38th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing

Wellington, New Zealand
1 – 5 December 2014

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TIMETABLE

The seminar rooms are Cotton Lecture Theatre 122, Alan MacDiarmid 102, and Alan MacDiarmid 104. Morning and afternoon teas will be served in Alan MacDiarmid 103. All plenary talks and the AGM are in CO122.

MONDAY 1 DECEMBER

09:00	Welcome and Introduction		
09:15	**Mike Atkinson** *Pattern classes and simple permutations* (11) Chair: M. Albert		
10:15	BREAK		
	CO 122 Chair: M. Albert	**AM 102** Chair: I. Wanless	**AM 104** Chair: A. Devillers
10:45	Paul Cordue *Phylogenetic Networks that Display a Tree Twice* (17)	Stelios Georgiou *On Supplementary Difference Sets* (19)	John Bamberg *Why do we care about generalised polygons?* (21)
11:15	Simone Linz *Subnetwork transfer operations on phylogenetic networks* (17)	Rosalind Hoyte *Doyen-Wilson Results for Odd Length Cycle Systems* (19)	Eric Swartz *Antiflag-transitive generalized quadrangles* (21)
11:45	Patrick Andersen *Minimum Weight Resolving Sets of Grid Graphs* (18)	Nevena Francetić *Upper bounds on the asymptotic size of covering arrays via entropy compression* (20)	Stephen Glasby *Generalized quadrangles and AS-configurations of finite p-groups* (22)
12:15	Pawaton Kaemawichanurat *Hamiltonicity of claw-free graphs that are critical with respect to domination numbers* (18)	Diana Combe *Using Holey Designs to construct generalized Bhaskar Rao designs* (21)	Tomasz Popiel *Point-primitive generalised hexagons and octagons* (22)
12:45	LUNCH		

14:30	**Stefan van Zwam** *Beyond total unimodularity* (11) Chair: D. Mayhew		
15:30	BREAK		
	CO 122 Chair: J. Oxley	**AM 102** Chair: S. Georgiou	**AM 104** Chair: M. Atkinson
16:00	Ben Clark *Towards an excluded-minor characterisation of the Hydra-5 matroids* (23)	Sarada Herke *Extending the Bruck-Ryser-Chowla Theorem to Symmetric Coverings* (24)	Daniel Krenn *Partitions and Compositions into Powers of b* (25)
16:30	Susan Jowett *Graphic Connectivity Functions* (23)	Daniel Horsley *Steiner triple systems without parallel classes* (24)	Michael Albert *Wilf-equivalence for Catalan structures* (25)
17:00	Geoff Whittle *Connectivity Functions* (23)	Ian Wanless *Chromatic Index of Steiner Triple Systems* (24)	Catherine Greenhill *Asymptotic enumeration of sparse uniform hypergraphs with given degrees* (26)

TUESDAY 2 DECEMBER

09:15	**Simeon Ball** *The polynomial method in combinatorial geometry* (12) Chair: A. Devillers		
10:15	BREAK		
	CO 122 Chair: G. Whittle	**AM 102** Chair: R. Coulter	**AM 104** Chair: C. Greenhill
10:45	Darryn Bryant *Vertex-transitive graphs that have no Hamilton decomposition* (27)	David Roberson *Unique Vector Colorings and Graph Cores* (28)	Darcy Best *Transversals in Latin Squares* (31)
11:15	Irene Pivotto *Which biased graphs are group-labelled graphs?* (27)	Marston Conder *Minimum genus embeddings of vertex-transitive graphs* (29)	Vaipuna Raass *Saturated critical sets of full Latin squares* (31)
11:45	Thomas Kalinowski *The incremental minimum weight basis problem for matroids* (27)	Min Yan *Tiling of the Sphere by Congruent Pentagons* (30)	Nick Cavenagh *Induced subarrays of Latin squares without repeated symbols* (31)
12:15	Molly Melhuish *The other Hass - music, climbing, family* (28)		
12:45	LUNCH		

14:30	**Andrew Thomason** *Hypergraph containers and some applications* (13) Chair: G. Royle		
15:30	BREAK		
	CO 122 Chair: T. Britz	**AM 102** Chair: A. Mani	**AM 104** Chair: N. Cavenagh
16:00	Peter Nelson *Circuits in graphs, matroids and binary codes* (32)	Daniel J. Harvey *Treewidth of General Line Graphs* (33)	Trent Marbach *The spectrum for 3-way k-homogeneous Latin Trades* (34)
16:30	Keisuke Shiromoto *On the covering dimension of a linear code and its relation to matroids* (32)	David R. Wood *Layered Separators* (33)	Jayama Mahamendige *Near-autoparatopisms of Latin squares* (35)
17:00	Klara Stokes *A geometric decoder for spread codes* (33)	Timothy Garoni *The worm algorithm for the Ising model is rapidly mixing* (34)	Rebecca Stones *A Latin square autotopism secret sharing scheme* (36)
17:30	AGM of the CMSA		

WEDNESDAY 3 DECEMBER

09:15	**Sergey Norin** *Densities of minor-closed families* (13) Chair: D. Wood		
10:15	BREAK		
	CO 122 Chair: G. Farr	**AM 102** Chair: P. Nelson	**AM 104** Chair: I. Pivotto
10:45	Arun Mani *Spanning forests on adjacent pairs of edges are negatively correlated* (36)	Thomas Britz *New directions in matroidal coding theory* (38)	S. Narjess Afzaly *Turan Numbers for Cycles* (39)
11:15	Douglas West *Minimum Degree and Dominating Paths* (37)	Daniel Hawtin *Elusive Codes in Hamming Graphs* (38)	Nick Wormald *On longest paths in random Apollonian networks* (40)
11:45	Stacey Mendan *Graphic and bipartite graphic sequences* (37)	Padraig Ó Catháin *Compressed sensing with Hadamard matrices and combinatorial designs* (38)	Xiaoya Zha *A lower bound for isoperimetric constants of (d^+, f^+)-plane tessellation* (40)
12:15	LUNCH		
14:00	Conference Excursion		

THURSDAY 4 DECEMBER

09:15	**Alice Devillers** *Tits' buildings as combinatorial objects* (13) Chair: J. Bamberg	
10:15	BREAK	
	CO 122 Chair: S. van Zwam	**AM 102** Chair: M. Wilson
10:45	Melissa Lee *Relative Hemisystems on the Hermitian Surface* (41)	Yen Hung Chen *Approximability results for the converse connected center problem* (43)
11:15	Henry Crapo *Homology of Projective Geometric Configurations* (41)	Nathan Van Maastricht *Using Ideas from Chess Engines to Search for Combinatorial Objects* (44)
11:45	Arjana Žitnik *Combinatorial configurations and quasiline arrangements* (42)	Lucy Ham *Preservation Theorems in Finite Structures* (44)
12:15	Gunter Steinke *Finite Minkowski planes of Klein type 20* (42)	Murray Smith *Finite Disjoint Representability of Semigroups* (45)
12:45	LUNCH	
14:30	**James Oxley** *A splitter theorem for internally* 4*-connected graphs and binary matroids* (14) Chair: G. Whittle	
15:30	BREAK	
	CO 122 Chair: J. McLeod	**AM 102** Chair: J. Bamberg
16:00	Amy Glen *Palindromically Rich GT-words* (45)	Gordon Royle *Primitive Groups and Synchronisation* (46)
16:30	Jamie Simpson *The proof of the runs conjecture* (45)	Marcel Jackson *Flexible satisfaction* (47)
17:00	Benjamin R. Smith *A multigraph generalisation of Alspach's cycle decomposition problem* (46)	Charles Semple *What is a Typical Matroid?* (47)

FRIDAY 5 DECEMBER

09:15	**Jaroslav Nešetřil** *Sparse versus dense* (14) Chair: M. Conder	
10:15	BREAK	
	CO 122 Chair: N. Wormald	**AM 102** Chair: J. Simpson
10:45	Sanming Zhou *Almost multicovers of complete graphs* (48)	Sara Sabrina Zemljič *Sierpiński graphs – Distances and symmetries* (50)
11:15	Gabriel Verret *Semiregular automorphisms of cubic vertex-transitive graphs* (48)	Graham Farr *The probabilistic method meets Go* (51)
11:45	Tim Penttila *Strongly regular graphs from large arcs in affine planes* (49)	Kiyoshi Yoshimoto *Locating Sets of Vertices on Hamiltonian Cycles* (52)
12:15	Bhaba Kumar Sarma *The completion problems for some classes of Q-matrices* (49)	Akira Kamibeppu *Bounds for the boxicity of Mycielskians of graphs* (53)
12:45	LUNCH	
14:30	**Mark Wilson** *Analytic combinatorics in several variables* (15) Chair: I. Wanless	
15:30	BREAK	
	CO 122 Chair: G. Royle	
16:00	Huseyin Acan *On a Random Tree Chosen From Permutation Graphs* (54)	
16:30	Kazuhiko Ushio *Balanced C_7-Foil Designs and Related Designs* (54)	
17:00		

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INVITED TALKS

PATTERN CLASSES AND SIMPLE PERMUTATIONS

Mike Atkinson
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Monday at 09:15 in CO122.

The theory of permutation patterns views a permutation as a set of points in the plane. With this viewpoint the set of all permutations is ordered by a natural subpermutation order. Pattern classes are downsets in this partial order and they arise in many contexts. Every pattern class can be characterised by a unique minimal set of forbidden permutations and determining this set is one of the central problems of the field.
The converse problem is to determine the structure of a pattern class given its forbidden set. Simple permutations are a useful tool to determine this structure since every permutation can be regarded as an "inflation" of a unique simple permutation. Some examples of their use in the theory of pattern classes will be given and the present state of knowledge will be summarised.

BEYOND TOTAL UNIMODULARITY

Stefan van Zwam
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Monday at 14:30 in CO122.

A matrix is totally unimodular if the determinant of each square submatrix is in $\{-1, 0, 1\}$. Such matrices are a cornerstone of the theory of integer programming, and they have been studied extensively.
In the late '90s, Whittle introduced several classes of matrices with similar properties: the determinants of the submatrices are restricted to a certain set. In this talk I will discuss some results from the theory of totally unimodular matrices, and outline which of those results will, won't, or might generalize to Whittle's classes. The natural context for these problems is matroid theory.

THE POLYNOMIAL METHOD IN COMBINATORIAL GEOMETRY

Simeon Ball

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Universitàt Politécnica Catalunya

Tuesday at 09:15 in CO122.

In recent years significant advances have been made in the application of algebraic methods to finite geometrical objects, see the recent survey by Tao [4]. Whether these objects are in real, finite or complex space, the finiteness of the object allows for some combinatorial methods to be used. Combining these with algebraic methods, most notably from algebraic geometry, one can hope to obtain theorems concerning the geometrical object under consideration.
In this talk I will consider Kakeya sets and Bourgain sets.
Let $\mathbb{F}$ be a field and let $\mathrm{AG}_k(\mathbb{F})$ denote the k-dimensional affine space over $\mathbb{F}$. Let $\mathbb{F}_q$ denote the finite field with q elements, $q = p^h$, for some prime p.
A *Kakeya set* in $\mathrm{AG}_n(\mathbb{F})$ is a set L of lines with the property that L contains no two lines with the same direction. I will explain an iterative geometric construction of Kakeya sets in $\mathrm{AG}_n(\mathbb{F})$ starting from a Kakeya set in $\mathrm{AG}_2(\mathbb{F})$. I will say something about Dvir's proof (from [1]) that if L is a Kakeya set in $\mathrm{AG}_n(\mathbb{F}_q)$ which contains a line in every direction then there is a constant $c = c(n)$ such that if S is the set of points incident with some line of L then

$$|S| \geqslant cq^n.$$

A *Bourgain set* in $\mathrm{AG}_n(\mathbb{F})$ is a set L of lines with the property that a plane contains few lines of L. Amongst other things I will sketch Guth and Katz's proof [3] that if L is a set of N^2 lines in $\mathrm{AG}_3(\mathbb{R})$, with at most N contained in any plane, and S is a set of points with the property that every line of L is incident with at least N points of S then there is a constant c such that

$$|S| \geqslant cN^3.$$

Furthermore, I will talk about Ellenberg and Hablicsek's article [2] on the finite analogue of this in which L is a set of aq^2 lines in $\mathrm{AG}_3(\mathbb{F}_q)$ with at most bq lines in a plane, for some constant b. They prove that if q is prime then there is a constant $c = c(a, b)$ such that if S is the set of points incident with some line of L then

$$|S| \geqslant cq^3.$$

This does not hold true over non-prime finite fields and we shall also consider this finite non-prime case. I will also detail some results about Bourgain sets in higher dimensions.

Bibliography

[1] Zeev Dvir, On the size of Kakeya sets in finite fields, `http://arXiv:0803.2336v3`

[2] Jordan S. Ellenberg and Márton Hablicsek, An incidence conjecture of Bourgain over fields of positive characteristic, `arXiv:1311.1479v1`.

[3] Larry Guth and Nets Hawk Katz, Algebraic methods in discrete analogs of the Kakeya problem, *Adv. Math.*, **225** (2010), 2828–2839.

[4] Terrence Tao, Algebraic combinatorial geometry: the polynomial method in arithmetic combinatorics, incidence combinatorics, and number theory, `http://arXiv:1310.6482v5`.

Hypergraph containers and some applications

Andrew Thomason
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University of Cambridge

(Joint work with David Saxton)

Tuesday at 14:30 in CO122.

It has recently been discovered that every uniform hypergraph has a small collection of subsets such that every independent set is contained in one of these subsets. This fact, when suitably quantified, has many applications that appear to have no connection with hypergraphs, such as to counting F-free graphs, sparse arithmetic progressions and so on. The talk will survey some of these applications and outline a new, simpler proof of the container theorem itself.

Densities of minor-closed families

Sergey Norin
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McGill University

(Joint work with Rohan Kapadia and Robin Thomas)

Wednesday at 09:15 in CO122.

The *density* of a sparse family of graphs is defined as the supremum of $|E(G)|/|V(G)|$ over graphs in the family. For example, the density of forests is 1 and the density of planar graphs is 3. Eppstein has recently initiated the systematic study of the set of possible densities of minor-closed graph families. In this talk we discuss rationality of densities for classes of bounded treewidth, and densities of K_t-minor free t-connected graphs.

Tits' buildings as combinatorial objects

Alice Devillers
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Thursday at 09:15 in CO122.

Buildings were invented in the 1960s by the Belgian-French mathematician Jacques Tits. They are a useful tool to ”visualise” algebraic groups (such as classical and exceptional Lie groups). The simplest examples are the projective spaces. Other examples include polar spaces, generalised polygons, infinite trees.

I will give a general introduction to the concept of buildings, from several points of view, with special emphasis on the chamber system point of view, which is very combinatorial. I will then illustrate how that combinatorial structure can be used to show results that apply to many different types of buildings at once.

A SPLITTER THEOREM FOR INTERNALLY 4-CONNECTED GRAPHS AND BINARY MATROIDS

James Oxley
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Thursday at 14:30 in CO122.

Tutte proved in 1961 that every 3-connected simple graph G, other than a wheel, has an edge whose deletion or contraction is both 3-connected and simple. Seymour (1980) and Negami (1982) independently strengthened Tutte's theorem by proving that, for any 3-connected simple proper minor H of G, we can delete or contract an edge from G to get a graph that, in addition to being both 3-connected and simple, maintains a minor isomorphic to H. Tutte generalized his theorem to matroids in 1966 while Seymour's original proof of his splitter theorem was done in the more general context of matroids. These theorems give us powerful inductive tools for working with graphs and matroids provided our structures are 3-connected. A number of authors have sought corresponding results for graphs and matroids of higher connectivity. This talk, which is based on joint work with Carolyn Chun and Dillon Mayhew, will discuss our project to find analogues of these theorems for internally 4-connected binary matroids and hence for internally 4-connected graphs, where such graphs are 4-connected except for the possible presence of degree-3 vertices. The talk will assume no prior knowledge of matroid theory.

SPARSE VERSUS DENSE

Jaroslav Nešetřil
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Charles University

(Joint work with Patrice Ossona de Mendez)

Friday at 09:15 in CO122.

What is a sparse graph? We present a possible answer in the form of Nowhere Dense vs Somewhere Dense dichotomy. This very robust dichotomy can be characterized in several different ways and using most combinatorial invariants. It also generalizes many concrete instances and with several algorithmic consequences such as restricted colorings and model checking.

Analytic combinatorics in several variables

Mark Wilson
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Friday at 14:30 in CO122.

Multivariate generating functions arise in combinatorial enumeration at least as often as univariate ones, but difficulties in their analysis have prevented their full potential being realized. Robin Pemantle and the speaker set out to systematize a substantial part of the theory of asymptotic coefficient extraction from multivariate generating functions. The results of this work (with other coauthors) can be found in the book Analytic Combinatorics in Several Variables (Cambridge 2013), which we see as a complement to the univariate work by Flajolet and Sedgewick. I will present a selection of applications chosen from the book and from my current work, along with open problems suitable for students interested in both the theory and applications.

CONTRIBUTED TALKS

MONDAY MORNING

PHYLOGENETIC NETWORKS THAT DISPLAY A TREE TWICE

Paul Cordue
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(Joint work with Charles Semple and Simone Linz)

Monday at 10:45 in CO122.

Evolutionary [phylogenetic] trees have successfully described evolution since Darwin's 1859 paper Origin of Species. The reconstruction of evolution now faces new challenges, as evolution may not be fully represented by an evolutionary tree but by an entwined network that reflects how a species inherits its DNA from more than one ancestor.

Such a network is a better representation of the evolution of the species when there are a significant number of events such as hybridization, lateral gene transfer, and recombination. New questions and concepts arise when studying evolutionary [phylogenetic] networks, and one such question is: When does a phylogenetic network display a phylogenetic tree twice? This talk will introduce the concepts that are needed to answer the above question, and an efficient algorithm will be presented that decides the question for a class of phylogenetic networks that lies strictly between tree-child networks and tree-sibling networks.

SUBNETWORK TRANSFER OPERATIONS ON PHYLOGENETIC NETWORKS

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(Joint work with Katharina Huber, Vincent Moulton, and Taoyang Wu)

Monday at 11:15 in CO122.

In evolutionary biology, phylogenetic trees and networks are widely used as a tool to unravel the ancestral history of sets of species. While phylogenetic trees are mostly restricted to represent speciation events, phylogenetic networks additionally allow for the representation of processes in which two distinct parental species recombine their genetic material to create a new species such as hybridization. A variety of different techniques exist for reconstructing phylogenetic trees and networks. However, different techniques often yield different results in which case it is important to determine how far apart two phylogenetic trees or networks are from each other.

In the first part of the talk, we will review some popular graph-theoretic operations that can be used to quantify the dissimilarities between two phylogenetic trees. These operations rearrange trees locally and induce metrics on the space of all phylogenetic trees. In the second part, we will then generalize one of these operations, the so-called *nearest neighbor interchange operation*, to phylogenetic networks and investigate some of its properties for classes of relatively simple networks.

MINIMUM WEIGHT RESOLVING SETS OF GRID GRAPHS

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The University of Newcastle

(Joint work with Cyriac Grigorious and Mirka Miller)

Monday at 11:45 in CO122.

For a simple graph $G = (V, E)$ and for a pair of vertices $u, v \in V$, we say that a vertex $w \in V$ resolves u and v if the shortest path from w to u is of a different length than the shortest path from w to v. A set of vertices $R \subseteq V$ is a resolving set if for every pair of vertices u and v in G, there exists a vertex $w \in R$ that resolves u and v. The minimum weight resolving set problem is to find a resolving set M for a weighted graph G such that $\sum_{v \in M} w(v)$ is minimum, where $w(v)$ is the weight of vertex v. In this talk, we explore the possible solutions of this problem for grid graphs $P_n \Box P_m$ where $3 \leq n \leq m$. We give a complete characterisation of solutions whose cardinalities are 2 or 3, and show that the maximum cardinality of a solution is $2n - 2$. We also provide a characterisation of a class of minimals whose cardinalities range from 4 to $2n - 2$.

HAMILTONICITY OF CLAW-FREE GRAPHS THAT ARE CRITICAL WITH RESPECT TO DOMINATION NUMBERS

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(Joint work with Louis Caccetta)

Monday at 12:15 in CO122.

A graph G is said to be $k-\gamma-$critical if the domination number $\gamma(G)=k$ and $\gamma(G+uv)<k$ for every $uv \notin E(G)$. For the connected domination number $\gamma_c(G)=k$ and the independent domination number $i(G)=k$, a $k-\gamma_c-$critical graph and a $k-i-$critical graph are similarly defined. In our previous work, we proved that $k-\gamma_c-$critical graphs are hamiltonian if and only if $k=1,2$ or 3. The problem of interest is the determine a sufficient condition for $k-\gamma_c-$critical graphs to be hamiltonian for $k \geq 4$. In this paper, we prove that $2-$connected $4-\gamma_c-$critical claw-free graphs are hamiltonian. We also show that the condition claw-free of these graphs is tight. For $k \geq 5$, we provide $k-\gamma_c-$critical claw-free non-hamiltonian graphs of connectivity two. However, we can show that $3-$connected $k-\gamma_c-$critical claw-free graphs are hamiltonian for $1 \leq k \leq 6$. In the context of independent domination critical graphs, Ao(1994) characterized $2-i-$critical graphs and, in 2013, Ao et al. proved that $3-i-$critical graphs with $\delta \geq 3$ are hamiltonian. In this paper, we provide $k-i-$critical non-hamiltonian graphs with $\delta \geq 2$ for $k \geq 4$. Therefore, $k-i-$critical graphs with $\delta \geq 3$ are hamiltonian if and only if $k=1,2$ or 3. We, further, prove that every $3-$connected $4-i-$critical claw-free graph is hamiltonian. For domination critical graphs, it was conjectured that every $(k-1)-$connected $k-\gamma-$critical graph is hamiltonian. Although this conjecture was rejected for $k=4$, we can prove that it is true for $k=4$ under the condition that the graph is claw-free.

ON SUPPLEMENTARY DIFFERENCE SETS

Stelios Georgiou

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Monday at 10:45 in AM102.

In this paper we study Supplementary Difference Sets (SDSs). We considered 2-SDSs and investigated the possible construction of certain cases by using some multiplication techniques. New infinite families of SDSs, having specific parameters, are constructed using the developed multiplication techniques. The 2-SDSs that are included in these infinite families were previously unknown. Small examples of new 2-SDSs and their constructions are explicitly described. These methods are easy to apply and all the results can be obtained by elementary theoretical calculations that are conducted by hand.

Doyen-Wilson Results for Odd Length Cycle Systems

Rosalind Hoyte
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(Joint work with Daniel Horsley)

Monday at 11:15 in AM102.

The Doyen-Wilson theorem states that, for integers u and v such that $v > u$, there exists an embedding of a Steiner triple system of order u in a Steiner triple system of order v if and only if $v \geq 2u+1$. A Steiner triple system of order v is equivalent to a 3-cycle system of order v. In this talk we discuss a result that shows that, for odd $m \geq 3$, an m-cycle system of order u can be embedded in an m-cycle system of order v for every feasible value of v when $u > \frac{(m-1)(m-2)}{2}$ and in the remaining cases it can be embedded for every feasible value of $v \geq u+m+1$.

Upper bounds on the asymptotic size of covering arrays via entropy compression

Nevena Francetić
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(Joint work with Brett Stevens)

Monday at 11:45 in AM102.

A covering array is a two dimensional array with k columns and N rows, and each cell of the array is assigned one of v alphabet symbols. Moreover, any $N \times t$ subarray must contain each of v^t possible t-tuples over the alphabet at least once. Covering arrays have been extensively studied due to their numerous applications, the most prominent one being as a software interactions testing suite. However, the asymptotic size of covering arrays is only known for arrays of strength $t = 2$. Here we present an application of the entropy compression argument to obtain algorithmic upper bounds on the asymptotic size of balanced covering arrays of any strength.

USING HOLEY DESIGNS TO CONSTRUCT GENERALIZED BHASKAR RAO DESIGNS

Diana Combe
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(Joint work with Julian Abel, The University of New South Wales; Adrian Nelson, The University of Sydney; Bill Palmer, The University of Sydney)

Monday at 12:15 in AM102.

In this talk I will use examples to explain the structure of a generalized Bhaskar Rao design (GBRD) and outline some of the questions and problems (and answers) that arise in this area.

One question that arises is whether there exist designs for particular sets of 'feasible' values of the design parameters, and a few years ago we were struggling with existence questions for designs over a particular group of order 36. We have introduced 'Holey' GBRDs and use them in constructions of generalized Bhaskar Rao designs, and have thus nearly completed proving the necessary and sufficient conditions for the existence of a GBRD over all groups with orders of the form 2^n3^m. I will give examples of constructions using 'Holey' designs.

WHY DO WE CARE ABOUT GENERALISED POLYGONS?

John Bamberg
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Monday at 10:45 in AM104.

There will be a few talks on finite generalised polygons by colleagues of mine at this conference, and in order for the common combinatorialist to access these talks, there should be time devoted to understanding what a generalised polygon is and why we care about them. This talk aims to fill this gap. In particular, the emphasis will be on stating the main open problems in regard to the possible groups of automorphisms that such objects admit. No prior knowledge of generalised polygons will be assumed.

ANTIFLAG-TRANSITIVE GENERALIZED QUADRANGLES

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The University of Western Australia

(Joint work with John Bamberg and Cai-Heng Li)

Monday at 11:15 in AM104.

A generalized quadrangle is a point-line incidence geometry $\mathcal{Q}$ such that (1) any two points lie on at most one line, and (2) given a line ℓ and a point P not incident with ℓ, P is collinear with a unique point of ℓ. An antiflag of a generalized quadrangle is a non-incident point-line pair (P, ℓ), and we say that the generalized quadrangle $\mathcal{Q}$ is antiflag-transitive if the group of collineations (automorphisms that send points to points and lines to lines) is transitive on the set of all antiflags. We prove that if a finite thick generalized quadrangle $\mathcal{Q}$ is antiflag-transitive, then $\mathcal{Q}$ is one of the following: the unique generalized quadrangle of order $(3,5)$, a classical generalized quadrangle, or a dual of one of these.

GENERALIZED QUADRANGLES AND AS-CONFIGURATIONS OF FINITE p-GROUPS

Stephen Glasby
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University of Western Australia; University of Canberra

(Joint work with John Bamberg and Eric Swartz)

Monday at 11:45 in AM104.

A generalized quadrangle is an important point-line geometry without triangles containing (many) quadrangles. Classical examples arise from considering the geometry of maximal totally isotopic subspaces of certain symplectic, unitary, and orthogonal groups. Another method to construct generalized quadrangles involves finding a certain family of subgroups of a group. Given a group G of order q^3 we seek a family of $q+2$ subgroups $U_0, U_1, ..., U_{q+1}$ of G, each of order q, such that U_0 is normal in G and $U_iU_j \cap U_k = \{1\}$ for all distinct i, j, k in $\{0, 1, ..., q+1\}$. Such a family is called an *AS-configuration* for G. We determine all the AS-configurations for q odd, as well as $q = 2, 4, 8$. To determine $q = 8$ we showed, using extensive theory and computation, that only one of the 10 494 213 groups of order 2^9 admits an AS-configuration!

POINT-PRIMITIVE GENERALISED HEXAGONS AND OCTAGONS

Tomasz Popiel
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The University of Western Australia

(Joint work with John Bamberg, S. P. Glasby, Cheryl E. Praeger and Csaba Schneider)

Monday at 12:15 in AM104.

In 2008, Schneider and Van Maldeghem proved that if a group acts flag-transitively, point-primitively, and line-primitively on a generalised hexagon or generalised octagon, then it is an almost simple group of Lie type. We show that point-primitivity is sufficient for the same conclusion, regardless of the action on lines or flags. This result narrows the search for generalised hexagons or octagons with point- or line-primitive collineation groups beyond the classical examples, namely the two generalised hexagons and one generalised octagon admitting the Lie type groups $G_2(q)$, ${}^3D_4(q)$, and ${}^2F_4(q)$, respectively.

Monday Afternoon

Towards an excluded-minor characterisation of the Hydra-5 matroids

Ben Clark
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Victoria University of Wellington

Monday at 16:00 in CO122.

An excluded-minor characterisation of the Hydra-5 matroids can be thought of as the first step towards an excluded-minor characterisation of the matroids representable over the 5-element field. This talk will provide an overview of the progress towards an excluded-minor characterisation of the class of Hydra-5 matroids, and will discuss how the problem of bounding an excluded minor can be reduced to a fragility problem. An outline of the work that remains will also be given.

Graphic Connectivity Functions

Susan Jowett
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Monday at 16:30 in CO122.

Connectivity functions are set valued function which axiomatically capture connectivity in many mathematical structures, in particular in graphs. However, not all connectivity functions are the connectivity functions of graphs. We shall consider the problem of deciding when a connectivity function, λ, is graphic, that is, when there is a graph which has λ as its connectivity function.

Connectivity Functions

Geoff Whittle
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Victoria University of Wellington

Monday at 17:00 in CO122.

For a finite set E a function $\mu : 2^E \to \mathbb{Z}$ is a *connectivity function* if it is symmetric and submodular. Matroid connectivity and vertex connectivity in graphs are captured by associated connectivity functions. Moreover, fundamental properties associated with branch width and tangles of matroids and graphs hold at the level of general connectivity functions. The fact that we can prove interesting things about them motivates the study of connectivity functions as objects of interest in their own right. In the talk I will discuss some initial findings of such a study. This is joint work with MSc students Songbao Mo and Susan Jowett.

Extending the Bruck-Ryser-Chowla Theorem to Symmetric Coverings

Sarada Herke

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Monash University

(Joint work with Daniel Horsley and Nevena Francetić)

Monday at 16:00 in AM102.

The well-known Bruck-Ryser-Chowla theorem establishes the non-existence of certain symmetric (v, k, λ)-designs. It is natural to ask if the proof techniques can be extended to the case of symmetric (v, k, λ)-coverings, which requires every pair of points to occur together in *at least* λ blocks. This was done by Bose and Connor in the 1950's for the case where the excess is 1-regular. In 2011, Bryant et al. were able to adapt the arguments concerning determinants to the significantly more complicated case of 2-regular excesses. We describe how to apply the well-established theory of quadratic form invariants to this case.

Steiner triple systems without parallel classes

Daniel Horsley

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Monash University

(Joint work with Darryn Bryant)

Monday at 16:30 in AM102.

A parallel class of a Steiner triple system is a subset of its triples such that each point of the system occurs in exactly one triple in the class. Up until now, no infinite family of Steiner triple systems of order 3 (mod 6) without parallel classes was known – in fact the only known examples of such systems had order 15 or 21. In this talk I will exhibit an infinite family of Steiner triple systems of order 3 (mod 6) without parallel classes.

Chromatic Index of Steiner Triple Systems

Ian Wanless

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Monash University

(Joint work with Darryn Bryant, Charlie Colbourn, Daniel Horsley)

Monday at 17:00 in AM102.

The chromatic index of a Steiner triple system (STS) is the smallest number of colours with which the triples can be coloured in such a way that no two intersecting triples have the same colour. The chromatic index of an STS measures how close it is to being resolvable.

I will survey what is known about the chromatic index of STSs. A related question is 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!

PARTITIONS AND COMPOSITIONS INTO POWERS OF b

Daniel Krenn
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Graz University of Technology

Monday at 16:00 in AM104.

For a fixed integer base b, we consider the class of representations (either *partitions* or *compositions*) of 1 as a sum of unit fractions whose denominators are powers of b. This is, among many others, equivalent to a class of *Huffman codes* and to special types of *trees*.

How many solutions with a given number of summands are there? What are the largest exponents occurring and how many of them show up? How many different summands does a representation have? Those and related questions will be discussed and answered. For the proofs of the presented *asymptotic results* tools from *analytic combinatorics* are used.

WILF-EQUIVALENCE FOR CATALAN STRUCTURES

Michael Albert
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University of Otago

(Joint work with Mathilde Bouvel)

Monday at 16:30 in AM104.

The existence of apparently coincidental equalities (also called Wilf-equivalences) between the enumeration sequences, or generating functions, of various hereditary classes of combinatorial structures has attracted significant interest. We investigate such coincidences among non-crossing matchings and a variety of other Catalan structures. In particular we consider principal classes defined by not containing an occurrence of a single given structure. An easily computed equivalence relation among structures is described such that if two structures are equivalent then the associated principal classes have the same enumeration sequence. We give an asymptotic estimate of the number of equivalence classes of this relation among structures of size n and show that it is exponentially smaller than the n^{th} Catalan number. In other words these "coincidental" equalities are in fact very common among principal classes. Our results also allow us to prove, in a unified and bijective manner, several known Wilf-equivalences from the literature.

ASYMPTOTIC ENUMERATION OF SPARSE UNIFORM HYPERGRAPHS WITH GIVEN DEGREES

Catherine Greenhill
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UNSW Australia

(Joint work with Vladimir Blinovsky)

Monday at 17:00 in AM104.

A hypergraph consists of a finite set of vertices and a finite multiset of edges, where each edge is a multisubset of the vertex set. A hypergraph is said to be

- *simple* if no edge contains a repeated vertex, and there are no repeated edges,
- *linear* if it is simple and each pair of edges intersects in at most one vertex,
- *uniform* if every edge has the same cardinality (counting multiplicities, in the non-simple case). If this cardinality is r then we say that the hypergraph is r-uniform.

Uniform hypergraphs are a particular focus of study, in particular because a 2-uniform hypergraph is a graph.

We present two asymptotic enumeration results, one for simple r-uniform hypergraphs with degree sequence $\boldsymbol{k} = (k_1, \ldots, k_n)$, and one for simple *linear* r-uniform hypergraphs with degree sequence $\boldsymbol{k}$. Here all degrees are positive and $r = r(n) \geq 3$. Let $M = M(n) = \sum_{j=1}^{n} k_j$ and denote the maximum degree in $\boldsymbol{k}$ by $k_{\max}$. The first result holds when $r^4 k_{\max}^3 = o(M)$ while the second result requires the more restrictive condition $r^5 k_{\max}^4 = o(M)$.

The proof proceeds by working with the incidence matrix of a random hypergraph, interpreted as the adjacency matrix of a random bipartite graph. This allows us to utilise a result of McKay's from 1981, which bounds the probability that a random bipartite graph contains a given subgraph, as well as an asymptotic enumeration formula for sparse bipartite graphs with given degrees (Greenhill, McKay and Wang, 2006).

TUESDAY MORNING

VERTEX-TRANSITIVE GRAPHS THAT HAVE NO HAMILTON DECOMPOSITION

Darryn Bryant
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(Joint work with Matthew Dean)

Tuesday at 10:45 in CO122.

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

WHICH BIASED GRAPHS ARE GROUP-LABELLED GRAPHS?

Irene Pivotto
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(Joint work with M. DeVos and D. Funk)

Tuesday at 11:15 in CO122.

A biased graph is a graph with a distinguished set of cycles, called balanced, with the property that no theta subgraph contains exactly two balanced cycles. One may construct biased graphs from group-labelled graphs: if Γ is a group, a Γ-labelled graph is a graph G where every edge is oriented and assigned an element from Γ. Then we obtain a biased graph on G by declaring a cycle to be balanced if the product of the group elements along the cycle is the group identity, where we take the inverse of a group element on an edge traversed backwards. In this talk we give a necessary and sufficient condition for a biased graph to be obtained from a group labelling.

THE INCREMENTAL MINIMUM WEIGHT BASIS PROBLEM FOR MATROIDS

Thomas Kalinowski
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(Joint work with Konrad Engel and Martin W.P. Savelsbergh)

Tuesday at 11:45 in CO122.

Let $M = (E, \mathcal{I})$ be a matroid of rank r, where E is the set of elements, and $\mathcal{I}$ is the family of independent sets. Let $w : E \to \mathbb{R}$ be a weight function, and let $E_0 \subset E$ be a set of elements such that the induced matroid on E_0 has rank r, i.e., E_0 contains a basis of M. For any subset

$A \subseteq E \setminus E_0$ let $f(A)$ denote the minimum weight of a basis B of M which is contained in $E_0 \cup A$. The *incremental minimum weight basis problem* asks for a sequence

$$\emptyset = A_0 \subset A_1 \subset A_2 \subset \cdots \subset A_T = E \setminus E_0$$

that minimizes $f(A_0) + f(A_1) + \cdots + f(A_T)$, where $T = |E \setminus E_0|$ and $|A_i| = i$ for all $i \in \{0, \ldots, T\}$.

We prove that this problem can be solved by the natural greedy algorithm: Set $A_{i+1} = A_i \cup \{e^*\}$ where e^* is a minimizer of $f(A_i \cup \{e\})$ for $e \in E \setminus A_i$. In addition, we describe how this can be implemented to run in time $O(\max\{|E|, |E| \log |E|\})$ (relative to an independence oracle). For the special case that M is a graphical matroid corresponding to a graph with n vertices and m edges, this gives a runtime of $O(\max\{n^2, m \log m\})$.

THE OTHER HASS - MUSIC, CLIMBING, FAMILY

Molly Melhuish

Tuesday at 12:15 in CO122.

In any reasonable accounting Hassler Whitney is one of the ten greatest mathematicians of the twentieth century. Amongst combinatorialists he is probably best known for his work in graph theory and for being the founder of matroid theory; but that, for Whitney, was a minor diversion on the way to much greater things. We live in a small world and it turns out that one of Whitney's daughters, Molly Melhuish, now lives in Wellington, where she is well known as an energy analyst. Molly has kindly agreed to share some reminiscences of her father with us. This is a unique opportunity and one not to be missed.

UNIQUE VECTOR COLORINGS AND GRAPH CORES

David Roberson
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Nanyang Technological University

(Joint work with Chris Godsil, Brendan Rooney, Robert Šámal, and Antonios Varvitsiotis)

Tuesday at 10:45 in AM102.

A vector k-coloring of a graph G is an assignment of real unit vectors to the vertices of G such that vectors assigned to adjacent vertices have inner product at most $-1/(k-1)$. The smallest k for which a vector k-coloring exists is known as the vector chromatic number of G. We say that a graph is uniquely vector colorable (UVC) if all of its optimal vector colorings are the same up to orthogonal transformations.

We prove that all non-bipartite Kneser graphs, and their subspace analogs the q-Kneser graphs, have unique vector colorings. We also show that an infinite family of graphs from the Hamming scheme all have unique vector colorings. Interestingly, the vectors used in the colorings are the vertices of the eigenpolytope of the least eigenvalue of these graphs. Our main tool in proving these results is a sufficient condition for uniqueness from the theory of tensegrity frameworks. We will discuss how this condition may be able to be applied to show uniqueness of vector colorings for a much more general class of graphs.

The above mentioned result on tensegrity frameworks can also be used to prove that, under certain conditions, G being UVC and H having vector chromatic number strictly larger than G implies that the categorical product $G \times H$ is UVC. Along the way to obtaining this result we also establish a new formulation for vector chromatic number which allows us to easily prove the analogue of Hedetniemi's conjecture for this parameter.

Lastly, we show that a graph G having a unique vector coloring often implies that G is a core (has no proper endomorphisms). This implies that the above mentioned Kneser and Hamming graphs are cores, which was previously know for the Kneser graphs but not for the Hamming graphs.

MINIMUM GENUS EMBEDDINGS OF VERTEX-TRANSITIVE GRAPHS

Marston Conder
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(Joint work with Ricardo Grande and Klara Stokes)

Tuesday at 11:15 in AM102.

By a theorem of v Skoviera and Nedela (1989), almost all vertex-transitive graphs are 'upper-embeddable', in that they have 2-cell embeddings on orientable surfaces of maximum conceivable genus, with just one or two faces. (The only exceptions are 3-valent examples of girth 3 and order 18 or more.) In particular, every finite connected Cayley graph is upper-embeddable.

In contrast, relatively little is known about the *minimum* genus of vertex-transitive graphs. Finding the minimum genus of a given connected graph is a notoriously difficult problem, except in some very special circumstances (such as when the graph is planar, or is a Cayley graph for some quotient of the $(2, 3, 7)$ triangle group).

In this talk I will describe some of what is known, and also give a brief account of two recent developments on the topic. One of these is some work with Ricardo Grande (Spain) on finding the minimum genus of families of connected circulants (Cayley graphs for cyclic groups), as reported at the ACCMCC in Perth last year. Another is some joint work in 2014 with Klara Stokes (Sweden) on exploiting symmetries to find the smallest genus of embedding of the Hoffman-Singleton graph, in both the orientable and non-orientable cases, with 69 faces and 70 pentagonal faces respectively.

TILING OF THE SPHERE BY CONGRUENT PENTAGONS

Min Yan
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Tuesday at 11:45 in AM102.

In an edge-to-edge tiling of the sphere by congruent polygons, the polygon is either triangle, or quadrilateral, or pentagon. The classification of triangular spherical tilings was started by Sommerville in 1923 and completed by Ueno and Agaoka [4] in 2002. We believe pentagonal spherical tilings are easier to study than quadrilateral tilings, simply because 5 is the "other extreme" among $3, 4, 5$. The belief is confirmed by many progresses we made about pentagonal spherical tilings.

I will first give some basic constructions of pentagonal spherical tilings. Then I describe the combinatorial aspects [5], which means ignoring the edge length and angles. Next I explain how to classify tilings in case there are enough variety of edge lengths [1]. After that, I go to the other extreme and describe how to classify tilings in case all edges have equal length [3]. Finally, I will discuss the remaining most difficult case that four edges in the pentagon have equal length, but the fifth edge has different length. Now we are cautiously optimistic that the whole classification can be completed.

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TRANSVERSALS IN LATIN SQUARES

Darcy Best
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Tuesday at 10:45 in AM104.

A transversal of a latin square of order n is a set of n entries which has exactly one representative from each row, column and symbol. A long standing conjecture of Ryser states that the number of transversals in a latin square is congruent to the order of the latin square modulo 2. In 1990, Balasubramanian confirmed this conjecture to be true in the even orders. In this talk, we extend this proof to show that in squares of order $2 \mod 4$, the number of transversals is necessarily a multiple of 4. Moreover, the set of transversals may be further broken down into smaller classes which also contain a special property modulo 2.

SATURATED CRITICAL SETS OF FULL LATIN SQUARES

Vaipuna Raass
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Tuesday at 11:15 in AM104.

A multi-Latin square of order n and index k (or a k-Latin square of order n) is an $n \times n$ array of multisets of cardinality k such that each symbol from a set of size n occurs k times in each row and k times in each column. The full n-Latin square is the n-Latin square of order n with symbols $1, 2, ..., n$ in each cell. A saturated critical set of order n is a partial n-Latin square of order n with an unique completion to the full n-Latin square, and each cell is either full or empty. Critical sets of the full n-Latin squares are analogous to minimal defining sets of full designs which have recently been studied by (Akbari, Maimani, Maysoori (1993)), (Donovan, Lefevre, Waterhouse (2009)), and (Kolotoglu, Yazici (2010)). In particular, the intersection of a critical set of the full n-Latin square with a Latin square of the same order gives a defining set of the Latin square. In this talk we present a formula for the size of the saturated critical set of the full n-Latin square.

INDUCED SUBARRAYS OF LATIN SQUARES WITHOUT REPEATED SYMBOLS

Nick Cavenagh
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(Joint work with Julian Abel (UNSW) and Jaromy Kuhl (University of West Florida))

Tuesday at 11:45 in AM104.

Given a Latin square of even order n, partitioning the rows and columns into pairs induces $n^2/4$ two-by-two subarrays. We pose the following problem: For large enough n, is it possible to find such partitions so that each induced subarray contains no repeated symbol? We present some partial results.

TUESDAY AFTERNOON

CIRCUITS IN GRAPHS, MATROIDS AND BINARY CODES

Peter Nelson
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(Joint work with Stefan van Zwam)

Tuesday at 16:00 in CO122.

A binary $[n,k,d]$ code is a rank-k subspace of $\mathbb{Z}_2^n$ in which every nonzero element has Hamming weight at least d. A simple example is when this subspace is the null space of the binary incidence matrix of a graph; this is a *graphic code*, and the class of all graphic codes is closed under a 'minor' operation that corresponds to deletion and contraction of edges of the underlying graph. Unfortunately, Kashyap showed that unlike the class of all binary codes, the class of graphic codes is not 'asymptotically good', essentially meaning that large graphic codes must have either k or d very small compared to n. I will present a recent result, proved with Stefan van Zwam using a deep theorem from structural matroid theory, that shows that this failure generalises to every proper subclass of the binary codes that is closed under minors. Our ideas come from graph and matroid theory, and no knowledge of coding theory will be assumed.

ON THE COVERING DIMENSION OF A LINEAR CODE AND ITS RELATION TO MATROIDS

Keisuke Shiromoto
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Kumamoto University

(Joint work with Thomas Britz)

Tuesday at 16:30 in CO122.

The *critical exponent* of a matroid is one of the important parameters in matroid theory and is related to the Rota and Crapo's Critical Problem. This talk introduces the *covering dimension* of a linear code over a finite field, which is analogous to the critical exponent of a representable matroid. An upper bound on the covering dimension is proven, improving a classical bound for the critical exponent. Finally, a construction is given of linear codes that attain equality in the covering dimension bound.

A GEOMETRIC DECODER FOR SPREAD CODES

Klara Stokes
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(Joint work with Axel Hultman, Linköping University)

Tuesday at 17:00 in CO122.

In classical coding theory, a code is a set of vectors over a finite field $\mathbb{F}_q$, and the code is linear if it forms a subspace of some vector space over $\mathbb{F}_q$. In a subspace code, the codewords themselves are subspaces of some vector space over F_q. If all the subspaces are of the same dimension k, then the code is called a constant-dimension subspace code and the code is contained in the Grassmannian $G_{\mathbb{F}_q}(n,k)$. For error-correcting purposes the code should be defined such that the distance between the codewords is large, where the distance between two subspaces U and V can be taken as $d(U,V) = \dim(U+V) - \dim(U \cap V)$. A t-spread is a collection of t-dimensional subspaces of $PG(n,\mathbb{F}_q)$ such that every point is contained in exactly one of the subspaces. This ensures that all elements of the spread is on a certain distance from each other, when regarded as elements of $G_{\mathbb{F}_q}(n+1,t+1)$. Therefore t-spreads make attractive subspace codes. In this talk I will describe an efficient decoder for 1-spreads in $PG(3,\mathbb{F}_q)$ which uses the Klein correspondence and discuss how this generalises to higher dimensions.

TREEWIDTH OF GENERAL LINE GRAPHS

Daniel J. Harvey
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(Joint work with David R. Wood)

Tuesday at 16:00 in AM102.

The treewidth of a graph is an invariant of fundamental importance to structural and algorithmic graph theory. Structurally, it is most notable for its role in Robertson and Seymour's seminal series of papers on graph minors; algorithmically, it has applications to fixed parameter tractability and dynamic programming. Here we consider the treewidth of *line graphs*. Specifically, we show that determining the treewidth of the line graph of a graph G is equivalent to determining the minimum vertex congestion of an embedding of G into a tree. This result allows us to prove sharp lower bounds on the treewidth of the line graph in terms of both the minimum degree and average degree of G which are significantly better than the naïve bounds.

These results significantly improve upon those previously presented at 36ACCMCC.

LAYERED SEPARATORS

David R. Wood
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(Joint work with Vida Dujmović, Fabrizio Frati,Gwenaël Joret, and Pat Morin)

Tuesday at 16:30 in AM102.

Graph separators are a ubiquitous tool in graph theory and computer science. However, in some applications, their usefulness is limited by the fact that the separator can be as large as $\Omega(\sqrt{n})$ in graphs with n vertices. This is the case for planar graphs, and more generally, for proper minor-closed families.

We study a special type of graph separator, called a *layered separator*, which may have linear size in n, but has bounded size with respect to a different measure, called the *breadth*. We prove, for example, that planar graphs and graphs of bounded Euler genus admit layered separators of bounded breadth. More generally, we characterise the minor-closed classes that admit layered separators of bounded breadth as those that exclude a fixed apex graph as a minor.

We use layered separators to prove $\mathcal{O}(\log n)$ bounds for a number of problems where $\mathcal{O}(\sqrt{n})$ was a long standing previous best bound. This includes the *nonrepetitive chromatic number* and *queue-number* of graphs with bounded Euler genus. We extend these results to all proper minor-closed families, with a $\mathcal{O}(\log n)$ bound on the nonrepetitive chromatic number, and a $\log^{\mathcal{O}(1)} n$ bound on the queue-number. Only for planar graphs were $\log^{\mathcal{O}(1)} n$ bounds previously known. Our results imply that every graph from a proper minor-closed class has a *3-dimensional grid drawing* with $n \log^{\mathcal{O}(1)} n$ volume, whereas the previous best bound was $\mathcal{O}(n^{3/2})$.

See `arXiv:1306.1595` for details.

THE WORM ALGORITHM FOR THE ISING MODEL IS RAPIDLY MIXING

Timothy Garoni
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Monash University

(Joint work with A. Collevecchio, T. Hyndman and D. Tokarev)

Tuesday at 17:00 in AM102.

We prove rapid mixing of the Prokofiev-Svistunov (or worm) process for the zero-field ferromagnetic Ising model, on all finite graphs and at all temperatures. As a corollary, we construct fully-polynomial randomized approximation schemes for the Ising susceptibility and two-point correlation function, both of which we prove to be #P-hard problems.

THE SPECTRUM FOR 3-WAY k-HOMOGENEOUS LATIN TRADES

Trent Marbach

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The University of Queensland

Tuesday at 16:00 in AM104.

In this talk we will define a μ-way k-homogeneous Latin trade of order m. The problem of determining the spectrum for these objects has been completed for the case $\mu = 2$, using graph-theoretic constructions, block theoretic constructions, and finding pairs of transversals of given intersection in the back-circulant Latin squares. Some partial result have appeared for the case when $\mu = 3$.

We will show some new constructions for these objects in the general case, including a construction using resolvable pairwise balanced designs. We then use the results of this work to complete the spectrum for the case $\mu = 3$ for all but a small list of exceptions.

NEAR-AUTOPARATOPISMS OF LATIN SQUARES

Jayama Mahamendige

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Monash University

(Joint work with Prof. Ian Wanless)

Tuesday at 16:30 in AM104.

A Latin square L of order n is an $n \times n$ array containing n symbols from $[n] = \{1, 2, \ldots, n\}$ such that each element of $[n]$ appears exactly once in each row and each column of L. Rows and columns of L are indexed by elements of $[n]$. The element in the i^{th} row and j^{th} column is denoted by $L(i, j)$.
The set of n^2 ordered triples, $O(L) = \{(i, j, L(i, j)); i, j \in [n]\}$ is called the orthogonal array representation of L.

The Hamming distance between two Latin squares L and L' is defined by $dist(L, L') = \#\{d \in O(L); d \notin O(L')\}$.

The elements of the form $\sigma = (\alpha, \beta, \gamma; \lambda) \in S_n \wr S_3$ are known as paratopisms. When $\lambda = \varepsilon$, σ is said to be an isotopism. In other words, $\theta = (\alpha, \beta, \gamma) \in S_n^3$ is said to be an isotopism. When $\theta = (\alpha, \alpha, \alpha) \in S_n^3$, then α is known as an isomorphism.

If $dist(L, L^\sigma) = 0$, that is, $L^\sigma = L$, then σ is known as an autoparatopism. If $dist(L, L^\sigma) = 4$, then σ is called a near-autoparatopism of L. If $dist(L, L^\theta) = 0$, that is, $L^\theta = L$, then θ is known as an autotopism. If $dist(L, L^\theta) = 4$, then θ is called a near-autotopism of L. The similar definitions for isomorphisms are automorphisms and near-automorphisms.

If a submatrix M of a Latin square L is also a Latin square then M is called a subsquare of L. A subsquare of order 2 is an intercalate.

Cavenagh and Stones gave a proof to the following result.

For all $n \geq 2$ except $n \in [3, 4]$ there exists a Latin square L of order n that admits a near-automorphism. In this process, they found a necessary and sufficient condition for α to be a near-automorphism when α has the cycle structure $(2, n-2)$, where $n \geq 0$ and $n \equiv 2 \mod 4$.

We determine a family of Latin squares with unique subsquare of order two(intercalate) which admits a near-autoparatopism. In this process, we find a necessary and sufficient condition for $\sigma = (\varepsilon, \beta, \gamma : (12)) \in S_n \wr S_3$ to be a near-autoparatopism when the cycle structure of β and γ are $(n-2)^1 1^2$ and $(n-2)^1 2^1$ respectively.

A LATIN SQUARE AUTOTOPISM SECRET SHARING SCHEME

Rebecca Stones
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(Joint work with Ming Su, Xiaoguang Liu, Gang Wang, Nankai University, and Sheng Lin, Tianjin University of Technology)

Tuesday at 17:00 in AM104.

We present a novel secret sharing scheme where the secret is an autotopism (a symmetry) of a Latin square. We compare this scheme to previously proposed secret sharing schemes involving secret Latin squares.

WEDSENDAY MORNING

SPANNING FORESTS ON ADJACENT PAIRS OF EDGES ARE NEGATIVELY CORRELATED

Arun Mani
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Wednesday at 10:45 in CO122.

Let $G = (V, E)$ be a graph, and F be a spanning forest of G chosen uniformly at random. In this talk, we show that for any pair of adjacent edges $e, f \in E$, the events $e \in F$ and $f \in F$ are negatively correlated. This is joint work with David Wagner at the University of Waterloo.

MINIMUM DEGREE AND DOMINATING PATHS

Douglas West
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Zhejiang Normal University and University of Illinois

(Joint work with Ralph J. Faudree, Ronald J. Gould, and Michael S. Jacobson)

Wednesday at 11:15 in CO122.

A *dominating path* in a graph is a path P such that every vertex outside P has a neighbor on P. Let G be an n-vertex connected graph. If $\delta(G) \geq n/3 - 1$, then G contains a dominating path, and this is sharp (for 2-connected graphs, $\delta(G) \geq (n+1)/4$ suffices). The lengths of dominating paths include all values from the shortest up to at least $\min\{n-1, 2\delta(G)\}$, and this is sharp. For $\delta(G) > an$, where a is a constant greater than $1/3$, the minimum length of a dominating path is at most logarithmic in n when n is sufficiently large (the base of the logarithm depends on a). For constant s and $c' < 1$, an s-vertex dominating path is guaranteed by $\delta(G) \geq n - 1 - c'n^{1-1/s}$ when n is sufficiently large, but $\delta(G) \geq n - c(s \ln n)^{1/s} n^{1-1/s}$ (where $c > 1$) does not even guarantee a dominating set of size s. We also obtain minimum degree conditions for the existence of a spanning tree obtained from a dominating path by giving the same number of leaf neighbors to each vertex.

GRAPHIC AND BIPARTITE GRAPHIC SEQUENCES

Stacey Mendan
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La Trobe University

(Joint work with Grant Cairns and Yuri Nikolayevsky)

Wednesday at 11:45 in CO122.

A sequence $\underline{d}$ is *graphic* if there exists a finite, simple graph with degree sequence $\underline{d}$. A variety of results about graphic sequences can be found in the literature, including the Erdős–Gallai Theorem, which gives a characterisation of graphic sequences. More recently, published in 1990, Zverovich and Zverovich proved a sufficient condition for a sequence to be graphic. This condition uses the length of the sequence as well as the greatest and smallest element of the sequence. However, this condition is not sharp; there are many graphic sequences, which fail the Zverovich–Zverovich inequality. This talk will focus on presenting a sharp version of the result of Zverovich and Zverovich. We will begin with appropriate background material on graphic sequences.

NEW DIRECTIONS IN MATROIDAL CODING THEORY

Thomas Britz
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(Joint work with Trygve Johnsen, Keisuke Shiromoto and Thomas Westerbäck)

Wednesday at 10:45 in AM102.

Since the early 70's, there has been some interest in studying how the matroids and Tutte polynomials of linear codes over finite fields determine properties of those codes. Greene's Theorem was an early highlight of this study, showing that the Tutte polynomial determines the weight enumerator of the code. Recently, most of the big questions in this study have been answered, and a new chapter of research has begun, investigating related but deeper lines of research. In this talk, I will describe our progress along these new lines of research.

ELUSIVE CODES IN HAMMING GRAPHS

Daniel Hawtin
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(Joint work with Neil Gillespie, Michael Giudici and Cheryl Praeger)

Wednesday at 11:15 in AM102.

We consider a code to be a subset of the vertices of a Hamming graph. The *set of s-neighbours* of a code are those vertices which are distance s from some codeword, but not distance r from any codeword, for $0 \leq r < s$. The automorphism group of a code necessarily fixes the set of s-neighbours of the code. An *s-elusive code* is a code such that the automorphism group of the set of s-neighbours is strictly larger than the automorphism group of the code itself. We provide examples for $s = 1, 2, 3$, including a family of Reed-Muller codes and the Preparata codes. We also discuss some restrictions on the parameters of elusive codes and show that an elusive code gives rise to a q-ary s-design.

COMPRESSED SENSING WITH HADAMARD MATRICES AND COMBINATORIAL DESIGNS

Padraig Ó Catháin
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(Joint work with Darryn Bryant, Charles Colbourn, Daniel Horsley)

Wednesday at 11:45 in AM102.

Traditionally signal sampling and signal processing have been regarded as two separate tasks. Shannon's theorem relates the number of samples to the quality of the reconstruction: more samples are required for higher quality data. Compressed sensing is a new paradigm in signal processing in which sampling and compressing are combined into a single step. Under certain weak conditions, this reduces the number of samples required below the Shannon limit, without any loss in quality.

Tao's breakthrough papers on this topic showed that random matrices make good compressed sensing matrices. But such arrays are difficult to compute and to store, so are of limited practical interest. In this talk we will outline the properties required of a good compressed sensing matrix, and describe a construction for such arrays using Hadamard matrices and pairwise balanced designs.

TURAN NUMBERS FOR CYCLES

S. Narjess Afzaly

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The Australian National University

(Joint work with Brendan D. McKay)

Wednesday at 10:45 in AM104.

Extremal Graph Theory was introduced by Turan [1] in studying the maximum number of edges in graphs without cliques of given orders. For a given set of graphs, $\mathcal{H}$, the Turan Number of $\mathcal{H}$, $ex(n,\mathcal{H})$, is defined to be the maximum number of edges in a graph on n vertices without a subgraph isomorphic to any graph in $\mathcal{H}$. Denote by $EX(n,\mathcal{H})$, the set of all *extremal graphs* with respect to $(n,\mathcal{H})$, i.e, graphs with n vertices, $ex(n,\mathcal{H})$ edges and no subgraph isomorphic to any graph in $\mathcal{H}$. We consider this problem when $\mathcal{H}$ is a set of cycles.

Based on the method of *Generation by Canonical Construction Path*, we developed a set of algorithms that receive n and $\mathcal{C} \subset \{C_3, C_4, C_5, \ldots\}$ as input and produce the extremal graphs in $EX(n,\mathcal{C})$ by recursively extending smaller graphs without any cycle in $\mathcal{C}$.

Using these algorithms we implemented a set of procedures that for the first time calculated the exact value of $ex(n,C)$ and extremal graphs in $Ex(n,\mathcal{C})$ for several pairs of $(n,\mathcal{C})$, as well as improving upper or lower bounds for some other pairs. These procedures can also calculate the extremal graphs with extra restrictions for example on maximum and minimum degree or the number of vertices of minimum degree.

Bibliography

[1] P. Turán, On an extremal problem in graph theory, *Mat. Fiz. Lapok, 48* 1941 pp.436-452,

On longest paths in random Apollonian networks

Nick Wormald
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Wednesday at 11:15 in AM104.

Start with a triangle embedded in the plane. In each step, choose a bounded face uniformly at random, add a vertex inside that face and join it to the vertices of the face. After $n-3$ steps, we obtain a random triangulated plane graph with n vertices, which is called a random Apollonian network. Asymptotically almost surely, the longest path in this network has length at most n^{δ} for some $\delta < 1$. This result confirms a conjecture of Cooper and Frieze (and refutes an earlier conjecture of Frieze and Tsourakakis.) For its proof, we bound the size of the largest regular (r-ary) subtrees of random recursive trees.

This talk describes results obtained jointly with Andrea Collevecchio and Abbas Mehrabian.

A lower bound for isoperimetric constants of (d^+, f^+)-plane tessellation

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Middle Tennessee State University

(Joint work with Hays Whitlatch)

Wednesday at 11:45 in AM104.

An infinite plane graph G is called a (d^+, f^+)-plane tessellation if vertex-degree $\geq d$, face-degree $\geq f$, and $1/d + 1/f < 1/2$ (therefore a tessellation of the hyperbolic plane). The *isoperimetric constant* $\alpha(G)$ of G is the infimum of the ratio between the number of edges of a cycle and the number of all faces inside the finite region bounded by this cycle. The infimum is taking over all cycles and the finite regions bounded by these cycles. This isoperimetric constant is discrete analogue of the Cheeger's constant of a compact Riemannian manifold.

In this talk, we show $\alpha(G) \geq (f-2)\sqrt{1 - \frac{4}{(d-2)(f-2)}}$

Thursday Morning

Relative Hemisystems on the Hermitian Surface

Melissa Lee
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Thursday at 10:45 in CO122.

Hemisystems in finite geometry have a short but eventful history, dating back to B. Segre's definition of them as a special case of a regular system in 1965. Hemisystems are of great interest because they give rise to partial quadrangles, strongly regular graphs and association schemes. Segre gave the first example of a hemisystem on $\mathrm{H}(3, 3^2)$ in his original treatise.

Amazingly, for forty years after their introduction, no new examples of hemisystems were found, and in 1995, Thas even conjectured that none existed on $\mathrm{H}(3, q^2)$ for $q > 3$. This conjecture was proven false when Penttila and Cossidente discovered a new infinite family of hemisystems in 2005. Since then, hemisystems have been a moderately popular topic in finite geometry, with seventeen papers published on them over the past nine years.

In 2011, Penttila and Williford introduced the notion of relative hemisystems, an analogous concept of hemisystems that exist on $\mathrm{H}(3, q^2)$, for q even. These structures also produce rare association schemes, which are primitive and q-antipodal. Let Q be a generalised quadrangle of order (q^2, q), containing a generalised quadrangle Q' of order (q, q). Each of the lines in Q meet Q' in either $q + 1$ points or are disjoint from it. We call a subset $\mathcal{R}$ of the lines in $Q \setminus Q'$ a relative hemisystem of Q with respect to Q' if for every point P in $Q \setminus Q'$, exactly half the lines through p disjoint from Q' lie in $\mathcal{R}$.

Since their introduction, three infinite families of relative hemisystems have been found - one by Penttila and Williford, and two by Cossidente, as well as a sporadic example discovered by Cossidente and Pavese. In this talk, we describe our search to find more examples of relative hemisystems and provide a new set of sufficient criteria that unify the known examples.

Homology of Projective Geometric Configurations

Henry Crapo
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Thursday at 11:15 in CO122.

We describe a simple homology theory of complex figures in projective geometry, generalising the homology of cellular complexes The whole story starts with (1) constructions on plane drawings of spatial figures, touches upon (2) invariant theory (bracket polynomials), (3) higher order syzygies (derived matroids), (4) the cohomology of lifting, and ends at (5) homology of nerve and span). The aim is to establish direct relations between stages 1 and 5, to show how non-trivial homology arises from feasibility of certain geometric constructions.

COMBINATORIAL CONFIGURATIONS AND QUASILINE ARRANGEMENTS

Arjana Žitnik

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University of Ljubljana

(Joint work with Jürgen Bokowski, Jurij Kovič and Tomaž Pisanski)

Thursday at 11:45 in CO122.

It is well known that not every combinatorial configuration admits a geometric realization with points and lines. Moreover, some of them do not even admit realizations with pseudoline arrangements, i.e., they are not topological configurations.

We generalize the notion of a pseudoline arrangement (in the real projective plane) to the notion of a *quasiline arrangement* by relaxing the condition that two pseudolines intersect exactly once, and we define a subclass of quasiline arrangements that we call *monotone*. We also generalize well-known tools from pseudoline arrangements such as sweeps, wiring diagrams, and allowable sequences of permutations. It is known that every pseudoline arrangement can be represented by a wiring diagram and conversely, every wiring diagram can be viewed as a pseudoline arrangement. We show that every monotone quasiline arrangement can be represented by a generalized wiring diagram that is in turn also a monotone quasiline arrangement. In this respect the class of monotone quasiline arrangements is in some sense the weakest generalization of the class of pseudoline arrangements.

We introduce a generalization of topological incidence structures that we call *(monotone) quasi-topological incidence structures* by allowing the set of lines to form a (monotone) quasiline arrangement instead of a pseudoline arrangement. We show that every combinatorial incidence structure, in particular every combinatorial configuration, can be realized as a monotone quasi-topological incidence structure. Moreover, we show that any monotone quasi-topological configuration such that the underlying quasiline arrangement has no digons, is topologically equivalent to a polygonal monotone quasi-topological configuration with no bends (arcs connecting two vertices of the arrangement are all straight lines). Finally, a quasiline arrangement with selected vertices belonging to the incidence structure can be viewed as a map on a closed surface. Such a map can be used to distinguish between two distinct realizations of an incidence structure as a quasiline arrangement.

FINITE MINKOWSKI PLANES OF KLEIN TYPE 20

Gunter Steinke

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Thursday at 12:15 in CO122.

Minkowski planes are incidence geometries of points, lines and circles that axiomatise the geometry of plane sections of a ruled quadric in 3-dimensional projective space. A finite Minkowski plane of order n is equivalent to a sharply 3-transitive set of permutations of degree $n+1$. All known finite Minkowski planes have order a prime power q and correspond, under this equivalence, to $\mathsf{PSL}(2,q) \cup (\mathsf{PGL}(2,q) \setminus \mathsf{PSL}(2,q))\alpha$ where α is an automorphism of the Galois field of order q. In case α being the identity one obtains the so-called miquelian Minkowski planes.

Similar to the Lenz-Barlotti classification of projective planes Monica Klein classified in 1992 the set of all 2-sets $\{p, p'\}$ for which the group of all $\{p, p'\}$-homotheties in a given group Γ of automorphisms of a Minkowski plane $\mathcal{M}$ is transitive on $C \setminus \{p, p'\}$ where C is any circle through p and p' and where a $\{p, p'\}$-*homothety* is an automorphism of $\mathcal{M}$ that fixes the two points p and p' and every circle through p and p'. For many of the 23 possible configurations (the so-called Klein types of Γ) it is known that they can only occur for proper subgroups of the full automorphism group of finite miquelian Minkowski planes.

In this talk I consider finite Minkowski planes that admit a group of automorphisms of Klein type 20, where the configuration of 2-sets $\{p, p'\}$ as above consists of all points on a distinguished circle, and show that these planes are miquelian.

APPROXIMABILITY RESULTS FOR THE CONVERSE CONNECTED CENTER PROBLEM

Yen Hung Chen

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Thursday at 10:45 in AM102.

In this paper, we investigate a combinatorial optimization problem, called the converse connected center problem which is the converse problem of the connected p-center problem. This problem is a variant of the p-center problem. Given an undirected graph $G = (V, E, \ell)$ with a nonnegative edge length function ℓ and a vertex set $C \subseteq V$, for each vertex v in $V \setminus C$, let $d(v, C)$ denote the shortest distance from v to C (i.e., $d(v, C) = \min_{c \in C} d(c, v)$, in which $d(v, c)$ is the length of the short path of G from v to c). Let the *eccentricity* $ecc(C)$ of C be $max_{v \in V} d(v, C)$. Given an undirected graph $G = (V, E, \ell)$ with a nonnegative edge length function ℓ and an integer p, $0 < p < |V|$, the p-center problem is to find a vertex set C in V, called as *center set* with $|C| = p$, such that the eccentricity of C is minimized. The connected p-center problem is to find a center set P, $|P| = p$, such that the induced subgraph of P is restricted to be connected. Given an undirected graph $G = (V, E, \ell)$ with a nonnegative edge length function ℓ and an integer $\gamma > 0$, the converse connected center problem is to find a vertex set P in V with minimum cardinality such that the induced subgraph of P is restricted to be connected and the eccentricity $ecc(P) \leq \gamma$. One of the applications of the converse connected center problem has the facility location with load balancing and backup constraints. The connected p-center problem was shown to be NP-hard even for split graphs and block graphs. However, it is still unclear whether there exists a polynomial time approximation algorithm for the converse connected center problem. In this paper, we design the first approximation algorithm for the converse connected center problem with performance ratio of $(1 + \epsilon) \ln |V|$, $\epsilon > 0$. The algorithm is base on the approximation algorithm for the connected set cover problem. We also discuss the approximation class for the converse connected center problem. We show that there is no polynomial time approximation algorithm achieving a performance ratio of $(1 - \epsilon) \ln |V|$, $\epsilon > 0$, for the converse connected center problem unless $P = NP$.

This work was supported in part by the Ministry of Science and Technology of Taiwan under Contract MOST 103-2221-E-845-001 and NSC 102-2221-E-133-002.

Using Ideas from Chess Engines to Search for Combinatorial Objects

Nathan Van Maastricht
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Thursday at 11:15 in AM102.

Using ideas from chess engines to search for combinatorial objects. We will illustrate the principle for extremal C_t-free graphs. However the principle is more widely applicable.

Preservation Theorems in Finite Structures

Lucy Ham
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Thursday at 11:45 in AM102.

It is widely known that most classical results in model theory fail or become meaningless when restricted to the realm of finite structures. A famous example is the Łos-Tarski Preservation Theorem, which says that a first-order sentence is preserved by taking extensions if and only if it is equivalent to an existential sentence: this fails at the finite level for both relational and algebraic signatures.

The one notable exception is Rossman's Finite Homomorphism-Preservation Theorem: a first-order sentence is preserved under homomorphisms on finite relational structures if and only if it is equivalent, on the class of finite relational structures, to an existential positive sentence.

Relativising such theorems can change their truth: the Łos-Tarski Theorem for example is recovered at the finite level when restricted to classes of acyclic graphs closed under substructures and disjoint unions. We show that some broad cases of Rossman's result continue to hold under relativisations. But in contrast, we show the corresponding relativised theorem fails in algebraic signatures, giving perhaps the first case of a classical preservation theorem holding for relational structures at the finite level, but not for algebraic structures at the finite level. It remains unknown if Rossman's result (unrelativised) holds in the algebraic setting.

Finite Disjoint Representability of Semigroups

Murray Smith
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Thursday at 12:15 in AM102.

Cayley's Theorem for semigroups represents a finite semigroup over a finite set of binary relations. In the particular case of groups these binary relations are permutations, and moreover are pairwise disjoint. For finite semigroups, such a disjoint representation is not always possible over a finite set of binary relations. I will discuss my recent observations on disjoint, finite representability of finite semigroups, which are examined by way of edge-labelling digraphs. This is part of a larger topic of representations of algebras of relations, some cases of which give rise to algorithmic undecidability of representability.

Thursday Afternoon

Palindromically Rich GT-words

Amy Glen
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Murdoch University

(Joint work with Florence Levé, Université de Picardie Jules Verne)

Thursday at 16:00 in CO122.

Generalized trapezoidal words (or *GT-words* for short) were introduced by A. Glen and F. Levé in 2011. This new class of words naturally extends to an arbitrary finite alphabet the family of *binary trapezoidal words* that were originally introduced and studied by A. de Luca in 1999. Here, we completely describe all GT-words that are "rich" in palindromes, i.e., those that contain the maximal number of distinct palindromic factors.

The proof of the runs conjecture

Jamie Simpson
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Curtin University and Murdoch University

Thursday at 16:30 in CO122.

An *run* is a factor in a word which is periodic, whose length is at least twice its period and which cannot be extended to the left or right without altering the period. For example the word *abaababa* contains the runs *aa*, *ababa* and *abaaba*. In 1999 Kolpakov and Kucherov conjectured that the number of runs in a word of length n is always less than n. Since then many papers have been published on the conjecture. Until June this year the strongest result was that obtained by Crochemore and Ilie who showed, in a long very complicated paper, backed up by three years of CPU time, that the maximum number of runs is less than 1.029n. Then in June a group of Japanese mathematicians produced a stunning, simple, two page, computation-free proof of the conjecture. I will describe this proof.

A MULTIGRAPH GENERALISATION OF ALSPACH'S CYCLE DECOMPOSITION PROBLEM

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(Joint work with Darryn Bryant, Daniel Horsley and Barbara Maenhaut)

Thursday at 17:00 in CO122.

The recent solution of Alspach's cycle decomposition problem (Bryant, Horsley, Pettersson) proved that the obvious necessary conditions for the existence of a decomposition of the complete graph with n vertices into t cycles of specified lengths are also sufficient. We discuss some of the complications that arise when considering the natural generalisation of this problem to cycle decompositions of the complete multigraph with n vertices and λ edges joining each pair of distinct vertices, and determine the (not so obvious) necessary and sufficient conditions in this case.

PRIMITIVE GROUPS AND SYNCHRONISATION

Gordon Royle

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University of Western Australia

(Joint work with João Araújo, Wolfram Bentz, Peter Cameron, Artur Schaefer)

Thursday at 16:00 in AM102.

A permutation group G acting on a set Ω *synchronises* a transformation $f : \Omega \to \Omega$ if the transformation semigroup $\langle G, f \rangle$ contains a constant map, and G is called *synchronising* if it synchronises *every* transformation f that is not a permutation. A synchronising permutation group is necessarily a *primitive* group, but there are primitive groups that are not synchronising. If a primitive group is *not* synchronising, then there is a non-trivial G-invariant graph X with chromatic number $\chi(X)$ equal to clique number $\omega(X)$, and the "colouring map" $f : V(X) \to K_{\chi(X)}$ is a witness to the fact that G is not synchronising (i.e. for this particular f, the transformation semigroup $\langle G, f \rangle$ does not contain a constant map). This talk discusses recent progress (i.e. in the last month) on the conjecture that colourings, or maps closely related to colourings, are the *only* transformations that are not synchronised by a non-synchronising primitive group.

Flexible satisfaction

Marcel Jackson
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La Trobe University

Thursday at 16:30 in AM102.

We examine notions of "flexible satisfaction" for constraint satisfaction problems, such as the usual SAT variants and graph 3-colouring. Examples of such flexible satisfaction include "k-robust satisfiability" which arises in the study of minimal constraint problems, "unfrozenness" which arises in the study of phase transitions in satisfiability of random instances, but also the standard separation conditions associated with quasivarieties, going back to the mid 20th century work of Maltsev. The goal is to provide reductions mapping onto families of instances that are either not satisfiable at all, or are satisfiable in extremely flexible ways.

We give some new proofs that it is NP-complete to decide if a finite graph is flexibly 3-colourable: for every pair of nonadjacent vertices $u \neq v$ there is a 3-colouring giving u and v the same colour and also a 3-colouring giving u and v different colours. We show that this is possible to achieve in graphs where every edge forms part of a 3-clique, and use this to show that it remains NP-complete to decide natural flexible notions of satisfiability for monotone 1-in-3 3SAT. This last problem is a particular motivation for the work, as it was the crucial missing step in resolution of a long standing open problem in semigroup theory.

What is a Typical Matroid?

Charles Semple
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(Joint work with Lisa Lowrance, James Oxley, Dominic Welsh)

Thursday at 17:00 in AM102.

A set of vectors in a vector space and the set of edges of a graph are fundamental examples of a matroid. In this talk, we investigate the following question: What is a typical matroid? More precisely, if one selects an n-element labelled matroid uniformly at random, what properties does one expect to see when n is sufficiently large? Does it have high connectivity? What about its rank? How many bases does it have? For labelled graphs, the analogous question has been well-studied but, for labelled matroids, the question is largely unexplored with many more conjectures than theorems.

FRIDAY MORNING

ALMOST MULTICOVERS OF COMPLETE GRAPHS

Sanming Zhou
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The University of Melbourne

Friday at 10:45 in CO122.

A graph Γ is G-symmetric if G is a group of automorphisms of Γ that is transitive on the set of ordered pairs of adjacent vertices of Γ. If the vertex set of Γ admits a nontrivial G-invariant partition $\mathcal{B}$ such that, for blocks $B, C \in \mathcal{B}$ adjacent in the quotient graph $\Gamma_{\mathcal{B}}$ relative to $\mathcal{B}$, exactly one vertex of B has no neighbour in C, then we say that Γ is an almost multicover of $\Gamma_{\mathcal{B}}$. In this case an incidence structure with point set $\mathcal{B}$ arises naturally. This incidence structure is a $(G, 2)$-point-transitive and G-block-transitive 2-design if in addition $\Gamma_{\mathcal{B}}$ is a complete graph. I will talk about classifications of G-symmetric graphs Γ such that (i) $\mathcal{B}$ has block size at least 3, (ii) $\Gamma_{\mathcal{B}}$ is complete and almost multi-covered by Γ, and (iii) the incidence structure involved is a linear space.

SEMIREGULAR AUTOMORPHISMS OF CUBIC VERTEX-TRANSITIVE GRAPHS

Gabriel Verret
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Friday at 11:15 in CO122.

A permutation group is called semiregular if every point-stabiliser is trivial. Together with J. Morris and P. Spiga, we have characterised cubic graphs admitting a vertex-transitive group of automorphisms with an abelian normal subgroup that is not semiregular. While this looks rather technical, this result is surprisingly useful. We illustrate this by explaining how this result can be used to prove a conjecture of Cameron et al. about the order of semiregular subgroups in cubic vertex-transitive graphs.

STRONGLY REGULAR GRAPHS FROM LARGE ARCS IN AFFINE PLANES

Tim Penttila
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(Joint work with Liz Lane-Harvard, Stan Payne)

Friday at 11:45 in CO122.

Strongly regular graphs with parameters

$$(q^3+2q^2, q^2+q, q, q), (q^3+q^2+q+1, q^2+q, q-1, q+1), (q^3, q^2+q-2, q-2, q+2)$$

are constructed from k-arcs in affine planes of order q with

$$k = q, q+1, q+2.$$

Additionally, strongly regular graphs with parameters

$$(nq^3-q^3+nq^2, nq^2-q^2+nq-q, nq+2n-q-4, nq+2n-q-4)$$

are constructed from maximal arcs of degree n in affine planes of order q.

All these examples generalize examples known previously when the affine planes were assumed to be Desarguesian.

THE COMPLETION PROBLEMS FOR SOME CLASSES OF Q-MATRICES

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(Joint work with Kalyan Sinha)

Friday at 12:15 in CO122.

A *partial matrix* is a square array in which some entries are specified, while others are free to be chosen. A partial matrix M is said to *specify* a digraph D, possibly with loops, if the positions of the specified entries in M correspond to the arcs in D.

A real $n \times n$ matrix A is a *P-matrix* (*P_0-matrix*) if each of the principal minors of A is positive (nonnegative), and is a *Q-matrix* if for every $k = 1, 2, \ldots, n$, the sum $S_k(A)$ of all the $k \times k$ principal minors of A is positive. For a class Π of matrices (e.g., P-, P_0- or Q-matrices) a partial Π-*matrix* is one whose specified entries satisfy the required properties of a Π-matrix. For example, a partial P-matrix has all fully specified minors positive, and for a partial Q-matrix M, $S_k(M) > 0$ for each k for which all $k \times k$ principal submatrices are fully specified.

A Π-*completion* of a partial Π-matrix is a Π-matrix obtained by some choices of the unspecified entries. In many cases, the positions of the specified entries play a significant role for existence of completions of partial matrices of a given class. A digraph D is said to have Π-*completion*, if every partial Π-matrix specifying D can be completed to a Π-matrix. The (*combinatorial*)

Π-*matrix completion problem* attempts to study the digraphs having Π-completions. For an exposition in matrix completion problems, see the survey articles [2] and [3]. The study of the Q-matrix completion problem was initiated in [1].

We will present our recent work on the nonnegative and the positive Q-matrix completion problems. For these completion problems, necessary conditions and some sufficient conditions for a digraph to have completion will be discussed, and results on classifications of digraphs of order at most four will be presented.

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SIERPIŃSKI GRAPHS – DISTANCES AND SYMMETRIES

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Friday at 10:45 in AM102.

Sierpiński graphs S_p^n are graphs with a lovely fractal structure and were studied in various areas, including in the problem of the Tower of Hanoi puzzle. The puzzle is interesting because of the several open problems, for example an optimal solution for 4 pegs and more. These can be linked to the state graphs of the puzzle. Sierpiński graphs have a very similar structure to Hanoi graphs, yet they are a bit easier to study, hence we are interested in the metric properties of Sierpiński graphs.

For arbitrary two vertices of Sierpiński graphs, the general distance formula is given as the minimum of p values, which can be difficult to obtain for arbitrary values of p. Our aim is to find a closed or a simplified distance formula. In this seminar we will discuss symmetries of Sierpiński graphs, and how they might help us further with the metric properties of Sierpiński graphs.

THE PROBABILISTIC METHOD MEETS GO

Graham Farr
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Friday at 11:15 in AM102.

The game of Go — known as *Go* or *Igo* in Japan, *Wéiqí* in China and *Baduk* in Korea — is one of the oldest and deepest board games in the world, and has a huge following in east Asia.

Traditionally, the game involves placing black and white stones on the vertices of a square grid, usually with 19×19 vertices. But it can in fact be played on any graph G. A *position* is an assignment of colours from the set {Black, White} to some subset of $V(G)$. So each vertex is Black, White or Uncoloured. A *legal position* is one in which each monochromatic component is adjacent to some uncoloured vertex. (A *monochromatic component* is a component of the subgraph induced by the vertices of a specific colour.)

Among the most basic questions that can be asked about any game are:

- How many legal positions are there?
- What is the probability that a random arrangement of game elements (stones/pieces/...) on the board gives a legal position?

The author introduced *Go polynomials* to study these questions for Go [1]. Let $q \in [0, \frac{1}{2}]$ be a probability. Suppose each vertex is, randomly and independently, coloured Black with probability q, White with probability q, and is left uncoloured with probability $1 - 2q$. Then $\mathrm{Go}(G; q)$ is the probability that the resulting random position is a legal one. The author found links to the chromatic polynomial and proved that it is #P-hard to compute.

In this talk, we apply probabilistic methods to study the asymptotic behaviour of $\mathrm{Go}(G; q)$ when G is an $n \times n$ square grid, and also when $G \in \mathcal{G}(n; p)$ is an Erdős-Rényi random graph with edge probability p.

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Locating Sets of Vertices on Hamiltonian Cycles

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(Joint work with Ralph Faudree and Hao Li)

Friday at 11:45 in AM102.

Given an ordered set of vertices $S = \{x_1, x_2, \cdots, x_k\}$ in a graph, there are a series of results giving minimum degree conditions that imply the existence of a Hamiltonian cycle such that the vertices in S are located in order on the cycle with restrictions on the distance between consecutive vertices of S. Examples include results by Kaneko and Yoshimoto [7], Sárkőzy and Selkow [9], Kierstead, Sárkőzy and Selkow [8], Faudree, Gould, Jacobson, and Magnant [3], Faudree and Li [5], and Faudree, Lehel, and Yoshimoto [4]. We will consider a pair of disjoint sets of vertices X and Y, each with precisely $k \geq 2$ vertices in a graph G of order n. The objective is to determine the minimum degree $\delta(G)$ of G that implies the existence of a Hamiltonian cycle C such that the smallest interval of C that contains X and the smallest interval of C that contains Y are disjoint.

The following is our first result of this talk.

Theorem 1 *Let k be a positive integer. If G is a graph with $n \geq 5k+2$ and $\delta(G) \geq (n+k-1)/2$, then for any two sets X and Y of k disjoint vertices of G, there exists a Hamiltonian cycle C of G, such that the vertices of X precede the vertices of Y for appropriate initial vertex and orientation of the cycle C.*

A companion to the results of Theorem 1 is to place the vertices of X and Y on a cycle that the vertices alternate between being in X and being in Y, called *an alternating cycle for X and Y*. The following is the second result of this talk

Theorem 2 *If G is a $4k$-connected graph with $\delta(G) \geq (n+1)/2$ and $n \geq 40k-1$, then for any disjoint sets X and Y of k vertices of G, there exists an alternating Hamiltonian cycle for X and Y.*

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BOUNDS FOR THE BOXICITY OF MYCIELSKIANS OF GRAPHS

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Friday at 12:15 in AM102.

A *box* in Euclidean k-space is the Cartesian product of k closed intervals on the real line. The *boxicity* of a graph G, denoted by $\text{box}(G)$, is the minimum integer k such that the graph G can be isomorphic to the intersection graph of a family of boxes in Euclidean k-space. The notion of boxicity of graphs was introduced by F.S. Roberts (1969).

Roberts proved that the maximum boxicity of graphs with n vertices is $\lfloor \frac{n}{2} \rfloor$. Recently, L.S. Chandran et al. (2009) found a relation between boxicity and chromatic number: if the boxicity of a graph is very close to the maximum boxicity, the chromatic number of the graph must be very large. However, there is not much information about structure of graphs with large boxicity.

In this talk, we note that increasing boxicity may be possible by a graph operation increasing chromatic number. The *Mycielskian* $M(\cdot)$ is a well-known graph operation to construct triangle-free graphs with arbitrary large chromatic number. Since the inequality $\text{box}(M(G)) \geq \text{box}(G)$ holds for a graph G by definitions, we present bounds for the boxicity of Mycielskians of graphs and classify as many graphs as possible into $\text{box}(M(G)) > \text{box}(G)$ or $\text{box}(M(G)) = \text{box}(G)$. We also determine the boxicity of some Mycielskians of graphs.

FRIDAY AFTERNOON

ON A RANDOM TREE CHOSEN FROM PERMUTATION GRAPHS

Huseyin Acan
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Friday at 16:00 in CO122.

A permutation graph on vertex set $[n] := \{1, 2, \dots, n\}$ is a graph whose edges correspond to the inversions of a permutation. Let $\mathcal{T}_n$ denote the set of trees lying in the permutation graphs on vertex set $[n]$ and T_n denote a tree chosen uniformly at random from $\mathcal{T}_n$. I will talk about the highest degree in T_n, the diameter of T_n, and the number of leaves in T_n.

BALANCED C_7-FOIL DESIGNS AND RELATED DESIGNS

Kazuhiko Ushio
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Friday at 16:30 in CO122.

Let K_n denote *the complete graph* on n vertices. Let C_7 be *the* 7*-cycle*. *The C_7-t-foil* is a graph of t edge-disjoint C_7's with a common vertex and the common vertex is called *the center of the C_7-t-foil*. When K_n is decomposed into edge-disjoint sum of C_7-t-foils and every vertex of K_n appears in the same number of C_7-t-foils, we say that K_n *has a balanced C_7-t-foil decomposition* and this number is called *the replication number*. This decomposition is to be known as *a balanced C_7-t-foil design*.

Theorem 1. K_n has a balanced C_7-t-foil design if and only if $n \equiv 1 \pmod{14t}$.

Theorem 2. K_n has a balanced C_{14}-t-foil design if and only if $n \equiv 1 \pmod{28t}$.

Theorem 3. K_n has a balanced C_{21}-t-foil design if and only if $n \equiv 1 \pmod{42t}$.

Theorem 4. K_n has a balanced C_{28}-t-foil design if and only if $n \equiv 1 \pmod{56t}$.

Theorem 5. K_n has a balanced C_{35}-t-foil design if and only if $n \equiv 1 \pmod{70t}$.

Theorem 6. K_n has a balanced C_{42}-t-foil design if and only if $n \equiv 1 \pmod{84t}$.

Theorem 7. K_n has a balanced C_{49}-t-foil design if and only if $n \equiv 1 \pmod{98t}$.

Theorem 8. K_n has a balanced C_{56}-t-foil design if and only if $n \equiv 1 \pmod{112t}$.

Theorem 9. K_n has a balanced C_{63}-t-foil design if and only if $n \equiv 1 \pmod{126t}$.

Theorem 10. K_n has a balanced C_{70}-t-foil design if and only if $n \equiv 1 \pmod{140t}$.

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