CombinaTexas 2023
April 22-23, TAMU

(Central Standard Time Zone)

All the activities will be held at the first floor of Blocker Building on the campus of Texas A&M University. All the plenary talks will be at the main lecture room, BLOC 169. For contributed talks, session A is in BLOC 169, and session B is in BLOC 164. The Registration/Breakroom is at BLOC 140/141.

Schedule and Program

Saturday Morning, April 22, 2023

08:00–08:25: Registration and Breakfast
08:25–08:30: Opening Remarks
08:30–09:20: Plenary Talk 1: Sergi Elizalde
09:30–10:50: Contributed Session I
10:50–11:20: Break
11:20–12:10: Plenary Talk 2: Sheila Sundaram

12:20–02:00: Lunch Break

02:00–02:50: Plenary Talk 3: Joshua Cooper
03:10–04:30: Contributed Session II
04:30–05:00: Break
05:00–05:50: Plenary Talk 4: Andrew Suk

Sunday, April 23, 2023

08:00–08:30: Registration and Breakfast
08:30–09:50: Contributed Session III
09:50–10:20 Break
10:20–11:10: Plenary Talk 5: Patricia Klein
11:20–12:10: Plenary Talk 6: Bernard Lidicky

Schedule for Contributed Talks

Saturday Morning, Contributed Session I		
	Session A	Session B
	Chair: Lauren	Chair: Derek
09:30–09:50	Leon Banston	Seok Hyun Byun
09:50–10:10	Kassie Archer	Yi-Lin Lee
10:10–10:30	Noureen Khan	Alec Mertin
10:30–10:50	Sean Bailey	Charles Burnette
Saturday Afternoon, Contributed Session II		
	Session A	Session B
	Chair:	Chair: Byeongsu
3:10–3:30	Katie Anders	Art Duval
3:30–3:50	Kirin Martin	Leonard Mushunje
3:50–4:10	Rajat Gupta	Peter Marcus
4:10–4:30	Youngho Yoo	Máté László Telek
Sunday Morning, Contributed Session III		
	Session A	Session B
	Chair:	Chair: Derek
8:30–8:50	John Lopez	Byeongsu Yu
8:50–9:10	Noah Lebowitz-Lockard	Matthew Samuel
9:10–9:30	Wencai Liu	Nestor Diaz Morera
9:30–9:50	Nathan Williams	Jacob White

1 Plenary Talks

1. Joshua Cooper, University of South Carolina.

   Title: Probing the Structure of Graph Nullspaces with Zero Loci

   Abstract: The adjacency nullity of graphs' and hypergraphs' adjacency matrices is something of a mystery, though there are nice results for some narrow classes of graphs such as trees. There is, however, rich structure in their nullspaces (and, for hypergraphs, their nullvarieties), visible by partitioning nullvectors according to their zero loci: vertex sets which are indices of their zero coordinates. This set system is the lattice of flats of a "kernel matroid", a subsystem of which are the "stalled" sets closed under skew zero forcing (SZF), a graph percolation/infection model known to have connections with rank and nullity. These set systems have interesting descriptions in terms of matchings, vertex covers, and edges' influence on rank – especially for trees. For a wide variety of graphs, the lattice of SZF-closed sets is also a matroid, a fact which can be used to obtain a polynomial-time algorithm for computing the skew zero forcing number. This contrasts with the general case, where we show that the corresponding decision problem is NP-hard. We also define skew zero forcing for hypergraphs, and show that, for linear hypertrees, the poset of SZF-closed sets is dual to the lattice of ideals of the hypergraph's nullvariety; while, for complete hypergraphs, the SZF-closed sets and the zero loci of nullvectors are more loosely related. (Back to Schedule.)

2. Sergi Elizalde, Dartmouth College.

   TITLE: Descents on noncrossing and nonnesting permutations

   ABSTRACT: Stirling permutations were introduced by Gessel and Stanley to give a combinatorial interpretation of certain polynomials related to Stirling numbers, which count set partitions with a given number of blocks. A natural extension of Stirling permutations are noncrossing (also called quasi-Stirling) permutations, which are in bijection with labeled rooted plane trees. Archer et al. introduced these permutations, and conjectured that there are $(n+1)^{n-1}$ such permutations of size n having n descents.

   In this talk we prove this conjecture and, more generally, we find the generating function for noncrossing permutations by the number of descents. We show that some of the properties of descents on usual permutations and on Stirling permutations also hold for noncrossing permutations.

   Finally, we consider a nonnesting analogue, and we show that the polynomial giving the distribution of the number of descents on nonnesting permutations is a product of an Eulerian polynomial and a Narayana polynomial. It follows that, rather unexpectedly, this polynomial is palindromic. (Back to Schedule.)

3. Patricia Klein, Texas A&M University

   Title: Generalizations of vertex decomposition

   Abstract: The Stanley–Reisner correspondence relates abstract simplicial complexes to squarefree monomial ideals in polynomial rings. Much can be learned about the squarefree monomial ideal, and the variety it defines, by studying the corresponding simplicial

complex. For example, Reisner's criterion gives a way to assess Cohen–Macaulayness of a variety determined by a squarefree monomial ideal by studying the homology of its simplicial complex. Vertex decomposition is a technique of breaking down a simplicial complex into smaller simplicial complexes in a manner that tracks a good deal of information about the homology of the complex. More precisely, if a simplicial complex is vertex decomposable, then its associated ideal determines a Cohen–Macaulay variety. We will review basic definitions and properties of vertex decomposition and then consider generalizations of vertex decomposition to not-necessarily-monomial ideals in polynomial rings and to complexes of polytopes associated to toric varieties. (Back to Schedule.)

4. Bernard Lidicky, Iowa State University

   Title: Applications of Flag Algebras

   Abstract: Flag algebras is a tool developed by Razborov for solving problems in extremal graph theory and combinatorics. The tool is very general and it lead to breakthrough results on many long standing open problems. It was applied in the area of graphs, hypergraphs, permutations, Ramsey numbers, discrete geometry and phylogenetic trees to name a few areas. The method provides results in the limit, which can be translated to large structures with small error terms. The method is also closely related to the notion of dense graph limits. In the talk we give a brief introduction to the method and show some applications. (Back to Schedule.)

5. Andrew Suk, University of California San Diego

   Title: On higher dimensional point sets in general position

   Abstract: An old question of Erdos asks: Given a set of N points in R^d with no $d+2$ members on a common hyperplane, what is the size of the largest subset of points in general position (i.e., no $d+1$ members on a hyperplane)? In 2018, Balogh and Solymosi showed that one can use the hypergraph container method to tackle this problem in the plane. In this talk, I will show how to use the container method to tackle Erdos' question in any dimension. This is joint work with Ji Zeng. (Back to Schedule.)

6. Sheila Sundaram, Independent

   Title: Positivity problems in combinatorial representation theory

   Abstract: In this talk I will survey some positivity questions which arise in considering representations of the symmetric group. The first set of questions comes from the character table itself, which presents interesting conjectures. The second set of questions arises from poset homology. Here I will discuss various enumerative conjectures, some that are long-standing and others that are new. (Back to Schedule.)

2 Contributed Talks

(Ordered by the registration number)

1. Leon Bankston, Tulane University. (4)

   Title: Nonlocal games on Pauli measurements

   Abstract: The Pauli measurements are a collection well-studied quantum measurements with a rich combinatorial structure. We define a series of games where a referee questions Alice and Bob (who cannot communicate) with certain Pauli measurements, and they are challenged to provide consistent responses.

   It is trivial that Alice and Bob can always win all of our games with quantum entanglement, and well-known that they cannot win with certainty without quantum entanglement. We use the combinatorial structure of the Pauli measurements to bound (via the expander mixing lemma) the classical probability of winning.

   Our results show that the last game in our series has no strategy that significantly outperforms a random strategy. Our technique illustrates how combinatorial structure can be applied to address natural questions that involve the Pauli measurements. (Back to Schedule.)

2. Byeongsu Yu, Texas A&M University (8)

   Title: Local cohomology, multigradings, and polyhedral combinatorics

   Abstract: In this talk, we will introduce the generalized Ishida complex over $\mathbb{Z}^d$ multigraded modules of affine semigroup rings. Moreover, we introduce a notion of degree space, which is a space of $\mathbb{Z}^d$ with a topology generated by lattice points of polyhedral cones. From these two concepts, we derive two applications; 1) Cohen–Macaulayness criteria of quotients rings of polynomial rings by cellular binomial ideals/lattice ideals, 2) Duality between local cohomologies. This is a joint work with Laura Matusevich, and Erika Ordog. (Back to Schedule.)

3. Kirin Martin, Iowa State University (25)

   Title: Unfolding Universal Partial Cycles

   Abstract: A universal partial cycle is a generalization of a De Bruijn sequence which, in addition to an alphabet of size a, allows a wild card character called a diamond, representing every alphabet letter (so that multiple words are covered by the same window). As in a De Bruijn sequence, every n-length word over the alphabet must be covered exactly once in the course of a universal partial cycle. These cycles have length a^{n-d}, where d is the number of diamonds per n-length window, and can be visualized on $DB(a, n)$ or $DB(a, n-1)$ as structures similar to a Hamilton cycle or Euler tour, respectively. By choosing an order to express the alphabet letters with each diamond in the cycle, one can unfold (or "lift") a universal partial cycle into a De Bruijn sequence. This choice of order cannot be made carelessly, however. In fact, the key to successful unfolding turns out to be something called a perfect necklace. (Back to Schedule.)

4. Seok Hyun Byun, Clemson University (27)

   Title: Lozenge tilings of hexagons with intrusions

   Abstract: MacMahon's classical theorem on the number of boxed plane partitions has been generalized in several different directions. One way to generalize the theorem is to view boxed plane partitions as lozenge tilings of a hexagonal region, then to generalize it by making some holes in the region and counting its tilings. Recently, the number of lozenge tilings of hexagonal regions with several consecutive unit triangles removed from a certain axis was studied. After reviewing some previous results in this research direction, we will present a new result that generalize the aforementioned result. This talk is based on a joint work with Tri Lai. (Back to Schedule.)

5. Matthew Samuel, Prudential Financial (29)

   Title: A dual Pieri formula for double Schubert polynomials in different sets of coefficient variables

   Abstract: The Pieri formula for multiplying a Schubert polynomial by an elementary symmetric polynomial presented by Sottile is well known. In a soon to appear paper, we provide a generalization of this to double Schubert polynomials in different sets of coefficient variables, a special case of the computation of the coefficients $c_{u,v}^{w}(y;z)$ such that

$$\mathfrak{S}_u(x;y)\mathfrak{S}_v(x;z) = \sum_{w\in S_\infty} c_{u,v}^{w}(y;z)\mathfrak{S}_w(x;y)$$

   Though multiplication in the polynomial ring is of course commutative, there is very little relationship between $c_{u,v}^{w}(y;z)$ and $c_{v,u}^{w}(y;z)$ in general. In this talk we present the dual Pieri formula that allows us to flip u and v in the product in this case. (Back to Schedule.)

6. Yi-Lin Lee, Indiana University at Bloomington (30)

   Title: Off-diagonally symmetric domino tilings of the Aztec diamond

   Abstract: We introduce a new symmetry class of domino tilings of the Aztec diamond, called the off-diagonal symmetry class, which is motivated by the off-diagonally symmetric alternating sign matrices introduced by Kuperberg in 2002. We use the method of non-intersecting paths and a modification of Stembridge's Pfaffian formula for families of non-intersecting paths to enumerate our new symmetry class. The number of off-diagonally symmetric domino tilings of the Aztec diamond can be expressed as a Pfaffian of a matrix whose entries satisfy a nice and simple recurrence relation. (Back to Schedule.)

7. Nestor Diaz Morera, Tulane University (33)

   Title: Dyck paths and nearly toric Schubert varieties

   Abstract: We consider Ding's partition Schubert varieties whose members are very close to being a toric variety. More precisely, we characterize the spherical partition Schubert varieties in terms of Dyck paths. We introduce a notion of a nearly toric variety. We identify the nearly toric partition Schubert varieties as well as all singular

nearly toric Schubert varieties. We find the cardinalities of the sets of these Schubert varieties. (Back to Schedule.)

8. Peter Marcus, Tulane University (37)

   Title: Transfer Systems

   Abstract: Transfer systems are combinatorial objects that arise in equivariant homotopy theory. They are defined as a certain type of partial order on the set of subgroups of a fixed finite group. The central question is enumerating all possible transfer systems for a given group. I will discuss this and other related results. (Back to Schedule.)

9. Máté László Telek, University of Copenhagen (39)

   Title: Reaction networks and a generalization of Descartes' rule of signs to hypersurfaces

   Abstract: The classical Descartes' rule of signs provides an easily computable upper bound for the number of positive real roots of a univariate polynomial with real coefficients. Descartes' rule of signs is of special importance in applications where positive solutions to polynomial systems are the object of study. This is the case in reaction network theory where variables are concentrations or abundances. Motivated by this setting, we give conditions based on the geometrical configuration of the exponents and the sign of the coefficients of a polynomial that guarantee that the number of connected components of the complement of the hypersurface where the defining polynomial attains a negative value is at most one or two. Furthermore, we discuss how these results can be applied to show that the parameter region of multistationarity of a reaction network is connected. (Back to Schedule.)

10. Noah Lebowitz-Lockard, University of Texas at Tyler (40)

    Title: Runs of Integers with the Same Number of Divisors

    Abstract: In 1952, Erdos and Mirsky asked for the length of the longest sequence of consecutive numbers ¡= x which all have the same number of divisors. A few months ago, Spataru found the first non-trivial upper bound for this problem. We discuss Spataru's proof, as well as some recent improvements on it. Finally, we discuss the analogous problem for other arithmetic functions and write a few heuristic bounds. (Back to Schedule.)

11. Rajat Gupta, University of Texas at Tyler (41)

    Title: FFW function and the smallest part function of Andrews

    Abstract: In this talk we discuss about the FFW-function introduced by Fokkink, Fokkink and Wang. They shows that if D_n is the collection of partitions of n into distinct parts and $s(\pi)$ denotes the smallest part in partition π; then

$$\sum_{\pi \in D_n} (-1)^{\#(\pi)} s(\pi) = d(n),$$

    where $d(n)$ is the number of divisors of n.

Later, we will be introducing a new generalization $\mathrm{FFW}_c(n)$ of a function of Fokkink, Fokkink and Wang and combinatorially derive an identity for its generating function. This gives, as a special case, a recent representation for the generating function of $\mathrm{spt}(n)$ given by Andrews, Garvan and Liang. We also obtain some weighted partition identities along with new representations for two of Ramanujan's third order mock theta functions through combinatorial techniques. (Back to Schedule.)

12. Katie Anders, University of Texas at Tyler (42)

    Title: Early results on which integers can be written as quotients of sums of distinct powers of three

    Abstract: We will discuss the motivation for this question, including its connection to the Cantor middle-third set, and early progress toward an answer. This is joint work with Madeline Locus Dawsey, Bruce Reznick, and Simone Sisneros-Thiry. (Back to Schedule.)

13. Sean Bailey, Texas A&M University Texarkana (43)

    Title: Combinatorially Orthogonal Paths

    Abstract: Vectors $x = (x_1, x_2, \cdots, x_n)^T$ and $y = (y_1, y_2, \cdots, y_n)^T$ are *combinatorially orthogonal* if $|\{i : x_i y_i \neq 0\}| \neq 1$. An undirected graph $G = (V, E)$ is a *combinatorially orthogonal graph* if there exists $f : V \to \mathbb{R}^k$ for some k such that for any $u, v \in V$ $uv \notin E$ iff $f(u)$ and (v) are combinatorially orthogonal. We will show the bounds for the combinatorially orthogonal dimension of any path P_n. (Back to Schedule.)

14. Kassie Archer, University of Texas at Tyler (45)

    Title: Arithmetical structures of star graphs

    Abstract: An arithmetical structure is a way of assigning of positive integers to the vertices so that the label of a given vertex v divides the sum of the labels of the vertices adjacent to v. Associated to each arithmetical structure of a graph is a group called the critical group. In this talk, we discuss critical groups for star graphs. (Back to Schedule.)

15. Alec Mertin, Clemson University (48)

    Title: Statistics on Fences Under Rowmotion

    Abstract: We show certain statistics on the order ideals of fence posets are equivalent to a constant plus a linear combination of "toggleability statistics." In doing so, not only do we recover a number of known homomesy results for classical rowmotion on fences, but we also obtain (for free, using a process outlined in recent papers) several homomesies for piecewise-linear and birational rowmotion. We also discuss the "antichain toggleability space" for fences having segments with an equal number of unshared elements. (Back to Schedule.)

16. Leonard Mushunje, Columbia University (50)

    Title: High Dimensional Functional Data Analysis via Algebraic Geometry

Abstract: When regressing high-dimensional functional data, challenges are often encountered mainly for the in-sample than out-sample results and even worse when subjected to the curse of dimensionality. For example, on the in-sample, minimal bounds on the eigenvalues of the covariance matrix for the covariates, when using ridge regression, are not generally considered. This study aims to explore the in-sample MSPE properties of different regression methods (except ridge regression) and understand whether the eigenvalue lower bounding conditions are generally avoidable in high-dimensional Hilbert settings. (Back to Schedule.)

17. Art Duval, University of Texas at El Paso (52)

    Title: Counting topologies of metrics of holomorphic polynomial vector fields with simple zeros

    Abstract: We reduce the problem in the title to the problem of counting unlabeled planar trees with black and white vertices, where each white vertex has degree at least three, and where no white vertices are adjacent. We use the theory of species to solve this problem. A key tool is an extension of the Dissymmetry Theorem to certain multi-sort species. (Back to Schedule.)

18. Youngho Yoo, Texas A&M University (56)

    Title: Approximating TSP walks in subcubic graphs

    Abstract: The Graphic Travelling Salesman Problem is the problem of finding a spanning closed walk (a TSP walk) of minimum length in a given connected graph. The special case of the Graphic TSP on subcubic graphs has been studied extensively due to their worst-case behaviour in the famous $\frac{4}{3}$-integrality-gap conjecture on the "subtour elimination" linear programming relaxation of the Metric TSP.

    We prove that every simple 2-connected subcubic graph on n vertices with n_2 vertices of degree 2 has a TSP walk of length at most $\frac{5n+n_2}{4} - 1$, confirming a conjecture of Dvořák, Král', and Mohar. This bound is best possible and we characterize the extremal subcubic examples meeting this bound. We also give a quadratic time combinatorial algorithm to find such a TSP walk. In particular, we obtain a $\frac{5}{4}$-approximation algorithm for the Graphic TSP on cubic graphs. Joint work with Michael Wigal and Xingxing Yu (Back to Schedule.)

19. Wencai Liu, Texas A&M University (60)

    Title: Isospectrality of periodic graph operators

    Abstract: The eigenvalue problem of periodic graph operators with the Floquet-Bloch boundary condition can be realized by permutations of directed graphs. In this talk, we will discuss the isospectrality of periodic graph operators. (Back to Schedule.)

20. John Lopez, Tulane University (61)

    Title: The lexicographically least square-free word with a given prefix

    Abstract: The lexicographically least square-free infinite word on the alphabet of non-negative integers with a given prefix p is denoted $L(p)$. When p is the empty word,

this word was shown by Guay-Paquet and Shallit to be the ruler sequence. For other prefixes, the structure is significantly more complicated. We show that $L(p)$ reflects the structure of the ruler sequence for several words p. We provide morphisms that generate $L(n)$ for letters $n = 1$ and $n \geq 3$. (Back to Schedule.)

21. Noureen Khan, University of North Texas at Dallas (62/63)

    Title: Invariants of Mosaic Tangles

    Abstract: A knot mosaic consists of a set of tiles arranged in a square grid to represent knot diagrams. Despite the fact that this branch of knot theory is relatively new, many interesting facts have been discovered, including the space efficiency with which knots are drawn as mosaics. We study mosaics as tangles and calculate classical invariants associated with the algebraic tangles. We show that mosaic tangle number is realized with the mosaic crossing number. (Back to Schedule.)

22. Jacob White, University of Texas Rio Grande Valley (64)

    Title: Orbital Chromatic Polynomials for Combinatorial Hopf monoids

    Abstract: We discuss the orbital chromatic polynomial of a graph, and the orbital order polynomial of a poset. Both of these are generalizations of chromatic polynomials and order polynomials. We then present a general framework for defining orbital polynomial invariants arising from combinatorial Hopf monoids and species, and show how properties of the combinatorial Hopf monoids can be used to prove properties about the resulting orbital polynomial invariants. (Back to Schedule.)

23. Charles Burnette, Xavier University of Louisiana (65)

    Title: Fixed-point free involution factorizations

    Abstract: The problem of factoring random permutations into the product of two involutions with a prescribed number of fixed points has connections to arithmetic dynamics and the analysis of perfect shuffle algorithms. Given a permutation σ of $[n]$, let $\mathsf{invol}(\sigma)$ denote the number of ways σ can be expressed as a composition of two involutions of $[n]$. In a joint paper with Eric Schmutz, we proved that invol is asymptotically lognormal for uniform random permutations.

    In this talk though, we will consider the conditional distribution of invol over permutations that admit fixed-point free involution factorizations, which are precisely the permutations with an even number of k-cycles for $k = 1, 2, \ldots$ Through a combination of singularity analysis, the method of moments, and an appeal to the classical Shepp-Lloyd model, we will see that the conditional distribution of $\log \mathsf{invol}$ has a discrete limit law instead of a Gaussian one. (Back to Schedule.)

24. Nathan Williams, University of Texas at Dallas (70)

    Title: Coxeter Combinatorics and Braid Varieties

    Abstract: We discuss a recent framework for finding and proving interesting combinatorial formulas. The combinatorics parametrizes a decomposition of certain braid varieties over finite fields, while the proofs relate the point count of these varieties to

traces in Hecke algebras. We present several case-studies and open problems using this framework. This is based on joint work with Pavel Galashin, Thomas Lam, and Minh-Tâm Trinh. (Back to Schedule.)