Friday, April 6th

John Chiarelli (Rutgers University) **FO 2.208, 5:00PM**

A Tight Bound on the Number of Relevant Vars in a Low Degree Boolean Function

Abstract. The degree of the polynomial representation of a Boolean function is an important measure of sensitivity for such a function. It is possible to construct functions with $2n$ relevant variables that have degree equal to n. In this talk, I will show that the maximum number of relevant variables a Boolean function of degree n can have is $C \cdot 2n$, where C is a constant.

Ezgi Kantarci Oguz (University of Southern California) **FO 2.702, 5:00pm**

A queer crystal structure on shifted tableaux

Abstract. We define queer crystal operators to construct a connected queer crystal on semistandard shifted tableaux of a given shape, providing a new proof that Schur P-polynomials are Schur positive. We also give local axioms for queer regular graphs generalizing Stembridge's axioms that we conjecture characterize queer crystals.

Shuai Shao (University of Wisconsin–Madison) **FO 2.208, 5:30pm**

A Complexity Trichotomy for the Six-Vertex Model

Abstract. We prove a complexity classification theorem that divides the six-vertex model on graphs into exactly three types. For every setting of the parameters of the model, the computation of the partition function is precisely: Either (1) solvable in polynomial time for every graph, or (2) #P-hard for general graphs but solvable in polynomial time for planar graphs, or (3) #P-hard even for planar graphs. The classification has an explicit criterion.

Roger Fidele Ranomenjanahary (UT Dallas) **FO 2.702, 5:30pm**

Confocal IC-nets in the plane

Abstract. We are going to talk about confocal IC-nets in the plane (see [1]) and their geometric and combinatorial properties . These are congruence of straight lines in the plane with the combinatorics of a square grid, with an additional property: every elementary quadrilateral possesses an inscribed circle. After [2], we consider a confocal family of conics and billiards generated by these conics as boundaries. We are going to show that a confocal IC-net can be constructed by using two different billiard trajectories within the same boundary and with the same caustic. They are winding either in the same direction or in the opposite directions. Then we show how to get a checkerboard IC-net from the confocal IC-net.

Xi Chen (Middle Tennessee State University) **FO 2.208, 6:00pm**

Resonant patterns in hexagonal systems

Abstract. A hexagonal system is a finite 2-connected plane bipartite graph in which every interior face is bounded by a regular hexagon. A hexagonal system is called cata-condensed if it is outer planar. A perfect matching is a set of independent edges which cover every vertex exactly once. A set of disjoint hexagons S of a hexagonal system H is a resonant set if the subgraph obtained from H by deleting all vertices of hexagons in S has a perfect matching. The resonant set is forcing if the subgraph has a unique perfect matching. The forcing resonance polynomial of H can be used to enumerate the number of forcing resonant sets, which is defined as $f(x) = \sum_{i=0}^{cl(H)} a_i x^i$ where a_i is the number of distinct forcing resonant set of size i and $cl(H)$ is the Clar number of H. The coefficient vector of the resonance polynomial of a hexagonal system has physical meaning in terms of its resonance energy. In this talk, we focus on resonant sets in hexagonal system and how to compute the forcing resonance polynomial of cata-condensed hexagonal system G.

Ching Wong (University of British Columbia) **FO 2.702, 6:00pm**

An application of kissing numbers in sum-product estimates

Abstract. Erdős and Szemerédi conjectured in 1983 that no finite subset of the reals can have good structures in both addition and multiplication. More precisely, they conjectured that for every finite set A of real numbers having large enough cardinality,

$$\max(|A+A|, |AA|) \geq |A|^{2-\varepsilon},$$

holds, where $\varepsilon \to 0$. Here,

$$A + A = \{a + b : a, b \in A\} \qquad \text{and} \qquad AA = \{ab : a, b \in A\}$$

are called the sumset and productset of A, respectively. The conjecture is far from being settled and the best current bound is given by Rudnev, Shkredov and Stevens:

$$\max(|A+A|, |AA|) \gg |A|^{4/3+1/1509}.$$

We use a tool from convex geometry, namely the boundedness of the kissing numbers of convex bodies, to prove the sum-product estimate

$$\max(|A+A|, |AA|) \gg \frac{|A|^{4/3}}{\log |A|^{1/3}}$$

for finite sets A of quaternions and of a certain family of well-conditioned matrices. This is a joint work with József Solymosi.

Saturday, April 7th

Dr. Karola Mészáros (Cornell) — SLC 1.102, 8:00am

Flow polytopes in combinatorics and algebra

Abstract. The flow polytope $\mathcal{F}_G(bfv)$ is associated to a graph G on the vertex set $\{1, \ldots, n\}$ with edges directed from smaller to larger vertices and a netflow vector $\mathbf{v} = (v_1, \ldots, v_n) \in \mathbb{Z}^{\times}$. The points of $\mathcal{F}_G(bfv)$ are non-negative flows on the edges of G so that flow is conserved at each vertex. Postnikov and Stanley established a remarkable connection of flow polytopes and Kostant partition functions two decades ago, developed further by Baldoni and Vergne. Since then, flow polytopes have been discovered in the context of Schubert and Grothendieck polynomials and the space of diagonal harmonics, among others. This talk will survey a selection of results about the ubiquitous flow polytopes.

Sunita Chepuri (University of Minnesota) — FO 1.202, 9:30am

Plabic Networks on a Cylinder

Abstract. We discuss the inverse boundary problem for planar directed networks on a cylinder. In particular, we introduce a family of graphs on a cylinder and examine a semi-local transformation on weights for these graphs that preserves boundary measurements. If time allows, we will discuss an underlying cluster algebra structure for this transformation.

Corey Vorland (North Dakota State University) — FO 2.208, 9:30am

Toward toggling on monomial ideals

Abstract. The actions of rowmotion and promotion on order ideals of a finite poset have been studied using local actions called toggles. This perspective gave insight on the orbit structure of these actions for certain finite posets. We extend these toggle actions by defining rowmotion and promotion on order ideals of an infinite poset. We explore preliminary results, including a bijection to boundary paths for the poset $\mathbb{N}^2$. From this, we determine how rowmotion and promotion affects the number of minimal generators of a corresponding monomial ideal in $k[x, y]$.

Karthik Chandrasekhar (University of Kentucky) — FO 2.702, 9:30am

"Arranging" a Converse for the Euler Relation

Abstract. We are all aware that any CW-complex X satisfies the Euler relation

$$\sum_{i=0}^{d}(-1)^i f_i = \chi(X)$$

where $\chi(X)$ is the Euler characteristic of X and d is its dimension. For a certain subclass of cellular decompositions (in this talk $d = 2$ and X is an orientable 2-manifold) we ask:

Which 3-tuples (f_0, f_1, f_2) occur as numbers of 0-,1- and 2-cells in a cell decomposition of a given topological space X?

For this talk the subclass will be that of *line arrangements* - a collection of 1-dimensional sub-manifolds of a 2-dimensional manifold. This stratifies the space into 0-,1- and 2-dimensional components. We consider only those arrangements in which the stratification is cellular. In particular, this talk addresses arrangements of geodesic lines on the torus $S^1 \times S^1$. A complete characterization answering the question asked will be discussed in this talk. I have gone on to address the same question for the hyperbolic plane. The talk ends with a note on prospects of answering the concerned question on surfaces of genus g as also on some of the work that has been done in certain higher-dimensional tori.

Songpon Sriwongsa (Wisconsin–Milwaukee) — FO 1.502, 9:30am

Orthogonal graphs modulo power of 2

Abstract. In this work, we define an orthogonal graph on the set of equivalence classes of $(2\nu+\delta)-$tuples over $\mathbb{Z}_{2^n}$ where n and ν are positive integers and $\delta = 0, 1$ or 2. We classify our graph if it is strongly regular or quasi-strongly regular and compute all parameters precisely. We show that our graph is arc transitive. The automorphisms group is given and the chromatic number of the graph except when $\delta = 0$ and ν is odd is determined. Moreover, we work on subconstituents of this orthogonal graph.

George Wang (University of Pennsylvania) — FO 1.202, 10:00am

On the Schur expansion of Jack polynomials

Abstract. It is well known that Jack polynomials are not Schur positive in the standard basis, however, perhaps there is hope in other bases. In this work, we explore the Schur expansion of Jack polynomials under two binomial coefficient bases, and discover some surprising combinatorics that emerge.

Angelica Castillo (UT Rio Grande Valley) — FO 2.208, 10:00am

Extending a known result on first differences of partitions of n into at most 4 parts into partitions of n into at most 4 parts no part bigger than N

ABSTRACT. The coefficients of Gaussian polynomials are also known as partitions of n into at most m parts, no part larger than N and are denoted by $p(n, m, N)$ with $p(n, m)$ denoting partitions of n into at most m parts. In this talk we prove the following result on first differences of a certain family of these partitions:

Theorem. *For $a < \frac{2N-9}{12}$ we have*

$$p(2a-3, 4, N) - p(2a-4, 4, N-1) = p(a-3, 3)$$

and

$$p(2a-4, 4, N) - p(2a-5, 4, N-1) = p(a-2, 3).$$

Our proof comes from a novel manipulation of q-series informed by the polyhedral geometry of Ehrhart. This extends a known result on partitions of n into at most 4 parts.

Keith Frankston (Rutgers University) — FO 2.702, 10:00am

On regular 3-wise intersecting families

ABSTRACT. Ellis and Narayanan showed, verifying a conjecture of Frankl, that any 3-wise intersecting family of subsets of $\{1, 2, \ldots, n\}$ admitting a transitive automorphism group has cardinality $o(2^n)$, while a construction of Frankl demonstrates that the same conclusion need not hold under the weaker constraint of being regular. Answering a question of Cameron, Frankl and Kantor from 1989, we show that the restriction of admitting a transitive automorphism group may be relaxed significantly: we prove that any 3-wise intersecting family of subsets of $\{1, 2, \ldots, n\}$ that is regular and increasing has cardinality $o(2^n)$.

Jingmei Zhang (University of Central Florida) — FO 1.502, 10:00am

Gallai-Ramsey numbers of C10 and paths of order at most 11

ABSTRACT. A *Gallai coloring* is a coloring of the edges of a complete graph without rainbow triangles. Given an integer $k \geq 1$ and graphs $H_1, H_2, \ldots, H_k$, the Gallai-Ramsey number $GR(H_1, H_2, \ldots, H_k)$ is the least integer n such that every Gallai coloring of the complete graph K_n with k colors contains a monochromatic copy of H_i in color i for some $i \in \{1, 2, \ldots, k\}$. When $H = H_1 = \cdots = H_k$, we simply write $GR_k(H)$. We study Gallai-Ramsey numbers of even cycles and paths. For all $n \geq 3$ and $k \geq 1$, let $G_i = P_{2i+3}$ be a path on $2i+3$ vertices for all $i \in \{0, 1, \ldots, n-2\}$ and $G_{n-1} \in \{C_{2n}, P_{2n+1}\}$. Let $i_j \in \{0, 1, \ldots, n-1\}$ for all $j \in \{1, 2, \ldots, k\}$ with $i_1 \geq i_2 \geq \cdots \geq i_k$. Song recently conjectured that $GR(G_{i_1}, G_{i_2}, \ldots, G_{i_k}) = 3 + \min\{i_1, n^*-2\} + \sum_{j=1}^{k} i_j$, where $n^* = n$ when $G_{i_1} \neq P_{2n+1}$ and $n^* = n+1$ when $G_{i_1} = P_{2n+1}$. The truth of this conjecture implies that $GR_k(C_{2n}) = GR_k(P_{2n}) = (n-1)k + n + 1$ for all $n \geq 3$ and $k \geq 1$, and $GR_k(P_{2n+1}) = (n-1)k + n + 2$ for all $n \geq 1$ and $k \geq 1$. In this talk, I will present that the aforementioned conjecture holds for $n \in \{3, 4, 5\}$ and all $k \geq 1$. Our proof relies only on Gallai's result and the classical Ramsey numbers $R(H_1, H_2)$, where $H_1, H_2 \in \{C_{10}, C_8, C_6, P_9, P_7, P_5, P_3\}$. We believe the recoloring method we developed here will be very useful for solving subsequent cases, and perhaps the conjecture.

Pauline Hubert (Université du Québec à Montréal) — FO 1.202, 10:30am

$GL_k \times S_n$ action on multivariate polynomials

ABSTRACT. Let W be a module over $\mathbb{Q}[X]$, with X representing n sets of k variables, generated by a symmetric polynomial in the variables of X and some derivative operators. The aim is to describe the action of GL_k and S_n on W. We will talk about why these modules are interesting and how we construct them. Then, we act simultaneously on W with GL_k nd S_n and we compute the irreducible characters of this double action.

Acadia Larsen (UT Rio Grande Valley) — FO 2.208, 10:30am

A generalization of partition identities for first differences of partitions n into at most m parts

ABSTRACT. Partitions of a non-negative integer n into at most m parts is the number of non-increasing positive integer sequences with at most m terms that sum to n, denoted $p(n, m)$. We show a certain family of number of parts m that first differences of partitions into at most m parts can be expressed as non-negative linear combination of partitions into at most $m-1$ parts. To show this relationship, we combine a quasipolynomial construction of $p(n, m)$ with a new partition identity of a finite number of parts. Furthermore, we extend these identities to partitions generated by Gaussian polynomials.

Filip Jevtic (University of Texas at Dallas) — FO 2.702, 10:30am

Combinatorial Structure of Finite Metric Spaces

ABSTRACT. Each finite metric space (X, ρ) is associated a *fundamental polytope* $KR(\rho)$ (Kantorovich-Rubinstein polytope) spanned by $e_{x,y} = \frac{e_x - e_y}{\rho(x,y)}$ where $\{e_x\}_{x \in X}$ is the canonical basis in $\mathbb{R}^X$. The combinatorial structure of (X, ρ) is defined as the combinatorial structure of its associated Kantorovich-Rubinstein polytope. We present some recent results related to the combinatorial structure of finite metric spaces. We show that the cyclohedron (Bott-Taubes polytope) W_n arises as the dual of a Kantorovich-Rubinstein polytope $KR(\rho)$, where ρ is a quasi-metric (asymmetric distance function) satisfying strict triangle inequality. From a broader perspective, this phenomenon illustrates the relationship between a nestohedron $\Delta_{\widehat{\mathcal{F}}}$ (associated to a building set $\widehat{\mathcal{F}}$) and its non-simple deformation $\Delta_{\mathcal{F}}$, where $\mathcal{F}$ is an *irredundant* or *tight basis* of $\widehat{\mathcal{F}}$. Among the consequences are a new proof of a recent result of Gordon and Petrov about f-vectors of generic Kantorovich-Rubinstein polytopes, and an extension of a theorem of Gelfand, Graev, and Postnikov, about triangulations of the type A, positive root polytopes.

Christian Bosse (University of Central Florida) **FO 1.502, 10:30am**

Gallai-Ramsey Numbers of C9, C11, C13, and C15

ABSTRACT. A Gallai-coloring of a complete graph is an edge-coloring such that no triangle is colored with three distinct colors. We study Ramsey-type problems in Gallai-colorings. Given a graph G and an integer $k \geq 1$, the Gallai-Ramsey number $GR_k(G)$ is the least positive integer n such that every Gallai-coloring of K_n with k colors contains a monochromatic copy of G. It turns out that $GR_k(G)$ behaves more nicely than the classical Ramsey number $R_k(G)$. However, finding exact values of $GR_k(G)$ is far from trivial. In this talk, I will present our recent results on Gallai-Ramsey numbers of odd cycles. We prove that $GR_k(C_{2n+1}) = n \cdot 2^k + 1$ for $n \in \{4,5,6,7\}$ and all integers $k \geq 1$. This provides partial evidence for the first four open cases of the Triple Odd Cycle Conjecture of Bondy and Erdős from 1973. We believe the method we developed can be used to determine the exact values of $GR_k(C_{2n+1})$ for odd integers $n \geq 8$.

Dr. Fan Chung (University of California, San Diego) SLC 1.102, 11:10am

Can you hear the shape of a network? — New directions in spectral graph theory

ABSTRACT. We will discuss some recent developments in several new directions of spectral graph theory and mention a number of related problems.

Brian Davis (University of Kentucky) **FO 1.202, 2:00pm**

Infinite Free Resolutions

ABSTRACT. Minimal free resolutions of the kinds of ideals that arise in combinatorics are typically an algebraic version of inclusion/exclusion, and terminate after a finite number of steps. There are contexts in which minimal free resolutions have infinite length; what happens when inclusion/exclusion goes on forever?

Westin King (Texas A&M) **FO 2.208, 2:00pm**

Counting Prime Parking Functions on Rooted Trees

ABSTRACT. A parking function is a sequence $s \in [n]^n$ such that for any $i \in [n]$, we have $|\{j : s_j \leq i\}| \geq i$. This has a "physical" interpretation of drivers, preferring spaces s_i, seeking to park in a linear lot. If the spot they desire is taken, they continue on and park in the first available spot. The preference sequences s that result in all drivers parking are precisely the parking functions. In this talk, I discuss the notion of *prime* parking functions and generalize them to trees with edges oriented towards a root. I then give a bijective argument proving the total number of prime parking functions on trees with n vertices is $(2n-2)!$.

Joseph Doolittle (University of Kansas) **FO 2.702, 2:00pm**

Partition Extenders

ABSTRACT. In joint work with Bennet Goeckner and Alex Lazar, we define partition extenders for a simplicial complex. In this talk we will show that they exist for all complexes, can be made pure for pure complexes and provide a combinatorial interpretation of the h-vector of a simplical complex. We also provide some bounds on the size of a partition extender, and explain some barriers to minimality.

Esmaeil Parsa (University of Montana) **FO 1.502, 2:00pm**

On uniquely D-colorable digraphs

ABSTRACT. The notion of uniquely D-colorable digraphs is defined in two different ways, either in terms of automorphisms or by vertex partitions which are not necessarily equivalent for all D. In this research we show that these two diffinitions are not always identical as study conditions under which they are identical.

Daniël Kroes (University of California San Diego) **FO 1.202, 2:30pm**

Generalized coinvariant algebras in the Stanley Reisner setting

ABSTRACT. The coinvariant algebra R_n is a well studied algebraic object attached to the symmetric group S_n. It is the quotient of $\mathbb{Q}[x_1, \ldots, x_n]$ by the ideal generated by symmetric functions with zero constant term. Its behaviour as a $\mathbb{Q}$-vector space is related to various permutation statistics and as an S_n-module it is isomorphic to the regular representation of S_n. Garsia showed that R_n can also be defined as a quotient of the Stanley Reisner ring of the Boolean algebra, which is a quotient of the polynomial ring in 2^n variables. Recently, Haglund, Rhoades and Shimozono defined a 2 parameter generalization $R_{n,k}$ whose behaviour is controlled by ordered set partitions. In this talk we will show how to obtain the analogue of $R_{n,k}$ in the Stanley Reisner setting.

Swee Hong Chan (Cornell) **FO 2.208, 2:30pm**

Necklaces and subset-sums: How can they be related?

ABSTRACT. It was shown in Stanley's EC1 (by counting both objects) that (1) necklaces of length n with two colors, and (2) subsets of $\mathbb{Z}_n$ with zero subset-sum, have the same cardinality. An explicit bijection between these two seemingly unrelated objects was posed as an open problem in EC1. In this talk, I will present a bijection between (1) and (2) by viewing necklaces as cyclic polynomials over $\mathbb{F}_2$, answering this problem.

Bennet Goeckner (University of Kansas) **FO 2.702, 2:30pm**

Decomposing k-fold acyclic complexes

ABSTRACT. In 1993, Stanley showed that if a simplicial complex Δ is acyclic over some field, then there exists a perfect matching between a subcomplex Δ' and the remaining faces of Δ. This led Stanley to conjecture that complexes with certain acyclic subcomplexes (we will call these complexes k-fold acyclic) have an even stronger decomposition into boolean intervals. We will show that a relaxation of Stanley's conjecture is true and show that it holds in some special cases. We will also outline a technique that may produce a counterexample to Stanley's original conjecture.

Abigail Raz (Rutgers University) **FO 1.502, 2:30pm**

What do the largest subgraphs of $G_{n,p}$ with a given matching number look like?

ABSTRACT. There are many statements across math of the form "a structure with property X must have one of the following forms." In 1959 Erdos and Gallai showed that every largest subgraph with matching number k of K_n must have one of two basic forms (here largest refers to the number of edges). We will discuss how this result extends to the random graph for sufficiently large p.

Alexander Heaton (Wisconsin–Milwaukee) **FO 1.202, 3:00pm**

Graded Multiplicity in Harmonic Polynomials from the Vinberg Setting

ABSTRACT. We consider a family of examples falling into the following context: Let G be a connected reductive algebraic group over the complex numbers. A subgroup, K, of fixed points of a finite-order automorphism acts on the Lie algebra of G. Each eigenspace of the automorphism is a representation of K. Let V be one of the eigenspaces. We consider the harmonic polynomials on V as a representation of K, which is graded by homogeneous degree. Given any irreducible representation of K, we will see how its multiplicity in the harmonic polynomials is distributed among the various graded components. The results have a satisfying description in terms of counting integral points in a polytope. Then, the graded multiplicity is given by the intersections of the polytope with an expanding sequence of "shells."

Ayomikun Adeniran (Texas A&M) **FO 2.208, 3:00pm**

Gončarov Polynomials in Exponential Families

ABSTRACT. R. Lorentz, S. Tringali and C. Yan introduced the sequence of generalized Goncarov Polynomials $\mathcal{T} = \{t_n(x, \delta, Z)\}_{n\geq 0}$, which is a basis for the solutions to the Generalized Goncarov Interpolation Problem with respect to a delta operator. In the same paper, they showed that the $\{t_n(x, \delta, Z)\}_{n\geq 0}$ satisfy the recursion $p_n(x) = \sum_{i=0}^{n} \binom{n}{i} p_{n-i}(z_i)t_i(x)$, where the polynomial sequence $\{p_n(x)\}_{n\geq 0}$ are polynomials of binomial type that count Reluctant Functions. We introduce a more general family of polynomial sequences $\{t_n(x; \mathcal{B}; Z)\}_{n\geq 0}$ associated to the enumeration of Exponential Families $\mathcal{B}$. Then, we prove that such polynomial sequences provide an algebraic tool for counting combinatorial structures with linear constraints on their order statistics.

Chase Meadors (Oklahoma State University) **FO 2.702, 3:00pm**

A Generalization of Transitivity to Directed Hypergraphs and their Connection to Shellable Complexes and Cohen-Macaulay Monomial Ideals

ABSTRACT. We generalize results from Herzog and Hibi, Carra'ferro and Farrarello that concern a method for associating an undirected graph to a directed graph, and studying the edge ideal of the undirected graph in terms of properties of the original directed graph. In particular, said edge ideal is Cohen-Macaulay if and only if the original directed graph is transitive. We generalize the "if" direction of this theorem to directed hypergraphs and find that, for a suitably-chosen generalization of transitivity, the result still holds. Though the generalized theorem is straightforward, the machinery of the proof requires entirely different techniques, and reveals some interesting connections with shellable simplicial complexes arising from posets.

Jiapeng Zhang (University of California San Diego) **FO 1.502, 3:00pm**

Sunflowers and Quasi-sunflowers from Extractors

ABSTRACT. The structure of sunflower (and quasi-sunflower) has been extensively studied in combinatorics, and they have a lot of applications in theoretical computer science. However the famous sunflower conjecture has been opened for 40 years. In this work, we study a new framework to show the existence of sunflower and also quasi-sunflower. Our approach makes the connections from the extractor theory, which is also a well-studied topic in theoretical computer science.

Olasupo Felemu (University of Ibadan) **FO 1.202, 4:00pm**

On the Geometry of Springer Varieties

ABSTRACT. In this work, we review the geometry of Springer varieties in type A, and compare the two algorithms on row strict Young tableaux used by Juliana Tymoczko, and Lucas Fresse to compute Betti numbers of Springer varieties.

Gene B. Kim (University of Southern California) **FO 2.208, 4:00pm**

Distribution of descents in matchings and derangements

ABSTRACT. The distribution of descents in certain conjugacy classes of S_n have been previously studied, and it is shown that its moments have interesting properties. This talk provides a bijective proof of the symmetry of the descents and major indices of matchings and uses a generating function approach to prove a central limit theorem for the number of descents in matchings. We also extend this result to derangements.

Chad Duna (University of Kansas) **FO 2.702, 4:00pm**

Higher Nerves of Simplicial Complexes

ABSTRACT. For a simplicial complex Δ, we show that the homologies of these higher nerve complexes determine the depth of the Stanley-Reisner ring S/I_Δ as well as the f-vector and h-vector of Δ.

Sam Spiro (University of California San Diego) **FO 1.502, 4:00pm**

Polynomial Relations of Matrices of Graphs

ABSTRACT. Let A_G and L_G denote the adjacency matrix and Laplacian matrix of the graph G. If G is d-regular, then $A_G = dI - L_G$, and it is easy to use this relationship to translate from eigenvalues of A_G to eigenvalues of L_G, and vice versa. If G is (d_1, d_2)-regular, then $A_G^2 = (L_G - d_1 I)(L_G - d_2 I)$. Remarkably, it also turns out that this relationship allows one to translate between the eigenvalues of A_G and L_G. Given these results, it is natural to ask which graphs G have the property that there exists a polynomial f and positive integer r such that $A_G^r = f(L_G)$. It turns out that the only such graphs satisfying such a relation are the regular and biregular graphs.

In this talk we show how to use the relation $A_G^2 = (L_G - d_1 I)(L_G - d_2 I)$ to translate between eigenvalues of A_G and L_G when G is biregular, and we shall prove that the only graphs with this property are the regular and biregular graphs. We shall also briefly discuss more general relations of the form $f(A_G) = g(L_G)$ for polynomials f and g, and relations involving the signless and normalized Laplacian of a graph.

Nadia Lafrenière (Université du Québec à Montréal) **FO 1.202, 4:30pm**

From eigenvalues of shuffling operators to mixing time

ABSTRACT. You have probably tried more than once to shuffle a deck of cards. Have you ever wondered when you should stop? I will show how combinatorics, linear algebra and probability could help you solve this long-standing problem.

Dylan Heuer (North Dakota State University) **FO 2.208, 4:30pm**

Chained permutations inspired by three-person chess

ABSTRACT. We define and enumerate two new two-parameter permutation families, namely, placements of a maximum number of non-attacking rooks on k chained-together $n \times n$ chessboards, in either a circular or linear configuration. We also look at certain promising properties of these permutations.

Andrew Newman (The Ohio State University) **FO 2.702, 4:30pm**

Small simplicial complexes with prescribed torsion in homology

ABSTRACT. By Kalai's higher-dimensional generalization of Cayley's formula for counting spanning trees in the complete graph, it is known that there exist small simplicial complexes which have extremely large torsion in homology. More precisely, for every n, there is a d-dimensional simplicial complex on n vertices so that the torsion subgroup of the $(d-1)$st homology group has size $\exp(\Theta(n^d))$. In this talk I use the probabilistic method to prove an inverse result. That is, I show that for any finite abelian group G there is a d-dimensional simplicial complex on $\Theta(\sqrt[d]{\log |G|})$ vertices which realizes G as the torsion subgroup of the $(d-1)$st homology group.

Victor Summers (North Carolina State University) **FO 1.502, 4:30pm**

Magnitude Homology of Finite Graphs

ABSTRACT. Any mathematical constructions come equipped with a canonical measure of size; the cardinality of a set, Euler characteristic of a topological space, dimension of a vector space, to name just three. Tom Leinster added magnitude of a metric space to this list of cardinality-like invariants. Magnitude extends more generally to enriched categories of which metric spaces are a particular example. While the definition of magnitude is highly abstract, it turns out to be mysteriously rich in geometric information. Graphs can be regarded as metric spaces; as such they have magnitude. Richard Hepworth and Simon Willerton went on to categorify the magnitude of graphs, realizing the invariant as the Euler characteristic of a bigraded homology theory; Magnitude Homology. I will describe magnitude of graphs along with its categorification as well as some recent results.

Kara Stasikelis (Clemson University) **FO 1.202, 5:00pm**

On reordering books and self-organizing libraries

ABSTRACT. The Tsetlin library is a model for the way an arrangement of books on a library shelf evolves over time. It assumes that, given n books, one book is read and returned at the end of the shelf before another one is picked up. Suppose the probability that a book i is picked up is x_i. An interesting property of this Markov chain is that its eigenvalues can be computed exactly and they are linear in the x_i's. This result has been extended by Brown and Diaconis (1998) and Bidigare, Hanlon, and Rockmore (1999) to random-to-back pop shuffles, where a subset of books can be picked up and placed at the end of the shelf in their respective order before another subset is picked up. It has been extended to hierarchies of libraries with a tree structure by Björner (2008, 2009). In this work, we describe the eigenvalues of the transition matrix of a similar Markov chain in the case when the possible orderings of the books on the shelves are restricted to linear extensions of prescribed posets.

Michael Weselcouch (North Carolina State University) **FO 2.208, 5:00pm**

P-Partition Generating Function Equivalence of Naturally Labeled Posets

ABSTRACT. Given a poset P, we define the P-partition generating function. This is a quasisymmetric function determined by the linear extensions of P. We will discuss the case when two distinct posts have the same P-partition generating function and state necessary conditions that these posits must satisfy.

Alex Chandler (North Carolina State University) **FO 2.702, 5:00pm**

A Categorification of the Vandermonde Determinant

Abstract. In the spirit of Bar Natan's construction of Khovanov homology, we give a categorification of the Vandermonde determinant. Given a knot diagram D with n crossings and a list of natural numbers $x_1, ..., x_n$, we will construct a chain complex whose Euler characteristic is equal to the Vandermonde determinant $\det(x_i^j)_{i,j=1}^n$.

Xujun Liu (University of Illinois) **FO 1.502, 5:00pm**

Cubic graphs with small independence ratio

Abstract. Let $i(r,g)$ denote the infimum of the ratio $\frac{\alpha(G)}{|V(G)|}$ over the r-regular graphs of girth at least g, where $\alpha(G)$ is the independence number of G, and let $i(r,\infty) := \lim_{g\to\infty} i(r,g)$. Recently, several new lower bounds of $i(3,\infty)$ were obtained. In particular, Hoppen and Wormald showed in 2015 that $i(3,\infty) \geq 0.4375$, and Csóka improved it to $i(3,\infty) \geq 0.44533$ in 2016. Bollobás proved the upper bound $i(3,\infty) < \frac{6}{13}$ in 1981, and McKay improved it to $i(3,\infty) < 0.45537$ in 1987. There were no improvements since then. In this paper, we improve the upper bound to $i(3,\infty) \leq 0.454$. Joint work with József Balogh and Alexandr Kostochka.

Dr. Oleg Musin (UT Rio Grande Valley) **SLC 1.102, 5:30pm**

Packing equal circles into spheres and flat tori

Abstract. The Tammes problem is to find the arrangement of N equal circles on a unit sphere which maximizes the radius of these circles. This problem is presently solved for several values of N, namely for $N = 3, 4, 6, 12$ by L. Fejes Toth (1943); for $N = 5, 7, 8, 9$ by Schutte and van der Waerden (1951); for $N = 10, 11$ by Danzer (1963) and for $N = 24$ by Robinson (1961). The optimal configurations of 13 and 14 circles were conjectured more than 65 years ago. In the talk will be considered solutions of these long-standing open problems in geometry.

I will also consider periodic planar packings of congruent circles, i.e. packings of tori with the maximal circle radius. We have found optimal arrangements for $N = 6, 7$ and 8 circles. Surprisingly, for the case $N = 7$ there are three different optimal arrangements.

Sunday - April 8th

Dr. Catherine Yan (Texas A&M) — **SLC 1.102, 8:00am**

Parking Functions, Interpolation Polynomials, and the Operator Method

Abstract. Parking function is an object lying in the center of combinatorics and appearing in many discrete and algebraic structures. Originated in the theory of hashing and searching in computer science, parking functions are related to labeled trees, graph searching, hyperplane arrangements, noncrossing partitions, order statistics, sandpile models, and diagonal harmonics. In this talk we discuss the vector parking functions, which correspond naturally to the Goncarov polynomials, the solution of the Goncarov Interpolation Problem in Numerical Analysis. Using the Finite Operator Calculus, we introduce the delta-Goncarov polynomials, develop the algebraic and analytic theory, and show that such polynomial sequences provide a natural algebraic tool for enumerating combinatorial structures with a linear constraint on their order statistics.

Peter Kagey (University of Southern California) — **FO 2.208, 9:30am**

Extending Ron Graham's sequence and other explorations in the OEIS.

Abstract. Ron Graham's sequence is given by $A006255$ in the On-Line Encylopedia of Integer Sequences (OEIS), where $A006255(n)$ is the smallest m for which there is a strictly increasing sequence $n = a_1 < a_2 < \ldots < a_T = m$ such that the product of the terms of the sequence $a_1 \cdot a_2 \cdot \ldots \cdot a_T$ is a perfect square.

This talk discusses a constructive way to compute large terms of the sequence with linear algebra, and explores how this technique generalizes to related problems—including counting the number of square-product subsets of a finite set of integers.

James McKeown (University of Miami) — **FO 2.702, 9:30am**

A New Geometric picture of Permutations and Alternating Sign Matrices

Abstract. The Permutahedron and its polar are classical objects used to study the symmetric group and its combinatorics. In this talk, we will examine a new (but related) geometric picture of permutations arising from work of Waldspurger and Meinrenken from the early 2000's. We will see that, among other things, the combinatorics underlying this geometry is deeply related to the Bruhat order and its completion to a (poset-theoretic) lattice.

Erika Berenice Roldan Roa (Ohio State University) — **FO 2.208, 10:00am**

Complete Characterization of the number of solutions of the Instant Insanity puzzle

Abstract. Puzzles based on coloured cubes and other coloured geometrical figures have a long history in the recreational mathematical literature. One of the most commercially famous of these puzzles is the Instant Insanity that consists of four cubes. Their faces are coloured with four different colours in such a way that each colour is present in each one of the four cubes. To solve the puzzle, one needs to stack the cubes in a tower in such a way that each one of the colours appears exactly once in the four long faces of the tower. In this talk we are going to study the combinatorial richness of a mathematical model of this puzzle by analysing all possible ways of colouring the cubes to form a puzzle analogous to the Instant Insanity. We have done this analysis for n cubes and n colours for $n = 4, 5, 6$. This combinatorial analysis allowed us to design the Mutando of Insanity, a puzzle that we presented at Gathering for Gardner 12 (G4G12).

Yonggyu Lee (UC Davis) — **FO 2.702, 10:00am**

Geometrical structure of Tesler polytopes

Abstract. Tesler polytope is the set of upper triangular matrices with non negative entries satisfying certain equations called hook sum conditions. We will show that the Tesler polytopes of positive hook sums are all combinatorially isomorphic to each other and any polytopes that are combinatorially isomorphic to Tesler polytope of hook sum $(1, \ldots, 1)$ are the translations of positive hook sum Tesler polytopes.

Max Castroparedes (University of St. Thomas) — **FO 2.208, 10:30am**

Impartial Redistricting: A Markov Chain Approach

Bhuvan Mittal — **FO 2.702, 10:30am**

Statistics for Managerial Decision Making

Abstract. In this talk, I will introduce basic concepts and examples on using optimization based on linear & non-linear regression and stochastics for managerial decision making. In particular, I would introduce a couple of problems in the areas of operations and finance and how they were solved optimally using these techniques.