2019 Coast Combinatorics Conference
11-14 February, 2019
Pacific Room, East-West Center (Jefferson Hall)
University of Hawai'i, Manoa

Schedule and Abstracts

Monday, Feb. 11, Pacific Room, East-West Center

9:40 **Coffee** is available

10:00 *Limited Visibility Cops and Robber*
Nancy E. Clarke, Acadia University

10:30 *Uniquely H-colouring large-girth digraphs*
Mark Kayll, University of Montana

11:00 *Inverse graphs*
Monther Rashed Alfuraidan, King Fahd University of Petroleum and Minerals

11:30 *Sparse Spanners in Temporal Cliques*
Joseph Peters, Simon Fraser University

12:00 **Lunch break**: many options nearby

1:00 *Infectious Power Domination for Hypergraphs*
Beth Bjorkman, Iowa State University

1:30 *The Total Coloring Game*
Chuck Dunn, Linfield College

2:00 *Coloring squares of planar graphs with no 4-cycles*
Ilkyoo Choi, Hankuk University of Foreign Studies

2:30 *A Universal Cycle Construction for Weak Orders*
Joe Sawada, University of Guelph

3:00 **End** of scheduled talks

Tuesday, Feb. 12, Pacific Room, East-West Center

9:40 **Coffee** is available

10:00 *Chromatic Polynomials of Oriented Graphs*
Danielle Cox, Mt. St. Vincent University

10:30 *Partitions and compositions over finite fields*
Steven Wang, Carleton University

11:00 *Rainbow matchings of size m in graphs with total color degree at least $2mn$*
Jürgen Kritschgau, Iowa State University

11:30 *Sharp spectral bounds for the edge-connectivity in simple regular graphs*
Suil O, SUNY-Korea

12:00 **Lunch break**: many options nearby

1:00 *Convex Hull Representation of Predicates in Constraint Programming*
Niko Kaso, Oakland University

1:30 *Throttling for the cop versus robber game*
Jesse Geneson, Iowa State University

2:00 *Plain Change Order for Permutation Patterns: Gray Codes for Catalan Structures, Rectangulations, Quotientopes, and More*
Aaron Williams, Williams College / Bard College at Simon's Rock

2:30 **Coffee break**

3:00 *Searching for max-cliques in circulant k-hypergraphs*
Lucia Moura, University of Ottawa

3:30 *Counting Steiner triple systems of given 2-rank or 3-rank*
Vladimir Tonchev, Michigan Technological University

4:00 *Cut-edges and Regular Subgraphs in Odd-degree Regular Graphs*
Douglas B. West, Zhejiang Normal University and University of Illinois

4:40 **End** of scheduled talks

7:00 **Conference Dinner**: Side Street Inn Kapahulu
614 Kapahulu Ave, #100
Honolulu, 96814
(808) 739-3939

Wednesday, Feb. 13, Pacific Room, East-West Center

9:40 **Coffee** is available

10:00 *Distinguishing Numbers of Partially Ordered Sets*
Karen Collins, Wesleyan University

10:30 *Supermagic graphs with arbitrarily many different odd degrees*
Dalibor Froncek, University of Minnesota Duluth

11:00 *Skew-Regular Hadamard Matrices*
Hadi Kharaghani, University of Lethbridge

11:30 **Break**

11:45 *Nested Recurrence Relations and Morphisms: Two Examples*
Frank Ruskey, University of Victoria

12:15 *Fast Searching on Complete k-partite Graphs*
Boting Yang, University of Regina

12:45 *Projective and affine planes with ovals for blocks*
Brett Stevens, Carleton University

1:15 **End** of scheduled talks

Thursday, Feb. 14, Pacific Room, East-West Center

9:40 **Coffee** is available

10:00 *Aromaticity and Stability for Carbon Nanotubes*
Liz Hartung, Massachusetts College of Liberal Arts

10:30 *Rainbow Turán Problems*
Amites Sarkar, Western Washington University

11:00 *Infinite Sidon sets contained in sparse random sets of integers*
Sang June Lee, Duksung Women's University

11:30 *Testing morphisms for square-freeness on Thue's square-free words*
James D. Currie, University of Winnipeg

12:00 **Lunch break**: many options nearby

1:00 *Computing Permutation Polynomials*
Sergey Bereg, University of Texas at Dallas

1:30 *The class of (P_7, C_4, C_5)-free graphs: decomposition, algorithms, and χ-boundedness*
Kathie Cameron, Wilfrid Laurier University

2:00 *A Finite Field Construction of QC-LDPC Codes Free of Small Size Elementary Trapping Sets*
Daniel Panario, Carleton University

2:30 *Extending Fixing Numbers of Graphs to Matroids*
Nancy Ann Neudauer, Pacific University

3:00 **End** of scheduled talks

Conference Ends

Abstracts in alphabetical order by speaker's name

Monther Rashed Alfuraidan, King Fahd University of Petroleum and Minerals
Inverse graphs

Let $(\Gamma, *)$ be a finite group and S a possibly empty subset of Γ containing its non-self-invertible elements. In this talk, we introduce the inverse graph associated with Γ whose set of vertices coincides with Γ such that two distinct vertices u and v are adjacent if and only if either $u * v \in S$ or $v * u \in S$. We then investigate its algebraic and combinatorial structures.

Sergey Bereg, University of Texas at Dallas
Computing Permutation Polynomials

A polynomial $f()$ over a finite field $\mathbb{F}$ is a permutation polynomial if the function $f()$ from $\mathbb{F}$ to itself induces a permutation. A characterization of which polynomials are permutation polynomials is given by Hermite's criterion. Dickson was able to use it to find all permutation polynomials of degree at most five. Hermite's criterion is computationally intensive and can be difficult to use in finding permutation polynomials. In this talk we discuss a new approach to compute normalized permutation polynomials of degree up to 10.

Beth Bjorkman. Iowa State University
Infectious Power Domination for Hypergraphs

The power domination problem seeks to find the placement of the minimum number of sensors needed to monitor an electric power network. We generalize the power domination problem to hypergraphs using the infection rule from Bergen et al: given an initial set of observed vertices, S_0, a set $A \subseteq S_0$ may infect an edge e if $A \subseteq e$ and for any unobserved vertex v, if $A \cup \{v\}$ is contained in an edge, then $v \in e$. We combine a domination step with this infection rule to create *infectious power domination*. We compare this new parameter to the previous generalization by Chang and Roussel. We provide general bounds and the impact of hypergraph operations.

Kathie Cameron, Wilfrid Laurier University
The class of (P_7, C_4, C_5)-free graphs: decomposition, algorithms, and χ-boundedness

As usual, P_n ($n \geq 1$) denotes the path on n vertices, and C_n ($n \geq 3$) denotes the cycle on n vertices. For a family $\mathcal{H}$ of graphs, we say that a graph G is *$\mathcal{H}$-free* if no induced subgraph of G is isomorphic to any graph in $\mathcal{H}$. We present a decomposition theorem for the class of (P_7, C_4, C_5)-free graphs; in fact, we give a complete structural characterization of (P_7, C_4, C_5)-free graphs that do not admit a clique-cutset. We use the decomposition theorem to construct an $O(n^3)$ algorithm for the minimum coloring problem, an $O(n^2m)$ algorithm for the maximum weight stable set problem, and an $O(n^3)$ algorithm for the maximum weight clique problem for this class, where n denotes the number of vertices and m the number of edges of the input graph. We also use the decomposition theorem to show that every (P_7, C_4, C_5)-free graph G satisfies $\chi(G) \leq \frac{3}{2}\omega(G)$, where $\chi(G)$ is the chromatic number of G and $\omega(G)$ is the size of a largest clique in G. This is joint work with Shenwei Huang, Irena Penev and Vaidy Sivaraman.

Ilkyoo Choi, Hankuk University of Foreign Studies
Coloring squares of planar graphs with no 4-cycles

We study list coloring squares of planar graphs with no 4-cycles. We show that if G is such a graph, then $\chi_\ell(G^2) \le \Delta(G) + 73$. When $\Delta(G)$ is sufficiently large, we strengthen this bound to $\chi_\ell(G^2) \le \Delta(G) + 2$. Our bounds also hold for Alon–Tarsi number, paint number, and correspondence chromatic number. To complement these results, we show that 4-cycles are unique in having this property. Specifically, let S be a finite list of positive integers, with $4 \notin S$. For each constant C, we construct a planar graph $G_{S,C}$ with no cycle with length in S, but for which $\chi(G_{S,C}^2) > \Delta(G_{S,C}) + C$.

This is joint work with Daniel W. Cranston and Théo Pierron.

Nancy E. Clarke, Acadia University
Limited Visibility Cops and Robber

A variation of the Cops and Robber game is considered in which the cops can only see the robber when the distance between them is at most a fixed parameter ℓ. We see that the cops' strategy consists of a phase in which they need to "see" the robber (i.e. move within distance ℓ of the robber), followed by a phase in which they capture the robber. For some graphs, it is the first phase which is the most resource intensive while, for others, it is the second. We present a variety of results, including a characterization of those trees on which k cops are sufficient to guarantee a win for all $\ell \ge 1$. We also show that this Cops and Robber model is not monotonic.

This is joint work with D. Cox, C. Duffy, D. Dyer, S.L. Fitzpatrick, & M.E. Messinger.

Karen L. Collins, Wesleyan University
Distinguishing Numbers of Partially Ordered Sets

In this talk, we introduce the distinguishing chromatic number and the distinguish- ing number of a poset. The former is equal to the width of the poset, but the latter concept is more interesting. We use elementary methods to prove that every divisibility lattice has distinguishing number 2 and algebraic methods to prove that every distributive lattice has distinguishing number equal to two. We characterize those distributive lattices with distinguishing number equal to one. We prove an upper bound on the distinguishing chromatic number of a distributive lattice and consider the special case of a Boolean lattice. We also consider the distinguishing number for planar, ranked, Cohen-Macaulay posets.

This is joint work with Ann Trenk (Wellesley College).

Danielle Cox, Mt. St. Vincent University
Chromatic Polynomials of Oriented Graphs

The oriented chromatic polynomial of an oriented graph outputs the number of oriented k-colourings for any input k. In this talk we will fully classify those oriented graphs for which the oriented graph has the same chromatic polynomial as the underlying simple graph, closing an open problem posed by Sopena. The chromatic roots of the oriented chromatic polynomial will also be discussed.

Joint with Chris Duffy of University of Saskatchewan

James D. Currie, University of Winnipeg
Testing morphisms for square-freeness on Thue's square-free words

In 1906, Axel Thue initiated the study of infinite square-free words – words with no factor xx where x is non-empty. He showed that the smallest alphabet on which such words exist is $\{a, b, c\}$. In a follow-up paper in 1912, Thue constructed three infinite square-free words over $\{a, b, c\}$ which are minimal with respect to their sets of factors; for each of $S = \{aba, cbc\}, \{aba, aca\}$ and $\{aba, bab\}$ he found a square-free word w_S with none of its factors in S. In this talk, for each such S, I give necessary and sufficient conditions on a morphism h for $h(w_S)$ to be square-free.

Chuck Dunn, Linfield College
The Total Coloring Game

We will consider a variation of the coloring game on a graph G. First, we define an *element* of a graph to be an edge or vertex of the graph. The *total coloring game* is a game in which two players, Alice and Bob, take turns coloring the elements of a graph G with colors chosen from a set X of r colors such that no two neighboring elements share a color. A color is *legal* for an uncolored element u if it is not present among the set of colored neighbors of u. Alice goes first and wins if every element of the graph is eventually colored. Bob goes second and wins if some element of the graph cannot be legally colored. We define the *total game chromatic number* of a graph G, denoted $\chi''_{\mathrm{g}}(G)$, as the least number of colors with which Alice has a winning strategy for the total coloring game on G. We will discuss this game on forests and consider some possible variations of the game.

Dalibor Froncek, University of Minnesota Duluth
Supermagic graphs with arbitrarily many different odd degrees

A graph $G = (V, E)$ is called *supermagic* if there exists a bijection $f : E \to \{1, 2, \ldots, |E|\}$ called *supermagic labeling* such that for every $x \in V$ the sum of labels $f(xy)$ of all edges xy incident with x is equal to the same number m, called the *supermagic constant*.

Typically, the classes of graphs studied in this context are vertex-regular or even vertex-transitive.

Recently, Kovář et al. affirmatively answered a question by Madaras:

Does there exist a supermagic graph with k different degrees for any positive integer k?

Because their construction provided only graphs where all degrees were even, they asked the following more specific question:

Does there exist a supermagic graph with k different odd degrees for any positive integer k?

We answer this question in the affirmative by providing a construction based on the use of 3-dimensional magic rectangles.

This is joint work with Jiangyi Qiu.

Keywords: Supermagic graphs, magic-type labeling, edge labeling

Jesse Geneson, Iowa State University
Throttling for the cop versus robber game

Meyniel conjectured that the number of cops required to win the cop versus robber game on any connected n-vertex graph is at most a multiple of the square root of n. Despite the fact that several families of connected graphs are known to have cop number at least a multiple of the square root of n and none are known to have higher cop number, the best current upper bound on the cop number of n-vertex graphs is only slightly sublinear.

The cop-throttling number of a graph sums the number of cops with the capture time (allowing more cops than the minimal number that can win the graph). Like the cop number, the cop-throttling number was conjectured to be at most a multiple of the square root of n for any connected n-vertex graph. We discuss a family of graphs that refute this conjecture, along with bounds on cop-throttling for chordal graphs and other families.

Joint work with Anthony Bonato, Jane Breen, Boris Brimkov, Joshua Carlson, Leslie Hogben, K.E. Perry, and Carolyn Reinhart.

Liz Hartung, Massachusetts College of Liberal Arts
Aromaticity and Stability for Carbon Nanotubes

A fullerene is a 3-regular plane graph with only hexagonal and pentagonal faces, and models a pure carbon molecule. Nanotubes are a class of fullerenes that are cylindrical in shape and extremely useful in applications. The Clar number of a fullerene is a parameter related to its aromaticity and stability. In this talk, we partition nanotubes into two classes, those with relatively small and with relatively large Clar numbers. We describe the double bond structures, or perfect matchings, capable of forming in these two classes. This dichotomy corresponds with the classification of metallic and semiconducting nanotubes based on their chiral indices. This is joint work with Jack Graver (Syracuse University).

Niko Kaso, Oakland University
Convex Hull Representation of Predicates in Constraint Programming

There has constantly been a growing interest in Constraint Programming (CP) as it plays a vital role in modelling and solving combinatorial problems. Also, it is extensively applied in many domains, such as networks, planning, vehicle routing and scheduling. Although, CP originates and is mostly developed by Artificial Intelligence (AI) community, it is very effective to consider its interaction with Integer Programming (IP) which originates in Mathematics. One of the strengths of constraint programming, as contrasted with integer programming, lies in the use of predicates, or global high-level constraints, on a few variables to model complex and varied problem structures. We study the convex hull representation of two different predicates. The first predicate is the *at-least* predicate $at - least_m\{x_1, \dots, x_n\} = k$ which simply means that at least m of the n variables x_i take value k. We have completely characterized the polytope of a single $at - least$ predicate and two *at-least* predicates interacting. The other predicate for which we only have a class of facet-defining inequalities is the $at - least - m - different\{x_1, \dots, x_n\}$. It means that at least m variables must have different values from a domain, say $\{0, 1, \dots, l\}$, where l is an integer. Also, for both predicates we have provided a polynomial time separation algorithm to be used in the context of a branch and bound optimization approach.

Mark Kayll, University of Montana
Uniquely H-colouring large-girth digraphs

Erdős' 1959 article establishing the existence of graphs with arbitrarily high girth and chromatic number not only exposed a facet of the diamond that was the then-nascent probabilistic method but also sparked a cottage industry refining and polishing his gem. Partly historical, partly contemporary, this talk traces a thread analogizing graphs to digraphs and generalizing colouring to homomorphing.

Hadi Kharaghani, University of Lethbridge
Skew-Regular Hadamard matrices

A Hadamard matrix H of order $4n^2$ is said to be *skew-regular* if it is of skew-type and the absolute values of the row sums are all $2n$. It is conjectured that for each odd integer n there is a skew-regular matrix of order $4n^2$. The existence and applications of these matrices will be presented.

This is a joint work with Darcy Best, Kai Fender, and Sho Suda.

Jürgen Kritschgau, Iowa State University
Rainbow matchings of size m in graphs with total color degree at least $2mn$

The existence of a rainbow matching given a minimum color degree, proper coloring, or triangle-free host graph has been studied extensively. This paper, generalizes these problems to edge colored graphs with given total color degree. In particular, we find that if a graph G has total color degree $2mn$ and satisfies some other properties, then G contains a matching of size m; These other properties include G being triangle-free, C_4-free, properly colored, or large enough.

Keywords: Rainbow matchings, color degree

Sang June Lee, Duksung Women's University
Infinite Sidon sets contained in sparse random sets of integers

A set S of natural numbers is a *Sidon set* if all the sums $s_1 + s_2$,where $s_1, s_2 \in S$ and $s_1 \neq s_2$, are distinct. Let constants $\alpha > 0$ and $0 < \delta < 1$ be fixed, and let $p_m = \min\{1; \alpha m^{-1+\delta}\}$f or all positive integers m. Generate a random set $R \subset \mathbb{N}$ by adding m to $\mathbb{R}$ with probability p_m, independently for each m. We investigate how dense a Sidon set S contained in R can be. Our results show that the answer is qualitatively very different in at least three ranges of δ. We prove quite accurate results for the range $0 < \delta \leq 2/3$ but only obtain partial results for the range $2/3 < \delta \leq 1$. This is joint work with Y. Kohayakawa, C. G. Moreira and V. Rdl.

Lucia Moura, University of Ottawa
Searching for max-cliques in circulant k-hypergraphs

In this talk, we discuss different exhaustive search algorithms to find maximum cliques in circulant k-hypergraphs. The first algorithm combines binary necklace exhaustive generation and classical backtracking for cliques; this was first proposed in our joint work with Georgios Tzanakis, Daniel Panario and Brett Stevens (2016), motivated by a problem in covering array construction. The second algorithm is based on recent work with Lachlan Plant, where we use the Russian Doll search strategy combined with properties of circulant hypergraphs. Our experiments show that the second method is more efficient for denser hypergraphs (in particular for the original problem that motivated the first investigation), while the first method is more efficient for sparser hypergraphs.

Nancy Ann Neudauer, Pacific University
Extending Fixing Numbers of Graphs to Matroids

A subset S of the vertices of a graph G is a fixing set for G if and only if the identity automorphism is the only automorphism of G that fixes every vertex of S. That is, each automorphism of G is completely determined by its action on a fixing set S. The fixing number of G, denoted $\mathrm{fix}(G)$, is the cardinality of the smallest fixing set of G. Automorphism groups and fixing numbers allow us to describe the symmetry properties and structural complexity of a graph.

We begin by examining the automorphism groups and fixing numbers of various classes of graphs, show that two graphs with isomorphic automorphism groups may not have the same fixing number, and consider some bounds for fixing numbers. We then consider whether we can extend this to matroids. We find the fixing number for specific examples of matroids and give some results for fixing numbers of binary, transversal, and bicircular matroids.

This is joint work with Gary Gordon and Jennifer McNulty, and many students.

Suil O, SUNY-Korea
Sharp spectral bounds for the edge-connectivity in simple regular graphs

Let d and t be positive integers such that $3 \leq t \leq d-1$. In this talk, we give sharp upper bounds for the second largest eigenvalue in a simple d-regular graph G to guarantee that $\kappa'(G) \geq t+1$, where $\kappa'(G)$ is the edge-connectivity of G.

Daniel Panario, Carleton University
A Finite Field Construction of QC-LDPC Codes Free of Small Size Elementary Trapping Sets

Quasi-cyclic low-density parity-check codes (QC-LDPC codes) are an essential category of LDPC codes that have simple implementation and favorable performance. An (m, n)-regular code is a code whose parity-check matrix has m ones in each column and n ones in every row. We are interested in sparse regular codes.

One of the most important representations for codes is the Tanner graph in which the length of the shortest cycles, girth, has been known to influence the code performance. Since Tanner graphs with short cycles do not produce good results, constructions which lead to the existence of 4-cycles in their Tanner graphs are avoided. Indeed, in almost all of the algebraic-based constructions proposed up to now Tanner graph has girth at least 6.

Another phenomenon that influences the performance of LDPC codes are trapping sets. An (a, b) trapping set of size a is an induced subgraph of the Tanner graph on a variable nodes and b check nodes of odd degrees, called the unsatisfied check nodes. The even degree check nodes are satisfied check nodes. Empirical results show that among all trapping sets, the most harmful ones are those with check nodes of degree 1 or 2. These are called elementary trapping sets (ETSs).

We construct $(3, n)$-regular QC-LDPC codes with girth 6 whose Tanner graphs are free of ETSs of small size. To reach our goal, first, we present an algebraic structure for the exponent matrix of QC-LDPC codes with girth at least 6 based on multiplicative cyclic subgroups of a finite field. Then, we obtain sufficient conditions for an exponent matrix to have a Tanner graph which is free of some ETSs with small size. Some algebraic-based QC-LDPC code constructions with girth 6 in the literature are special cases of our construction. Our experimental results show that removing ETSs with small size contribute to have better performance.

Joint work with Farzane Amirzade (Shahrood University of Technology, Iran) and Mohammad Reza Sadeghi (Amirkabir University of Technology, Iran).

Joseph Peters, Simon Fraser University
Sparse Spanners in Temporal Cliques

Let $G = (G, \lambda)$ be a labeled graph on n vertices with $\lambda : E_G \to \mathbb{N}$ a locally injective mapping that assigns to every edge a single integer label which is a discrete time when the edge is present. G is *temporally connected* if a path exists with increasing labels from every vertex to every other vertex. In a seminal paper, Kempe, Kleinberg, and Kumar (JCSS 2002) asked whether, given such a labeled graph, a *sparse* subset of edges can always be found that preserves temporal connectivity if the other edges are removed. We call such subsets *temporal spanners*. Recently, Axiotis and Fotakis (ICALP 2016) answered negatively, exhibiting a family of minimally connected temporal graphs with $\Omega(n^2)$ edges. The natural question then becomes whether sparse spanners can be found in specific classes of dense graphs. We settle the question *positively* for complete graphs, showing that one can always remove all but $O(n \log n)$ edges.

Joint work with Arnaud Casteigts and Jason Schoeters.

Frank Ruskey, University of Victoria
Nested Recurrence Relations and Morphisms: Two Examples

A typical nested recurrence relation is $Q(n) = Q(n-Q(n-1)+Q(n-Q(n-2))$; note the "nesting" $\ldots Q(\ldots Q(\ldots)\ldots)\ldots$ in the equation. As shown by Celaya and Ruskey (to appear) there is a close relationship between a class of nested recurrence relations and certain morphisms. We exploit this relationship in connection with two examples. In the first, we show that an "infinite" nested recurrence has a solution whose values at Fibonacci indices are Fibonacci numbers. In the second, we prove that the nth value in the solution of a nested recurrence relation of Cloitre is the nth largest of Fraenkel's so-called vile numbers.

This is joint work with Marcel Celaya and Peter Burcsi.

Amites Sarkar, Western Washington University
Rainbow Turán Problems

For a fixed graph F, the *rainbow Turán number* $ex^*(n, F)$ of F is the maximum number of edges in a properly edge-colored graph on n vertices which does not contain a *rainbow copy* of F, that is, a copy of F all of whose edges receive a different color. The systematic study of this function was initiated by Keevash, Mubayi, Sudakov and Verstraëte in 2007. I'll explain the motivation for this problem (additive number theory), survey what is known about it, and state some of the main open questions. This is joint work with Dan Johnston and Cory Palmer.

Joe Sawada, University of Guelph
A Universal Cycle Construction for Weak Orders

A *weak order* is a way n competitors can rank in an event where ties are allowed. For example, the results for the 100m men's butterfly final in the 2016 Summer Olympics corresponded to the weak order 82512276. There was a three way tie for the silver medal. No bronze was awarded. Let $\mathbf{W}(n)$ denote the set of all weak orders of order n. A *universal cycle* for a set $\mathbf{S}$ of strings of length n is a sequence that when considered cyclicly contains each string in $\mathbf{S}$ as a substring exactly once. Thus 1113213122123 is a universal cycle for the 13 weak orders in $\mathbf{W}(3)$. We provide the first efficient algorithm to construct a universal cycle for $\mathbf{W}(n)$. It generates each universal cycle in $O(n)$ time per symbol using $O(n)$ space. This answers Problem 477 (Problem 2) posed by Diaconis and Ruskey [*Research problems on Gray codes and universal cycles*, by Jackson, Stevens, Hurlbert, Discrete Mathematics, 309 (2009) 5341-5348], where they refer to weak orders as "permutations with ties".

This is joint work with Dennis Wong.

Brett Stevens, Carleton University
Projective and affine planes with ovals for blocks

A beautiful theorem states that the reverse of a line in the Singer Cycle presentation of a projective plane is an oval, a set of n+1 points that intersect with lines in at most two points. This implies that for every Desarguesian projective plane there is a companion plane on the same points, all of whose blocks are ovals in the first. This fact has been exploited to construct a family of very efficient strength 3 covering arrays. We present a simialar construction of affine planes whose blocks are ovals. We discuss the covering arrays these can construct. We discuss what is known about larger sets of planes that pairwise have this property.

Vladimir D. Tonchev, Michigan Technological University
Counting Steiner triple systems of given 2-rank or 3-rank

By a famous result of Doyen, Hubaut and Vandensavel [2], the p-rank of the incidence matrix of a Steiner triple system $STS(v)$ on v points can be smaller than v only if $p = 2$ or $p = 3$. In [1], Assmus proved that the block by point incidence matrices of all Steiner triple systems on v points which have the same 2-rank generate equivalent binary linear codes, and gave an explicit description of a generator matrix for such a code. The subject of this talk is an alternative, considerably simpler proof of the result of Assmus that employs parity check matrices of the relevant codes and allows to prove an analogous result for the ternary linear codes spanned by the block by point incidence matrices of Steiner triple systems [3]. As an application, formulae for counting $STS(2^n - 1)$ having 2-rank smaller than v, as well as formulae for counting $STS(3^n)$ having 3-rank smaller than $v - 1$ were found recently in [4].

References

[1] E. F. Assmus, Jr., On 2-ranks of Steiner triple systems, *Electronic J. Combinatorics* **2** (1995), paper #R9.

[2] J. Doyen, X. Hubaut, M. Vandensavel, Ranks of incidence matrices of Steiner triple systems, *Math. Z.* **163** (1978), 251 - 259.

[3] D. Jungnickel and V. D. Tonchev, On Bonisoli's theorem and the block codes of Steiner triple systems, *Designs, Codes and Cryptography* **86** (3) (2018), 449-462.

[4] D. Jungnickel and V. D. Tonchev, Counting Steiner triple systems with classical parameters and prescribed rank, *J. Combin. Theory* Ser. A **162** (2019), 10-33.

Steven Wang, Carleton University, Ottawa, Canada
Partitions and compositions over finite fields

In this talk we study the partitions and compositions over finite fields. First we obtain an exact formula for the number of partitions of an element z into m parts over a finite field, i.e. we find the number of nonzero solutions of the equation $x_1 + x_2 + \cdots + x_m = z$ over a finite field when the order of terms does not matter. This is equivalent to counting the number of m-multi-subsets whose sum is z. When the order of the terms in a solution does matter, such a solution is called a composition of z. We also obtain an formula for the number of compositions over finite fields. Finally we comment on some extensions and applications of our results.

Douglas B. West, Zhejiang Normal University and University of Illinois
Cut-edges and Regular Subgraphs in Odd-degree Regular Graphs

Hanson, Loten, and Toft proved that every $(2r+1)$-regular graph with at most $2r$ cut-edges has a 2-factor. We generalize this by proving for $k \leq (2r+1)/3$ that every $(2r+1)$-regular graph with at most $2r-3(k-1)$ cut-edges has a $2k$-factor. The restrictions on k and on the number of cut-edges are sharp. We characterize the graphs with exactly $2r-3(k-1)+1$ cut-edges but no $2k$-factor. For $k > (2r+1)/3$, there are graphs without cut-edges that have no $2k$-factor. (Joint work with Alexandr V. Kostochka, André Raspaud, Bjarne Toft, and Dara Zirlin.)

We determine the maximum guaranteed size of a 2-regular subgraph in a 3-regular n-vertex graph. In particular, we prove that every multigraph with maximum degree 3 and exactly c cut-edges has a 2-regular subgraph that omits at most $\max\{0, \lfloor(3n-2m+c-1)/2\rfloor\}$ vertices. The bound is sharp; we describe the extremal multigraphs. (Joint work with Ilkyoo Choi, Ringi Kim, Alexandr V. Kostochka, and Boram Park.)

Aaron Williams, Williams College / Bard College at Simon's Rock
Plain Change Order for Permutation Patterns: Gray Codes for Catalan Structures, Rectangulations, Quotientopes, and More

Plain change order is an adjacent-transposition Gray code for permutations that dates back to the 17th century. We generalize this order by considering pattern avoiding permutations ordered by jumps. A j ump moves a single value over some number of consecutive and smaller values. For example, in 625314 the value 5 can jump one position to the left, or up to three positions to the right. Equivalently, a jump changes a permutation's inversion table in exactly one position. We provide jump Gray codes for permutations that avoid any pattern whose largest symbol is not in the first or last position. For example, Knuth's stack sortable permutations avoid the pattern 2-3-1, so these permutations have a jump Gray code. Our result also applies to sets of these avoided patterns, such as the separable permutations which avoid $\{2-4-1-3, 3-1-4-2\}$. Vincular patterns only match when certain values in the permutation are adjacent, and this additional restriction is supported so long as the largest value is contained in the forced adjacency. For example, Baxter permutations avoid $\{2-41-3, 3-14-2\}$ and our result holds because the adjacencies 41 and 14 involve the largest value. Our jump Gray codes also provide natural Gray codes for combinatorial objects that are in one-to-one correspondence with these permutations. For example, permutations avoiding 1-3-2 are counted by the Catalan numbers and our order provides minimal change orders for binary trees, triangulations, and Dyck paths. More exotically, Baxter permutations are in correspondence with diagonal rectangulations which tile the square with n rectangles that each intersect with the main diagonal. Our order gives the first Gray code for diagonal rectangulations, as well the first Gray code for generic rectangulations which avoid $\{3-51-2-4, 3-51-4-2, 2-4-51-3, 4-2-51-3\}$. All of these Gray codes are generated with the greedy Gray code algorithm by repeatedly jumping the largest possible value the shortest possible distance starting from $\{12 \ldots n\}$ This generalizes the greedy interpretation of plain change order which repeatedly performs an adjacent-transposition on the largest possible value. Interestingly, the Gray codes that we create are not sublists of plain change order, so they would not have been discovered using the standard sublist approach. Time permitting we will also discuss further extensions of our results (e.g. skeletons of quotientopes).

This is joint work with Elizabeth Hartung (MCLA) and Torsten Mtze (TU Berlin).

Boting Yang, University of Regina
Fast Searching on Complete k-partite Graphs

We give lower bounds and upper bounds on the fast search number of complete k-partite graphs. We also investigate some special classes of complete k-partite graphs, such as complete bipartite graphs and complete split graphs. We solve the open problem of determining the fast search number of complete bipartite graphs, and present upper and lower bounds on the fast search number of complete split graphs.

This is joint work with Yuan Xue, Farong Zhong and Sandra Zilles.