R)^*$ be the set of all non-trivial left ideals of R. The intersection graph of ideals of R, denoted by $G(R)$, is a graph with the vertex set $I(R)^*$ and two distinct vertices I and J are adjacent if and only if $I \cap J \neq 0$. In this talk, all rings whose intersection graphs are not connected will be characterized. We prove that if $G(R)$ is a connected graph, then its diameter is at most 2. Next, some conditions under which the intersection graph of ideals of a ring is finite are given. Furthermore, some properties of the intersection graph of ideals of a ring are studied.

MSC2000: 05C69; 16A40.

Keywords: Intersection Graph of Ideals of a Ring, Artinian Ring.

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The edge cover polynomial of graphs and their roots

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(joint work with S. Akbari and P. Csikvari)

Let G be a simple graph of order n and size m. An edge covering of the graph G is a set of edges such that every vertex of the graph is incident to at least one edge of the set. Let $e(G, k)$ be the number of edge covering sets of G of size k. The edge cover polynomial of G is the polynomial

$$E(G, x) = \sum_{k=1}^{m} e(G, k)x^k.$$

In this talk we present some properties about the edge cover polynomial of graphs. Also we present some results on the roots of the edge cover polynomials. We show that for every graph G with no isolated vertex, all the roots of $E(G, x)$ are in the ball

$$\{z \in \mathbb{C} \, : \, |z| < \frac{(2 + \sqrt{3})^2}{1 + \sqrt{3}} \simeq 5.099\}.$$

We prove that if every block of the graph G is K_2 or cycle, then all real roots of $E(G, x)$ are in the interval $(-4, 0]$. We also show that for every tree T of order n we have

$$\xi_{\mathbb{R}}(K_{1,n-1}) \leq \xi_{\mathbb{R}}(T) \leq \xi_{\mathbb{R}}(P_n),$$

where $-\xi_{\mathbb{R}}(T)$ is the smallest real root of $E(T, x)$, and $P_n, K_{1,n-1}$ are the path and the star of order n, respectively.

MSC2000: 05C31,05C70.

Keywords: Graph polynomials, Edge cover polynomial, Edge covering.

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Decomposing the Higman-Sims graph into double Petersen graphs

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(joint work with Ivana Ilić, Emre Kolotoğlu and Spyros Magliveras)

In 1967, D. G. Higman and C. C. Sims discovered a new sporadic simple group G of order 44,352,000, as a group of automorphisms of a strongly regular graph Γ, the so called *Higman-Sims* graph. In this paper we show that Γ can be edge decomposed into the disjoint union of 5 double-Petersen graphs, each on 20 vertices. It is shown that this can be achieved in 36960 distinct ways. We present a group theoretic approach to constructing all such decompositions, and prove that all decompositions of Γ into double Petersen graphs fall into a single orbit under the action of G.

MSC2000: 68P25, 94A60.

Keywords: Higman-Sims group, Higman-Sims graph, Petersen graph, automorphism group, graph decomposition.

d-graceful labelings and graph decompositions

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We present the concept of a *d-graceful labeling*, which generalizes, at the same time, the very famous *graceful labelings* introduced in the sixties by A. Rosa and the *odd graceful labelings* recently considered by R.B. Gnana Jothi.
Let Γ be a graph of size e and let d be a divisor of e, say $e = d \cdot m$. A *d-graceful labeling* of Γ is an injective function $f : V(\Gamma) \to \{0, 1, 2, \ldots, d(m+1) - 1\}$ such that

$$\{|f(x) - f(y)| \mid [x, y] \in E(\Gamma)\} = \{1, 2, 3, \ldots, d(m+1) - 1\} - \{m+1, 2(m+1), \ldots, (d-1)(m+1)\}.$$

We find the ordinary and the odd graceful labelings in the extremal cases of $d = 1$ and $d = e$, respectively. It will be shown that this new kind of labelings is also useful to get cyclic graph decompositions. Existence results on d-graceful labelings will be presented for several classes of graphs.

MSC2000: 05B30, 05C78.

Keywords: graceful labeling, graph decomposition, difference family.

Colouring Block Designs

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(joint work with Daniel Horsley)

A block design with point set V and block set $\mathcal{B}$ is said to be c-colourable if the points of V can be partitioned into c sets called colour classes such that no block of $\mathcal{B}$ has all of its points in a single colour class. A design is said to be c-chromatic if it is c-colourable but not $(c-1)$-colourable. For all integers $c \geq 2$, $k \geq 6$ and $\lambda \geq 1$, we show that for sufficiently large v the obvious necessary conditions for the existence of a BIBD(v, k, λ) are sufficient for the existence of a c-chromatic BIBD(v, k, λ).

MSC2000: 05B05.

Keywords: BIBD, colouring, blocking set.

A Note on Roman Bondage Number of Graphs

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(joint work with S. Akbari)

A *Roman domination function* on a graph $G = (V(G), E(G))$ is a labeling $f : V(G) \to \{0, 1, 2\}$ satisfying the condition that every vertex with label 0 has at least a neighbor with label 2. A *Roman domination number* $\gamma_R(G)$ of G is the minimum of $\sum_{v \in V(G)} f(v)$ over such functions. A *Roman bondage number* $b_R(G)$ of G is the minimum cardinality of all sets $E \subseteq E(G)$ for which $\gamma_R(G - E) > \gamma_R(G)$. It was conjectured that $b_R(G) \leq n - 1$. In this talk we prove that this conjecture is true. Also, we show that $b_R(G) \leq n - \gamma_R(G) + 5$.

MSC2000: 05C69.

Keywords: Roman bondage number; Roman domination number.

Weinberger's Method For an Over-determined Elliptic Problem

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We deal with an over-determined elliptic problem in R^N, $N \geq 2$ subject to constant normal boundary condition. We prove that the domain in consideration is an N- ball. The tools of this investigation are maximum principles and P-functions.

MSC2000: 05B07, 05B40.

Keywords: Maximum Principles, P-Functions.

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On the spectral and switching invariants of Kneser graphs

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Two non-isomorphic graphs G and H are called cospectral if they share the same spectrum of the adjacency matrices. A property P of G is called spectral invariant if any cospectral mate of G, satisfies this property. As a method of constructing cospectral mates for a graph, we consider the Godsil-McKay switching method. We call a property P of a graph switching invariant if the property is invariant under any possible Godsil-McKay switching on the graph. In this research we consider Kneser graphs (denoted by $K(n,k)$) and study spectral and switching invariants of them. To construct some cospectral mates of Kneser graphs, we look for those properties of them which are not switching invariant. The problem is interesting in itself. Also if for instance, we prove that the chromatic number of a Kneser graph is spectral invariant, then there is a hope to find a spectral approach for resolving Kneser Conjecture.

MSC2000: 05C50.

Keywords: Spectrum, Godsil-McKay switching, spectral invariant, switching invariant,.

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New results on connectivity of cages

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(joint work with Camino Balbuena)

An $(r;g)$-cage is a r-regular graph of girth g of minimum order. We prove that all $(r;g)$-cages are at least $\lfloor r/2 \rfloor$-connected for every odd girth $g \geq 7$, by means of a matrix technique which allows us to construct graphs without short cycles. This lower bound on the vertex connectivity of cages is a new advance in proving the conjecture of Fu, Huang and Rodger which states that all (r,g)-cages are r-connected.

MSC2000: 05C40, 05C85.

Keywords: Connectivity, Cage.

The Total Number Of Fuzzy Subgroups Of $\mathbb{Z}_p^n$

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Abstract

In this paper, we compute the number of equivalence classes of fuzzy subgroups of the group $\mathbb{Z}_p^n$ for any given prime p and integer n. We give a direct formula to compute the number of fuzzy subgroups of $\mathbb{Z}_p^n$.

MSC2000: 05-XX
Keywords:Fuzzy subgroups, equivalence, p-groups.

Edge Intersections of Non-Splitting Paths in Trees

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(joint work with Arman Boyaci and Tinaz Ekim and Shmuel Zaks)

Given a tree and a set $\mathcal{P}$ of non-trivial simple paths of it, $\Omega(\mathcal{P})$ is the path graph (i.e. the vertex intersection graph) of $\mathcal{P}$, and $\Gamma(\mathcal{P})$ is the EPT graph (i.e. the edge intersection graph) of $\mathcal{P}$ [**?**]. These graphs have been extensively studied in the literature. Given two (edge) intersecting paths in a graph, their *split nodes* is the set of nodes having degree at least 3 in their union. Such a pair of paths is termed *non-splitting* if they have no split nodes, in other words their union is either a path or a cycle. In this work we define the edge intersection graph of non-splitting paths $\Lambda(\mathcal{P})$ termed the EPTN graph as the graph having a vertex for each path in $\mathcal{P}$, and an edge between every pair of intersecting and non-splitting paths. A graph G is an EPTN graph if there is a tree T and a set of paths $\mathcal{P}$ of T such that $G = \Lambda(\mathcal{P})$, and we say that $\langle T, \mathcal{P} \rangle$ is a *representation* of G. These graphs are of interest in all-optical networks using wavelength division multiplexing (WDM) technology, in which paths of a graph have to be colored, such that the set of paths in each color are pairwise non-splitting. In this first attempt to characterize these graphs, we show that the families of trees, cycles and cliques are contained in the family of EPTN graphs. Although $\Lambda(\mathcal{P})$ is a subgraph of $\Gamma(\mathcal{P})$ which is in turn a subgraph of $\Omega(\mathcal{P})$, EPTN graphs apparently have a more complex structure than EPT graphs. Our main result is a complete characterization of the representations of chordless cycles which turns out to be by far more complex than representations of cycles in EPT graphs, leading to a set of forbidden subgraphs of the family of EPTN graphs.

MSC2000: 05C62,05C75.

Keywords: Path graphs.

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On the Regular Digraph of Ideals of an Artinian Ring

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(joint work with M.J. Nikmehr)

Let R be a commutative ring and $\mathrm{Max}(R)$ be the set of maximal ideals of R. The regular digraph of ideals of R, denoted by $\overrightarrow{\Gamma_{reg}}(R)$, is a digraph whose vertex set is the set of all non-trivial ideals of R and for every two distinct vertices I and J, there is an arc from I to J whenever I contains a J-regular element (An element $x \in I$ is called J-regular if for every $y \in J \setminus \{0\}$, $xy \neq 0$). The undirected regular (simple) graph of ideals of R, denoted by $\Gamma_{reg}(R)$, has an edge joining I and J whenever either I contains a J-regular element or J contains an I-regular element. In this talk, for every Artinian ring R, it is shown that $|\mathrm{Max}(R)| - 1 \leq \omega(\Gamma_{reg}(R)) \leq |\mathrm{Max}(R)|$ and $\chi(\Gamma_{reg}(R)) = 2|\mathrm{Max}(R)| - k - 1$, where k is the number of fields, appeared in the decomposition of R into local rings. Also, the strong connectivity and the weak connectivity of $\overrightarrow{\Gamma_{reg}}(R)$ are investigated. Finally, the diameter and the girth of the regular graph of ideals of Artinian rings are determined.

MSC2000: 05C20, 05C69, 13E05, 16P20.

Keywords: Regular digraph, Clique number, Chromatic number, Artinian ring.

On the classification of Hadamard matrices of order 32

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(joint work with H. Kharaghani)

All equivalence classes of Hadamard matrices of order at most 28 have been found by 1994. Order 32 is where a combinatorial explosion occurs on the number of Hadamard matrices. We find all equivalence classes of Hadamard matrices of order 32 which are of certain types. It turns out that there are exactly 13,680,757 Hadamard matrices of one type and 26,369 such matrices of another type. Based on experience with the classification of Hadamard matrices of smaller order, it is expected that the number of the remaining two types of these matrices, relative to the total number of Hadamard matrices of order 32, to be insignificant.

MSC2000: 05B20, 05B05, 05B30.

Keywords: Hadamard matrices, classification of combinatorial objects, isomorph-free generation, orderly algorithm.

Relational Graphs and demonic semantics

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The approaches to semantics are categorized as operational, axiomatic or denotational. We will be concerned by the operational and the denotational semantics of nondeterministic programs. The operational semantics is described by the relation between the initial and the final states. In our case we consider the worst execution of the program i.e we suppose that the program behaves as badly as possible according to *demonic relational semantics* . Usually this last one is given an ad-hoc semantics definition, based on an intuitive understanding of the behavior of the program. Denotational semantics has been introduced by Scott and Strachey. To give the denotational semantics, we associate to a program a mathematical object in our case this object is a relational graph whose arrows are weighted by the different steps of the program. The operations are "the demonic choice" and "demonic composition". In a relational formalism, a graph is based on relational concepts : a representation relation of the graph, a set of vertices, an initial vertex and a final vertex. By using the same approach as above, we define a *relational graph* as being a quadruple constructed of a relation, a set of partial identities disjoint from each other (they have a role identical to the vertices of a graph) and also of two particular partial identities characterizing the input and the output of the program. We show how the notion of the relational graph can be exploited to give a single demonic operational semantics (with only demonic operators) for a wide range of programming constructs.

MSC2000: (2000):18C10 ,18C50, 68Q55,68Q65 03B70 ,06B35.

Keywords: Formal methods,relation algebra,relational graphs,demonic semantics, operational semantics.

On the Some Parameters of Random Graphs

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(joint work with Saeid Alikhani)

In this paper we consider random graphs $G(n, p)$ with fixed edge-probability p. We study some graph parameters such as domination number and chromatic numbers. We state some upper bounds for these parameters of $G(n, p)$.

MSC2000: 05C80, 05C69.

Keywords: Random graph, Domination number, Chromatic number, Borel Cantelli lemma.

2–starters, graceful labelings and a doubling construction for the Oberwolfach problem

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(joint work with M. Buratti)

Over the past few years, different methods have been devised in order to come to a complete solution of the Oberwolfach problem $\mathrm{OP}(\ell_1, \ell_2, \ldots, \ell_t)$ [**?**, **?**], which asks for a decomposition of the complete graph on $2n+1 = \sum \ell_i$ vertices into copies of $C_{\ell_1} \cup C_{\ell_2} \cup \ldots \cup C_{\ell_t}$ (that is the union of t cycles of lengths $\ell_1, \ell_2, \ldots, \ell_t$). The 1–rotational solutions [**?**, **?**] namely, those featuring an automorphism group G acting sharply transitively on all but one vertex turn out to be very interesting, since they can be constructed exploiting the algebraic properties of G.

In this talk, we show how the concepts of 2–starters and graceful labelings, together with a doubling construction, can be exploited to get infinitely many new solutions to the Oberwolfach problem. Among other things, we provide a method to construct solutions of $\mathrm{OP}(2\ell_1 + 1, 2\ell_2)$ and $\mathrm{OP}(2\ell_1 + 1, \ell_2, \ell_3)$ (not yet completely settled!) for any sufficiently large ℓ_1, solving many previously unsettled cases.

MSC2000: 05C25, 05C70, 05C78.

Keywords: 2–starter, graceful labeling, Oberwolfach problem.

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On new bounds for separating hash families

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(joint work with Marjan Bazrafshan)

An $(N; n, m, \{w_1, \ldots, w_t\})$-separating hash family is a set $\mathcal{F}$ of N functions $f:\ X \longrightarrow Y$ with $|X| = n$, $|Y| = m$, $t \geq 2$ having the following property. For any mutually disjoint subsets $C_1, \ldots, C_t \subseteq X$ with $|C_i| = w_i$, $i = 1, \ldots, t$, there exists at least one function $f \in \mathcal{F}$ such that $\{f(x) :\ x \in C_i\} \cap \{f(x) :\ x \in C_j\} = \emptyset$ for any $i \neq j$. Separating hash families generalize simultaneously several well-studied classes of combinatorial objects, such as perfect hash families, $t-$frameproof codes, $t-$secure frameproof codes, identifiable parent property codes. One of the main problems in studying separating hash families is to determine upper bounds for n when $N, m, \{w_1, \ldots, w_t\}$ are given. Establishing a good bound on n is a challenging problem. In this talk, we present our recent results on strong bounds for separating hash families.

MSC2000: 05B99.

Keywords: Separating hash families, bounds.

On the surviving rate of graphs

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Let G be a connected graph with $n \geq 2$ vertices. Suppose a virus breaks out at a vertex v of G and we can protect one vertex not yet infected at a time. Afterwards, the virus spreads to all its unprotected neighbors in each time interval. The virus and network protector takes turns and until the virus can no longer spread further.
The surviving rate is defined to the average value of the maximum number of vertices that can be saved over n^2. We shall investigate the surviving rate of varies graphs.

The number of subsquares in a latin square

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(joint work with Josh Browning, Doug Stones and Petr Vojtěchovský)

A *latin square* is a matrix in which each row and column form a permutation of the same set of symbols. A *subsquare* is a submatrix that is itself a latin square.
I will report on some recent results dealing with the question, "How many subsquares of order k can a latin square of order n possess?" We have some bounds that work for general k and n. For fixed small k, we can in some cases identify the maximum number of subsquares exactly. Unsurprisingly, the winners tend to have interesting algebraic structure.

MSC2000: 05B15.

Keywords: latin square, subsquare.

Total Coloring Of Thorny Graphs

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Over the 150 years various works have been done on the coloring of graphs such as vertex coloring, edge coloring. The last 40 years total coloring of the graphs has been considered by various authors.

A total coloring of a graph G is a coloring of all elements of G , i.e. vertices and edges, so that no two adjacent or indecent elements receive the same color. The minimum number of colors is called the total chromatic number $\chi_T(G)$ of G.

The thorny graph G^* of G is used to design communication networks and to represent molecular structure.

For any graph G^* that can be obtained from a parent connected graph G by attaching $p_i \geq 0$ new vertices of degree one to each vertex i, is called thorny graph.

In this talk we give the total chromatic number of the thorny graphs where $p_i = r$ $(r \in \mathbb{Z}^+)$ and some theorems about total chromatic number of thorny graphs.

MSC2000: 05C15.

Keywords: Total coloring, total chromatic number, thorny graphs..

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