INVITED TALKS

Andrea Burgess
Ryerson University

Generalized Designs, Packings, and Coverings

In 2009, Peter Cameron introduced a common generalization of various classes of combinatorial designs such as balanced incomplete block designs, resolvable designs and orthogonal arrays. Generalized covering and packing designs can be defined in analogous way. These objects bring into this framework further classes of designs, including covering and packing arrays, Howell designs, monogamous cycle decompositions and Kirkman signal sets. In this talk, I will review known results on generalized designs, packings and coverings, and discuss interesting open questions which arise in the search for further examples of optimal generalized packing designs. This talk will include discussions of joint work with Robert Bailey, Michael Cavers, Peter Danziger and Karen Meagher.

Asia Ivić Weiss
York University

Combinatorial Structure of Chiral Polyhedra

Classification of regular polyhedra in euclidean 3-space was initiated by Grnbaum in 1977 and completed by Dress by addition of a single polyhedron in 1985. In 2005 Schulte classified the discrete chiral polyhedra in euclidean 3-space and showed that they belong to six families. The polyhedra in three of the families have finite faces and the other three families consist of polyhedra with (infinite) helical faces. We show that all the chiral polyhedra with finite faces are combinatorially chiral. However, the chiral polyhedra with helical faces are combinatorially regular. Moreover, any two such polyhedra with helical faces in the same family are isomorphic.

This is a joint work with Daniel Pellicer.

Karen Meagher
University of Regina

Erdös-Ko-Rado Theorem for Permutations

Two permutations in the symmetric group on n vertices can be considered to be "intersecting" if they both map some $i \in \{1, ..., n\}$ to the same element (we say the permutations agree on i). With this definition, what is the largest set of permutations such that any two are intersecting? In the last 10 years, several different proofs have been published that show that the largest such set is either the stabilizer of a point or a coset of the stabilizer of a point. This result is known as the EKR theorem for permutations.

There are several questions that are natural to ask once this result is established. For example what is the largest set of permutations that agree on a set of t elements? There are other ways to define intersection for permutations, does an EKR type result hold for these as well? What is the largest set of intersecting permutations in a subgroup of the symmetric group? I will present some new results by various researchers on these questions.

Bruce Reed
McGill University

How Long Does It Take to Catch a Drunk Miscreant?

We discuss the answer to a question of Churchley who asked how long it will take a cop to catch a drunk robber who moves randomly. We begin by discussing other variants of the cop-robber paradigm. This is joint work with Alex Scott, Colin McDiarmid, and Ross Kang. We rely heavily on work of Komarov and Winkler.

Wenan Zang
University of Hong Kong

When is the Matching Polytope Box-Totally Dual Integral?

Let $G = (V, E)$ be a graph. The *matching polytope* of G, denoted by $P(G)$, is the convex hull of the incidence vectors of all matchings in G. As shown by Edmonds, $P(G)$ is determined by the following linear system $\pi(G)$:

- $x_e \geq 0$ for each $e \in E$;

- $x(\delta(v)) \leq 1$ for each $v \in V$;
- $x(E[U]) \leq \lfloor \frac{1}{2}|U| \rfloor$ for each $U \subseteq V$ with $|U|$ odd.

Cunningham and Marsh strengthened this theorem by showing that $\pi(G)$ is always totally dual integral. In 1984, Edmonds and Giles initiated the study of all graphs G for which $\pi(G)$ is box-totally dual integral. The purpose of this talk is to present a structural characterization of all such graphs. (Joint work with Guoli Ding and Lei Tan.)

Bei Zeng
Guelph University

Symmetries of Codeword Stabilized Quantum Codes

Symmetry is at the heart of coding theory. Codes with symmetry, especially cyclic codes, play an essential role in both theory and practical applications of classical error-correcting codes. Here we examine symmetry properties for codeword stabilized (CWS) quantum codes, which is the most general framework for constructing quantum error-correcting codes known to date. A CWS code Q can be represented by a self-dual additive code S and a classical code C, i.e., Q=(S,C), however this representation is in general not unique. We show that for any CWS code Q with certain permutation symmetry, one can always find a S with the same permutation symmetry as Q such that Q=(S,C). As many good CWS codes have been found by starting from a chosen S, this ensures that when trying to find CWS codes with certain permutation symmetry, the choice of S with the same symmetry will suffice. A key step for this result is a new canonical representation for CWS codes, which is in terms of a unique decomposition as union stabilizer codes. For CWS codes, so far mainly the standard form (G,C) has been considered, where G is a graph state. We analyze the symmetry of the corresponding graph of G, which in general cannot possess the same permutation symmetry as Q. We show that it is indeed the case for toric code on a square lattice with translational symmetry, even if its encoding graph can be chosen to be translational invariant.

CONTRIBUTED TALKS

Behrooz Bagheri Ghavam Abadi
Université de Montréal

On the Oriented Perfect Path Double Cover Conjecture

An oriented perfect path double cover (OPPDC) of a graph G is a collection of directed paths in the symmetric orientation G_s of G such that each edge of G_s lies in exactly one of the paths and each vertex of G appears just once as a beginning and just once as an end of a path. Maxová and Nešetřil (Discrete Math. 276 (2004) 287-294) conjectured that every graph except two complete graphs K_3 and K_5 has an OPPDC and they proved that the minimum degree of the minimal counterexample to this conjecture is at least four. In this talk, among some other results, we show that the minimal counterexample to this conjecture is 2-connected and 3-edge-connected. Finally, we state the relation between OPPDC and the oriented cycle double cover of simple graphs and some results.

Joint work with Behnaz Omoomi.

Amin Bahmanian
University of Ottawa

Embedding Factorizations in Hypergraphs

A *hypergraph* $\mathcal{G}$ is a pair (V, E) where V is a finite set called the *vertex* set, and E is the *edge* set, where every edge is a subset of V. The *degree* of a vertex is the number of edges containing that vertex. A *k-edge-coloring* of $\mathcal{G}$ is a mapping $f : E \to C$, where C is a set of k *colors*, and the edges of one color form a *color class*. An *r-factor* $\mathcal{H}$ of $\mathcal{G}$ is composed of all the vertices and some (or perhaps all) of the edges of $\mathcal{G}$ so that each vertex in $\mathcal{H}$ is of degree r.

Let $[m] = \{1, \dots, m\}$, and let $K_m^h = ([m], \binom{[m]}{h})$ ($\binom{[m]}{h}$ is the collection of all h-subsets of $[m]$). Given a k-edge-coloring of K_m^h, we discuss the conditions under which this coloring can be extended to a coloring of K_n^h (for $n \geq m$) so that each color class in K_n^h is an r-factor.

Robert Bailey
Ryerson University

Metric dimension of Imprimitive Distance-Regular Graphs

A *resolving set* for a graph Γ is a collection of vertices S, chosen so that for each vertex v, the list of distances from v to the members of S uniquely specifies v. The *metric dimension* of Γ is the smallest size of a resolving set for Γ.

A graph is *distance-regular* if, for any two vertices u, v at each distance i, the number of neighbours of v at each possible distance from u (i.e. $i-1$, i or $i+1$) depends only on the distance i, and not on the choice of vertices u, v. Distance-regular graphs are a natural class to study the metric dimension, and over recent years many papers have appeared on this subject, by the speaker and others.

In this talk, we will consider certain classes of so-called imprimitive distance-regular graphs, including bipartite doubles and Taylor graphs.

Deepak Bal
Carnegie Mellon University

The 2-Tone Chromatic Number of Random Graphs

Label each vertex of a graph with a pair of colors from the set $\{1, 2, ..., k\}$ such that any two adjacent vertices receive disjoint labels and any two vertices distance 2 apart receive distinct labels. This is known as a proper 2-tone coloring, and the smallest k which admits a proper 2-tone coloring is called the 2-tone chromatic number. In this talk I will describe an analysis of this property on the binomial random graph, $G(n, p)$. This is joint work with Patrick Bennett, Andrzej Dudek, and Alan Frieze.

Mohammad Bardestani
Université de Montréal

Product-Free Sets

Gowers in his paper on quasirandom groups studies a question of Babai and Sos asking whether there exists a constant $c > 0$ such that every finite group G has a product-free subset of size at least $c|G|$. We will consider the problem for compact groups. This is joint work with Keivan Mallahi-Karai.

Nevena Francetić
Carleton University

Group Divisible Packing Designs with Block Size 3: Relationship to Coverings

Group divisible designs (GDDs) are essential for constructions in the combinatorial design theory. A uniform GDD consists of a triple $(V, \mathcal{G}, B)$, where $\mathcal{G}$ is a partition of the set of elements, V, into groups of equal size, and B is a collection of subsets of V, called blocks, such that any pair of elements of V belonging to two distinct groups is contained in exactly one block. GDDs can be generalized into packings (GDPDs) and coverings (GDCDs) if we allow a pair of elements belonging to two distinct groups to be contained in at most or at least one block, respectively. Next, we can represent GDPDs and GDCDs in a form of an array to obtain packing and covering arrays with row limit, a generalization of packing and covering arrays.

In this talk, we consider two bounds on the size of GDCDs and GDPDs. Then we develop constructions of optimal GDCDs with block size three which can be transformed into optimal GDPDs in the least possible number of steps: delete the blocks contributing to the excess coverage and if necessary, add a number of new blocks to obtain a maximal packing.

Jing (Jane) He
Carleton University

The Linear Complexity Profile and Correlation Measure of Order k of a Family of Interleaved Sequences

Families of pseudorandom sequences with low cross correlation have important applications in communications and cryptography. Among several known constructions, interleaved construction is a well-known method proposed by Gong that uses two sequences of the same period. The constructed sequences possess nice cryptographic properties. The interleaving framework can be used to generate many types of sequence families.

In this talk, we first review Legendre symbols, the notions of period of a sequence, linear complexity and correlation measures. The we interleave two Legendre sequences of odd prime periods p and q. We provide nontrivial upper bounds on the linear complexity profile for any periods p and q, and on the correlation measures of order k when k is in a specific range.

Joint with D. Panario, Q. Wang and A. Winterhof.

Victoria E. Horan
Air Force Research Laboratory, Rome, New York

Overlap Cycles

Universal cycles and Gray codes are examples of listing elements of a combinatorial family in a specific manner, and overlap cycles were invented as a generalization of these in 2010. An s-overlap cycle orders a set of strings so that the last s letters of one string are the first s letters of the next (in order). Many combinatorial objects, such as permutations, do not lend themselves immediately to the universal cycle structure. In this talk we will discuss recent results over various types of objects such as k-permutations and Steiner triple systems. This is joint work with Glenn Hurlbert.

Nathaniel Johnston
University of Waterloo

Non-Uniqueness of Minimal Superpermutations

We examine the open problem of finding the shortest string that contains each of the $n!$ permutations of n symbols as contiguous substrings (i.e., the shortest superpermutation on n symbols). It has been conjectured that the shortest superpermutation has length $1!+2!+3!+...+n!$ and that this string is unique up to relabelling of the symbols. We provide a construction of short superpermutations that shows that, if the conjectured minimal length is true, then uniqueness fails for all $n >= 5$. Furthermore, uniqueness fails spectacularly; we construct more than doubly-exponentially many distinct superpermutations of the conjectured minimal length.

Rohan Kapadia
University of Waterloo

Modularity and Matroid Representation

Among the most important classes of matroids are binary matroids and graphic matroids. Two remarkable theorems of Seymour show that when a matroid has a certain small restriction of one of these two types, then either its binary or graphic structure extends to the whole matroid or there is an obvious obstruction. In this talk I discuss extensions of these results from the case of binary matroids to matroids representable over an arbitrary finite field. For example, when a matroid has a small restriction N with a property called modularity, then we can extend any representation of N over a finite field to a representation of the whole matroid (assuming sufficient connectivity).

This is joint work with Jim Geelen.

Nishad Kothari
University of Waterloo

Characterizing Prism-Free Planar Bricks

A 3-connected graph G is called a brick if for any two vertices u and v, $G - \{u, v\}$ has a perfect matching. Lovász showed that any brick contains either K_4 or the prism $\overline{C_6}$ as a conformal minor. A prism-free brick means a brick which does not contain the prism as a conformal minor. We show that the only prism-free planar bricks are the odd wheels, odd staircases and an exceptional graph on ten vertices. This implies a result of Carvalho, Lucchesi and Murty: odd wheels are the only solid planar bricks. Our characterization extends to prism-free planar matching covered graphs. (This is joint work with Joseph Cheriyan and U.S.R. Murty.)

Babak Moazzez
Carleton University

Sensitivity Analysis in Mixed Integer Programming
From Branch and Bound to Cutting Plane Algorithm

Mixed Integer Linear Programming has been one of the most useful tools in science and industry for few decades now. Many real world problems can be modeled and solved efficiently using MILP. After solving an instance, in order to make sure that we have solved the problem correctly and our solution is actually optimal, we need need a certificate for the optimal solution. Also, if our input data change after solving the problem, we have to use sensitivity analysis tools to avoid solving the problem from beginning since it is very expensive.

Having an MILP and its optimal solution in hand, generating a certificate using the branch and bound tree has been the main goal of our research. We have done this using disjunctive programming and split inequalities and polyhedral study for MILPs and corresponding valid inequalities. The certificate we generate is a (subadditive) dual vector which will give us the optimal value using subadditive generator functions. This system works in a similar way to linear programming duality and many of the results in LP duality can be extended to MILP using this method.

Hao Shen
Shanghai Jiao Tong University

Resolvable Designs and (k, r)-Colorings of Complete Graphs

A (k, r)-coloring of a complete graph K is a coloring of the edges of K with r colors such that all monochromatic connected subgraphs have at most k vertices. The Ramsey number $f(k, r)$ is defined to be the smallest u such that K_u does not admit a (k, r)- coloring. In this talk, we introduce applications of resolvable group divisible designs in determining the Ramsey $f(k, r)$ and give some new results.

Christino Tamon
Clarkson University

Which Exterior Powers are Balanced?

Given a graph $G = (V, E)$ on n vertices and a total ordering on the vertex set V, let $Q(V, k)$ be the collection of k-ordered subsets of V. The exterior k-th power of G has as its vertex set $Q(V, k)$ and its edges defined as follows. Two elements X and Y of $Q(V, k)$ are adjacent if there is a permutation T on k elements for which $T(X)$ and Y agree on all but one position, and in that one position the corresponding elements of $T(X)$ and Y are adjacent vertices in G. The sign of this edge (X, Y) is the sign of the permutation T. This definition extends in a natural way to when G is a signed graph whose edges are $(-1, +1)$-valued. The signless version of the exterior power had been studied earlier in the context of n-tuple vertex graphs (Zhu et al, 1992) and symmetric powers of graphs (Audenaert et al, 2007). A signed graph is called balanced if there is a bipartition of its vertex set so that the negative edges are precisely the ones crossing the partition. We characterize signed graphs whose exterior powers are balanced.

This is based on joint work with D. Mallory, A. Raz and T. Zaslavsky.

Andrew Wagner
University of Ottawa

Finding a Second Hamilton Cycle: The Missing Link

A uniquely hamiltonian graph is one that admits exactly one Hamilton cycle. In 1946, Smith proved that there are no 3-regular uniquely hamiltonian graphs, which result was extended by Thomason in 1978 to all regular graphs of odd degree. A conjecture made by Sheehan in 1975 suggests that there are no 4-regular uniquely hamiltonian graphs. If the conjecture is true, it can be extended to all regular graphs of even degree, which will mean that there are no non-trivial uniquely hamiltonian regular graphs.

In this talk, we will explore the techniques used to achieve the best known results. We also give a sufficient condition for finding a second Hamilton cycle in regular graphs whose degree is as small as 4.

Timothy R. Walsh
UQAM

Generating Nonisomorphic Maps and Hypermaps Without Storing Them

In 1979, while working as a senior researcher in the Computing Centre of the USSR Academy of Sciences in Moscow, I used A.B. Lehman's code for rooted maps of any orientable genus to generate these maps. By imposing an order on the code-words and keeping only those that are maximal over all the words that code the same map with each semi-edge chosen as the root, I generated these maps up to orientation-preserving isomorphism, and by comparing each of them with the code-words for the map obtained by reversing the orientation, I generated these maps up to a generalized isomorphism that could be orientation-preserving or orientation-reversing. The limitations on the speed of the computer I was using and the time allowed for a run restricted me to generating these maps with up to only six edges. In 2011, by optimizing the algorithms and using a more powerful computer and more CPU time I was able to generate these maps with up to eleven edges. An average-case time-complexity analysis of the generation algorithms is included. And now, by using a genus-preserving bijection between hypermaps and bicoloured bipartite maps that I discovered in 1975 and the condition on the word coding a rooted map for the map to be bipartite, I generated hypermaps, both rooted and unrooted, with up to twelve darts.