Contributed Talks

NORCOM 2025

16-18 June 2025

Akalu Tefera
Grand Valley State University

On Proofs Of Generalized Knuth's Old Sum

Abstract

In this talk, we present combinatorial and computer-assisted proofs of a generalized Knuth's sum using the Wilf-Zeilberger algorithm.

Aklilu Zeleke
Michigan State University
Combinatorial Properties Of Some Recursive Polynomials.

Abstract

We introduce a recursive polynomial sequence that generalizes the well known Fibonacci polynomial sequence. We derive Binet forms, generating functions, and discuss the relations of these polynomials to integer partitions and other known polynomial sequences such as the Bell polynomials.

Alperen Özdemir
KTH Royal Institute Of Technology
A Limit Law For Pattern Avoiding Permutations

Abstract

A way to illustrate the structural differences between the permutations avoiding 231 and 321 patterns is to study the first-order properties they satisfy. We show an application of random processes to prove that the probability of a random 321-avoding permutations satisfy such property converges to a limit. We discuss the different methods used for the 231 case and provide other applications of our method, such as in the setting of preferential attachment graphs.

Andrea Burgess
University Of New Brunswick

Existential Closure In Uniform Hypergraphs

Abstract

Given a positive integer n, a graph is said to be n-existentially closed if, for any pair of disjoint sets of vertices S and T with $|S \cup T| = n$, there exists a vertex x not in $S \cup T$ which is adjacent to every vertex in S but no vertex in T. We extend this concept to uniform hypergraphs, and show that basic properties of n-existentially closed graphs translate naturally into this setting. We show that random uniform hypergraphs are asymptotically n-existentially closed and give explicit constructions of n-existentially closed hypergraphs arising from combinatorial designs.

This is joint work with Robert Luther and David Pike.

Andrea Švob
Faculty Of Mathematics, University Of Rijeka
Regular Digraphs From Finite Groups

Abstract

In this talk, we will describe a construction of some regular digraphs, using finite groups. We will introduce the notion of orbit matrices of digraphs and point out some interesting results obtained by using some particular finite groups. In particular, we present the first example of a directed strongly regular graph with parameters (63,11,8,1,2).

Andreas Spomer
University Of Cologne
Packing N-Gons On The Unit Sphere

Abstract

What is the maximum number of pairwise non-overlapping regular tetrahedra in three dimensions that share a vertex? This question has a long history, tracing back to Plato. A simple geometric argument shows that the number cannot exceed 22. By associating each face of the icosahedron with a tetrahedron, we obtain a configuration of 20 tetrahedra that share the center of the icosahedron as a common vertex. This configuration is conjectured to be optimal. To tackle this problem, we developed a framework that allows us to upper bound the number of non-overlapping regular N-gons that can be placed on the unit sphere. The framework incorporates techniques from representation theory, trigonometric polynomial optimization, and semidefinite programming.

Anthony Bonato
Toronto Metropolitan University
Hypergraph Burning, Matchings, And Zero Forcing

Abstract

Lazy Burning in Hypergraphs via Matchings and Zero Forcing

We present lazy burning, a new variant of the graph burning process where only one set of vertices is initially burned and the spread continues in a hyperedge once all but one of its vertices are burned. We show that the lazy burning number of a hypergraph can be characterized in several equivalent ways using matchings and zero forcing. We prove that it equals the order of the hypergraph G minus the maximum cardinality of a certain matching in the incidence graph of G. This leads to new bounds and complexity results, including the NP-completeness of finding an upper bound on the lazy burning number, which resolves a conjecture. We also establish an equivalence between lazy burning on a hypergraph and zero forcing on its incidence graph, and connect skew zero forcing on a graph to lazy burning on its neighborhood hypergraph. As an application, we show that computing an upper bound on the skew zero forcing number for bipartite graphs is NP-complete. We conclude with open problems that highlight further directions for exploration.

Arturo Ortiz San Miguel
Northeastern University

The d-Regular Graph On n Vertices With The Most k-Cycles

Abstract

We construct the d-regular graph G with the maximum number of $k-$cycles for even k and k = 5. We reframe the problem as a continuous optimization problem on the eigenvalues of G by using a Mobius inversion relation between injective homomorphism numbers from C_k and homomorphism numbers from quotient graphs of C_k. For k = 5 and $d > 3$, we show G is a collection of disjoint K_{d+1} graphs. For d = 3, disjoint Petersen graphs emerge. For even k and d large enough, G consists of copies of $K_{d,d}$. These cases have non-spectral terms, which require bounding by spectral terms in a way that is sharp at the optimal graph. Additionally, we introduce and give formulas for non-backtracking homomorphism numbers and backtracking homomorphism numbers, respectively. Moreover, we find the d-regular graph on n vertices with the most non-backtracking closed walks of length k by considering an optimization problem on the non-backtracking spectrum of G. We also solve the same problem, but for backtracking closed walks. Lastly, a corollary gives formulas for the number of 4-cycles and 5-cycles of a graph with respect to its spectrum, regardless of regularity. We conjecture that for odd k and sufficiently large d, the optimal G is a collection of K_{d+1}.

Atli Fannar Franklín
University Of Iceland

State Machine Bounds On Pattern Avoiding Permutations

Abstract

A new lower bound on the growth rate of 1324-avoiding permutations could be achieved through analysing a state machine on 132-avoiding permutations. No improved bound has yet been achieved through this framework, but theoretical considerations suggest that finding the correct probability distribution on Catalan structures (such as 132-avoiding permutations) would be enough to yield a new record.

Bram Bekker
Delft University Of Technology

Bounds And Optimality Conditions For Almost-Equiangular Sets With A Large Angle

Abstract

For t between -1 and 1, a set of points on the $(n-1)$-dimensional unit sphere is called t-almost equiangular if among any three distinct points there is a pair with inner product t. We propose a semidefinite programming upper bound for the maximum cardinality $\alpha(n,t)$ of such a set based on an extension of the Lovász theta number to hypergraphs. This bound is at least as good as previously known bounds and for many values of n and t it is better.

We also refine existing spectral methods to show that $\alpha(n,t)$ is at most $2(n+1)$ for all n and nonpositive t, with equality only at $t=-1/n$. This allows us to show the uniqueness of the optimal construction at $t=-1/n$ for n at most 5 and to enumerate all possible constructions for n equal to 2 and 3 and nonpositve

Dana Ernst
Northern Arizona University

Structure Of Braid Graphs For Reduced Words In Coxeter Groups

Abstract

In this talk, we will discuss the architecture of braid graphs in Coxeter systems. It turns out that every reduced expression has a unique factorization as a product of so-called links, which in turn induces a decomposition of the braid graph into a box product of the braid graphs for each link factor. When the corresponding Coxeter graph avoids certain three-cycles, each braid graph is a median graph (i.e., for every triple of vertices, there is a unique vertex, called the median, that belongs to shortest paths between each pair). One consequence of this result is that every braid graph in Coxeter systems avoiding the banned three-cycles can be isometrically embedded into a hypercube.

Daniel Hawtin
Faculty Of Mathematics, University Of Rijeka
Symmetries Of Rank-Metric Codes

Abstract

A rank-metric code is a code in a bilinear forms graph. We study the automorphism groups of such codes. In particular, we give several infinite families of examples of neighbour-transitive codes. Moreover, we provide an upper bound for the minimum distance of a 2-neighbour-transitive code, and provide information about the structure of the automorphism group of a neighbour-transitive code.

David Bevan
University Of Strathclyde, Glasgow, Scotland

Irrational Enumeration: Analytic Combinatorics For Objects Of Irrational Size

Abstract

It is well known that the asymptotic behaviour of the number of objects in a combinatorial class can be determined from the singularities on the circle of convergence of its generating function. In this talk we extend the scope of analytic combinatorics to classes whose objects have irrational sizes by establishing an analogous result when it is no longer required that the size of an object must be an integer.

The generating function for such a class is a power series that admits irrational exponents (which we call a Ribenboim series). A transformation then yields a generalised Dirichlet series from which the asymptotics of the coefficients can be extracted by singularity analysis using an appropriate Tauberian theorem. In practice, the asymptotics can often be determined directly from the original generating function. The technique will be illustrated with a variety of applications, including tilings with tiles of irrational area, lattice walks with steps of irrational length, and trees with vertices of irrational size. We will also explore phase transitions in the asymptotics of families of irrational combinatorial classes.

This is joint work with Julien Condé and Andrew Elvey Price of l'Université de Tours.

David Garber
Holon Institute Of Technology

Pattern-Avoidance And Schur-Positivity In Restricted-Growth Words Of Type B

Abstract

In this talk, we deal with pattern-avoidance classes of restricted-growth words of type B associated with signed set partitions. We investigate such words which avoid patterns of lengths 2 and 3, by constructing generating trees in these cases. Additionally, we show how to use this data to explore connections between these pattern-avoidance classes and quasi-symmetric functions, addressing symmetry and Schur positivity in some special cases. Joint work with Eli Bagno, Toufik Mansour and Amir Safadi.

Dean Crnković
University Of Rijeka, Croatia

Constructing Self-Orthogonal And LCD Subspace Codes

Abstract

Recently, the notions of self-orthogonal subspace codes and LCD subspace codes were introduced. In this talk, we will give a method of constructing self-orthogonal and LCD subspace codes from a set of matrices under certain conditions. In particular, we will give constructions of self-orthogonal and LCD subspace codes from mutually quasi-unbiased weighing matrices, linked systems of symmetric designs, and linked systems of symmetric group divisible designs, Deza graphs and their equitable partitions.

This is a joint work with Keita Ishizuka, Hadi Kharaghani, Sho Suda and Andrea Švob.

Emil Verkama
KTH Royal Institute Of Technology
Enumerating 1324-Avoiders With Few Inversions

Abstract

In 2012, Claesson, Jelínek and Steingrímsson tackled the notoriously difficult problem of determining the number of permutations avoiding the pattern 1324, leading to the first good upper bound for their exponential growth rate. Furthermore, they conjectured that the number of 1324-avoiders of length $n$with a fixed number k of inversions grows with n, for each k. This inversion-monotonicity conjecture would further improve the upper bound for the growth rate of the 1324-avoiders to approximately 13.002. The bound proved by Claesson et al. was 16, and the current best is 13.5 due to Bevan et al.

In this work, we make the first significant bit of progress towards the inversion-monotonicity conjecture by proving that it holds for all k and n such that$n \geq (k + 7)/2$. Our proof relies on a structural characterization of the permutations in question in terms of a new notion of almost-decomposability, leading to an enumeration. Inversion-monotonicity follows as a corollary. We discuss this new method, possible improvements, and possible applications to other questions in the theory of pattern avoiding permutations.

Hans Höngesberg
University Of Ljubljana

A Littlewood-Type Identity For Robbins Polynomials

Abstract

In this talk, I provide a generalization of the Littlewood identity, both sides of which are related to alternating sign matrices. The classical Littlewood identity establishes a nice product formula for the sum of all Schur polynomials. Compared to the classical identity, Schur polynomials are replaced by so-called modified Robbins polynomials. These polynomials are a generalization of Schur polynomials and enumerate down-arrowed monotone triangles, and thus also alternating sign matrices. As an additional factor on the other side of the identity, we have a Pfaffian formula which we interpret in terms of the partition function of six-vertex model configurations corresponding to diagonally symmetric alternating sign matrices. This is joint work with Ilse Fischer.

Hans Zanna Munthe-Kaas
UiT The Arctic University Of Norway

Permutation Networks And Linear Recurrences Over Galois Fields

Abstract

I will discuss the problem of designing interconnection networks for massively parallel computers, which interested me very much in the early 1990s. Recently I have rediscovered this as a fascinating topic in the borderland between algebra, combinatorics, computational mathematics and computer science.

The classical Shuffle-Exchange (SE) network is built around the basic operations of card shuffling and bipartite Exchange swaps. SE networks can perform any permutation of n items in $2\log_2(n)$ steps, with only $3n$ interconnection wires, yielding an optimal 'cost' $c = 6n\log(n)$. SE networks are, however, difficult to design due to a complicated non-recursive structure.

A class of generalized Shuffle-Exchange (GSE) networks is defined. As permutation networks these have the same functionality as SE, but some of them possess recursive structures lacking in the classical SE net. This make them very attractive from a hardware-designers point of view.

Based on the theory of linear recurrences over Galois Fields and linear shift registers, we develop the theory of GSE nets and present general theorems showing how to construct networks built up recursively by using identical (or a small number of different) building blocks.

János Barát
University Of Pannonia

Monochromatic Structures In 2-Edge-Colored Ordered Complete Graphs

Abstract

If we color the edges of a complete graph with 2 colors, then there exists a monochromatic spanning tree. In the same setting, 3n-1 vertices are sufficient and necessary to ensure a monochromatic matching with n edges. We study the analogous questions for vertex ordered graphs, where the ground set is 1,2,...,m. Here two independent edges can have 3 relations: separated, crossing or nested. Therefore we get 6 meaningful problems on vertex ordered graphs, instead of one for unordered graphs. We can answer 5 of them for matchings and all 6 for spanning trees. What can we say about other structures such as paths or cycles? These Ramsey type questions have several connections to graph drawings as well.

Jason Smith
Nottingham Trent University

The Path Poset And Multipath Complex

Abstract

A multipath in a directed graph is a disjoint union of paths. The multipaths of a graph G create a poset called the path poset of G, where the partial order is subgraph containment. The path poset can be used to define a notion of homology on a directed graph called multipath cohomology. We will give some combinatorial results on the path poset for particular classes of directed graphs, which translate to topological results on the multipath cohomology of these graphs.

Jelena Sedlar
University Of Split, Faculty Of Civil Engineering, Architecture And Geodesy

On The Cost Of Making A Metric Basis Fault Tolerant

Abstract

A set of vertices S is a resolving set of a graph G, if for every pair of vertices x and y in G, there exists a vertex s in S such that x and y differ in distance to s. A smallest resolving set of G is called a metric basis. The metric dimension $\dim(G)$ is the cardinality of a metric basis of G. The fault-tolerant metric dimension $\mathrm{ftdim}(G)$ is the cardinality of a smallest resolving set S such that $S \setminus \{s\}$ remains a resolving set of G for every $s \in S$. A natural question is how much more vertices s need to be used to achieve a fault-tolerant metric basis. It is known in literature that there exists an upper bound on $\mathrm{ftdim}(G)$ which is exponential in terms of $\dim(G)$, i.e. $\mathrm{ftdim}(G) \leq \dim(G)(1 + 2 \cdot 5^{\dim(G)-1})$. We construct graphs G with $\mathrm{ftdim}(G) = \dim(G) + 2^{\dim(G)-1}$ for any value of $\dim(G)$, showing thus that the exponential upper bound is necessary. We also extend these results to the k-metric dimension which is a generalization of the fault-tolerant metric dimension. First, we establish a similar exponential upper bound on $\dim_{k+1}(G)$ in terms of $\dim_k(G)$, and then we show that there exists a graph for which $\dim_{k+1}(G)$ is indeed exponential. An interesting direction for further work is reducing the gap between the bounds.

Jonathan Jedwab
Simon Fraser University

Combinatorial Enumeration Of Lattice Paths By Flaws With Respect To A Linear Boundary Of Rational Slope

Abstract

Let a, b be fixed positive coprime integers. For a positive integer g, write $N_k(g)$ for the set of lattice paths from the startpoint $(0,0)$ to the endpoint (ga, gb) with steps restricted to $\{(1,0),(0,1)\}$, having exactly k flaws (lattice points lying above the linear boundary joining the startpoint and endpoint). We wish to determine $|N_k(g)|$.

The enumeration of lattice paths with respect to a linear boundary while accounting for flaws has a long and rich history, dating back to the 1949 results of Chung and Feller. The only previously known values of $|N_k(g)|$ are the extremal cases $k = 0$ and $k = g(a+b)-1$, determined by Bizley in 1954. We derive a recursion for $|N_k(g)|$ whose base case is given by Bizley's result for $k = 0$. We solve this recursion to obtain a closed form expression for $|N_k(g)|$ for all k and g. Our methods are purely combinatorial.

This is joint work with Federico Firoozi and Amarpreet Rattan.

Karla Leipold
University Of Cologne

Computing The EHZ Capacity Is NP-Hard

Abstract

The Ekeland-Hofer-Zehnder capacity (EHZ capacity) is a funda- mental symplectic invariant of convex bodies. We show that computing the EHZ capacity of polytopes is NP-hard. For this we reduce the feedback arc set problem in bipartite tournaments to computing the EHZ capacity of simplices.

Krishna Menon
KTH Royal Institute Of Technology

Do Paths Have The Most Zero Forcing Sets?

Abstract

Zero forcing in graphs is a coloring process where a colored vertex can 'force' its unique uncolored neighbor to be colored. A set of initially colored vertices capable of eventually coloring all vertices of the graph is called a zero forcing set. Zero forcing has been studied for its applications to algebraic graph theory and rumor spreading models. The study of enumerative aspects of zero forcing was initiated by Boyer et al. where they made the following conjecture: For any graph, the number of zero forcing sets of size k is at most that for the path graph on the same number of vertices. We will discuss a proof of this conjecture for certain classes of graphs, including outerplanar and threshold graphs, by studying how graph operations affect zero forcing sets. This is based on joint work with Anurag Singh.

Kristina Ago
University Of Novi Sad

On The Sharpest Upper Bound On The Mp-Ratio: Approaching The Problem By Geometric Insights

Abstract

It is easy to observe that every finite word over an n-ary alphabet contains a (scattered) palindromic subword whose length is at least $\lceil \frac{|w|}{n} \rceil$: for example, a palindrome that contains all occurrences of a prevalent letter from w. Words in which there are no palindromic subword longer than this are called *minimal-palindromic*. The quotient $\frac{|rws|}{|w|}$, where r and s are such that the word rws is minimal-palindromic and the length $|r|+|s|$ is the minimal possible, is called the *MP-ratio* of the word w.

In a recent work, it is shown that the MP-ratio is well-defined for words over alphabets of any size (originally, it was defined only for the binary case, leaving unresolved the question of the possibility of extending the definition to larger alphabets). However, it is still open what the sharpest upper bound on the MP-ratio for words of a given arity is; so far, all that can be said is that, for n-ary words, the answer is somewhere between $2n$ and $\sim n2^{\frac{n}{2}}$, while the explicit values are known only for the binary case: the answer is 4, and for the ternary case: the answer is 6. An approach employed for this latter result (by the same duo from this talk) uses, in one part of the proof, a certain geometric perspective of looking at the matters, by introducing some mappings on a sequence of letters of a given word that are motivated by Euclidean isometries (in particular, reflections and translations) and relying on them for the analysis.

In this talk, we present some newer results on the MP-ratio. A central spot will be occupied by further development of such geometric methods and discussing how they can be eventually applied to find the sharpest upper bound on the MP-ratio for 4-ary words.

This is a joint work with B. Bašić.

Lorenzo Vecchi
KTH Royal Institute Of Technology
Chow Functions For Partially Ordered Sets

Abstract

Three decades ago, Stanley and Brenti initiated the study of the Kazhdan–Lusztig–Stanley (KLS) functions, putting on common ground several polynomials appearing in algebraic combinatorics, discrete geometry, and representation theory. In this talk we present a theory that parallels the KLS theory. To each kernel in a given poset, we associate a function in the incidence algebra that we call the Chow function. The Chow function often exhibits remarkable properties, and sometimes encodes the graded dimensions of a cohomology or Chow ring. The framework of Chow functions provides natural polynomial analogs of graded module decompositions that appear in algebraic geometry, but that work for arbitrary posets, even when no graded module decomposition is known to exist. In this general framework, we prove a number of unimodality and positivity results without relying on versions of the Hard Lefschetz theorem. Our framework shows that there is an unexpected relation between positivity and real-rootedness conjectures about chains on face lattices of polytopes by Brenti and Welker, Hilbert–Poincaré series of matroid Chow rings by Ferroni and Schröter, and flag enumerations on Bruhat intervals of Coxeter groups by Billera and Brenti. This is joint work with Luis Ferroni and Jacob Matherne https://arxiv.org/abs/2411.04070.

Mario Osvin Pavcevic
University Of Zagreb, Croatia
On Higher-Dimensional Symmetric Designs

Abstract

We study two kinds of generalizations of symmetric block designs to higher dimensions. On one hand, we study n-dimensional binary matrices, the so-called n-cubes, such that all their 2-dimensional slices are incidence matrices of symmetric designs. A known construction of these objects obtained from difference sets is generalized so that the resulting n-cubes may have inequivalent slices, while previously known constructions of n-dimensional designs all give examples with equivalent slices.The second generalization is introduced under the name of projection n-cubes. These are n-dimensional v x v x ... x v matrices with binary entries such that its every 2-dimensional projection is an incidence matrix of a symmetric (v,k,l) design. For small parameters (v,k,l) all examples up to equivalence are determined by computer calculations. We also generalize some of the results known for symmetric designs acted upon their automorphism groups to these higher-dimensional generalizations. This talk is a joint work with Vedran Krcadinac and Kristijan Tabak.

Mark Dukes
University College Dublin, Ireland

Symmetries In The Sandpile Model And The Shuffle Conjecture

Abstract

In this talk we will present an overview of a collection of results from the last decade that concern unusual and unexpected symmetries in the Abelian sandpile model. Along the way we will meet several classes of bivariate polynomials, a new class of polyominos that we call sawtooth polyominos, and a new family of graphs terms clique-independent graphs. We will see how this work provides a combinatorial interpretation of some conjectured, and subsequently proven, results from algebraic combinatorics known as the shuffle conjecture.

Mrinmoy Datta
Indian Institute Of Technology Hyderabad

On The Second And Third Minimum Weight Of Projective Reed-Muller Codes

Abstract

Determining the weight distributions of the projective Reed-Muller codes is a very hard problem and has been studied extensively in the literature. We will present the recent progress towards second weight of the projective Reed-Muller codes $\mathrm{PRM}_q(d, m)$ where $m \geq 3$ and $3 \leq d \leq (q+3)/2$. We also classify the codewords that attain this weight. Furthermore, we compute the second weight of $\mathrm{PRM}_q(d, 2)$ for $3 \leq d \leq q$. Furthermore, we give an upper bound for the third weight of $\mathrm{PRM}_q(d, 2)$.

Nancy Clarke
Acadia University

Cops And Robber Pebbling On Graphs

Abstract

Both Cops and Robber and Graph Pebbling can be described by moving tokens (the cops) along the edges of a graph to capture a special token (the robber). In Cops and Robber all tokens move freely, whereas in Graph Pebbling some of the chasing tokens disappear with movement while the robber is stationary. We introduce Cops and Robber Pebbling, a paradigm in which some of the chasing tokens (cops) disappear with movement, while the robber moves freely. We define the cop pebbling number of a graph to be the minimum number of cops necessary to capture the robber in this context, and present upper and lower bounds and exact values, some involving various domination parameters, for an array of graph classes, including paths, cycles, trees, chordal graphs, high girth graphs, and copwin graphs, as well as graph products. Furthermore we show that the analogous inequality for Graham's Pebbling Conjecture fails for cop pebbling and posit a conjecture along the lines of Meyniel's Cops and Robber Conjecture that may hold for cop pebbling. Joint work with J. Forkin and G. Hurlbert.

Nikolina Miholjčić
University Of Novi Sad, Faculty Of Sciences, Serbia

Enumerating Finite Models Of Hilbert's Incidence Axioms

Abstract

The incidence axioms are the first among five groups of Hilbert's axiomatic system, establishing the fundamental framework of the Euclidean geometry. Despite their foundational significance, the study of finite models of these axioms did not really gain significant traction in the literature. This talk summarizes the results so far and present some new approaches on the classification and enumeration of such models.

A finite model is a triple (P, L, Pl) where P is a finite set of points, and L and Pl are some collections of subsets of P, representing lines and planes, respectively. Several classes of such models are presented, having their roots in some well-researched discrete structures, including projective and affine geometries, as well as combinatorial designs and matroids. In particular, the matroid theory was in the core of the recent result in which all the non-isomorphic models with up to 12 points have been enumerated. But it turns out that 12 is an unbreakable limit for the approach employed in that work.

We present some new strategies that can be used to enumerate models with more than 12 points. The main idea is to reframe the problem in a language that makes it susceptible to being addressed by some state-of-the-art algorithms for solving the Boolean satisfiability problem (SAT in short). Although the SAT problem is NP-complete, meaning that, at least in theory, it is hard to solve it, various heuristic SAT algorithms exist (some of them also using randomness in their design) that perform quite well in problems that arise from practice (either from the real-world or from research in other areas). We shall discuss how to redesign the more-than-hundred-year old system of axioms in order to make it prone to the attack by this (hyper)modern method, and we shall analyze by how far this approach can extend the range for the number of points for which the exact number of models can be calculated.

This is a joint work with K. Ago and B. Bašić.

Örs Rebák
UiT The Arctic University Of Norway

Special Values Of Ramanujan's Theta Function $\varphi(q)$

Abstract

In his notebooks, Ramanujan determined several explicit values for his theta function $\varphi(q)$. On page 206 in his lost notebook, Ramanujan provided an enigmatic, incomplete evaluation for $\varphi(e^{-7\pi\sqrt{7}})$, which was recently completed. We present a sketch of the proof. In joint work with Bruce C. Berndt, we develop general cubic and quintic analogues, and in joint work with Sun Kim, we present a ninth degree analogue of Ramanujan's now completed septic formula. It turns out that some of the values are expressible in terms of trigonometric function values. As corollaries, we are able to determine several new values of $\varphi(e^{-\pi\sqrt{n}})$.

Patric Östergård
Aalto University, Finland
Classifying Generalized Howell Designs

Abstract

"A t-GHD$_k(s, v; \lambda)$ generalized Howell design is an $s \times s$ array, each cell of which is either empty or contains a k-subset of elements of some set X of size v such that (i) each element of X appears exactly once in each row and in each column and (ii) no t-subset of elements from X appears in more than λ cells. Computer-aided classification of such designs is here considered in the framework of permutation codes with specific properties. Computations show among other things that there is a unique 2-GHD$_3(7, 18; 1)$; that there are 340 2- GHD$_3(7, 21; 1)$ (correcting an earlier result); and that the known 2-GHD$_5(8, 40; 1)$ is unique. Double counting is used to validate the results."

Peter Danziger
Toronto Metropolitan University
Packing Designs With Large Block Size

Abstract

Given positive integers v, k, t and λ with $v \geq k \geq t$, a packing design $\mathrm{PD}_\lambda(v,k,t)$ is a pair $(V,\mathcal{B})$, where V is a v-set and $\mathcal{B}$ is a collection of k-subsets of V such that each t-subset of V appears in at most λ elements of $\mathcal{B}$. When $\lambda = 1$, a $\mathrm{PD}_1(v,k,t)$ is equivalent to a binary code with length v, minimum distance $2(k-t+1)$ and constant weight k. The maximum size of a $\mathrm{PD}_\lambda(v,k,t)$ is called the packing number, denoted $\mathrm{PDN}_\lambda(v,k,t)$.

We consider packing designs with $t = 2$ and k large relative to v. In this case, we extend the second Johnson bound to arbitrary λ and show that this bound is tight. Specifically, we prove that for a positive integer n, $\mathrm{PDN}_\lambda(v,k,2) = n$ whenever $nk - \binom{n}{\lambda+1} \leq \lambda v < (n+1)k - \binom{n+1}{\lambda+1}$. We also extend this result to directed packings, by showing that if no point appears in more than three blocks, then the blocks of a $\mathrm{PD}_2(v,k,2)$ can be directed so that no ordered pair occurs more than once.

Joint work with Andrea Burgess, Daniel Horsley and Muhammad Tariq Javed

Péter Pál Pach
Hun-Ren Rényi Institute

Product Representation Of Perfect Cubes

Abstract

In this talk, we will investigate the largest possible size of a subset of $\{1, 2, \ldots, n\}$ that does not contain k distinct elements (for a fixed k) whose product is a perfect cube. The analogous problem about avoiding products equaling a perfect square was studied by Erdős, Sárközy and T. Sós, and very recently, also by Tao. In the case of perfect cubes we provide bounds for $k = 2, 3, 4, 6$ and 9, furthermore, in the general case, as well. In particular, we refute an 18-year-old conjecture of Verstraëte. In our proofs we combine graph theoretic tools with further combinatorial and number theoretic ideas. Joint work with Zsigmond Fleiner, Blanka Kövér, Márk Juhász and Csaba Sándor.

Petr Lisonek
Simon Fraser University

On A New Class Of Hadamard Matrices

Abstract

In this talk we focus on the class of complex Hadamard matrices called S-Hadamard, which satisfy the additional condition that the element-wise product of the matrix with itself (Schur product) is also a complex Hadamard matrix. We will discuss algebraic constructions of such matrices, as well as various methods that can be employed for computational constructions. Our computational results are partially based on the classification of Butson Hadamard matrices by P. Lampio, P. Östergård and F. Szöllősi (Math. Comp. 2020). Our recently discovered parametric construction provides further insight into possible structure of these matrices. Existence results will be presented; for some matrix orders the existence question remains open. The study of these matrices is motivated by an application in quantum information theory (P. Lisonek, Theor. Comp. Sci. 2019). This is joint work with Jasleen Phangara.

Petter Brändén
KTH Royal Institute Of Technology

Totally Nonnegative Matrices, Chain Enumeration And Zeros Of Polynomials

Abstract

We prove a general theorem that relates totally nonnegative matrices to chain enumeration in partially ordered sets, and f-vectors of simplicial complexes and posets. It is used to develop a general theory for chain enumeration in posets and zeros of chain polynomials. The results obtained extend and unify results of the speaker, Brenti, Welker and Athanasiadis. In the process we define a notion of h-vectors for a large class of posets which generalize the notions of h-vectors associated to simplicial and cubical complexes. We also use the methods developed to answer an open problem posed by Forgács and Tran on the real-rootedness of polynomials arising from certain bivariate rational functions. This is joint work with Leonardo Saud Maia Leite.

Rohinee Joshi
TU Delft

θ-Free Matching Covered Graphs

Abstract

A nontrivial connected graph is matching covered if each edge belongs to some perfect matching. For most problems pertaining to perfect matchings, one may restrict attention to matching covered graphs; thus, there is extensive literature on them. A cornerstone of this theory is an ear decomposition result due to Lovász and Plummer. Their theorem is a fundamental problem-solving tool, and also yields interesting open problems; we discuss two such problems, and we solve one of them. A subgraph H of a graph G is conformal if $G-V(H)$ has a perfect matching. This notion is intrinsically related to the aforementioned ear decomposition theorem — which implies that each matching covered graph (apart from K2 and even cycles) contains a conformal bisubdivision of θ, or a conformal bisubdivision of K4, possibly both. (Here, θ refers to the graph with two vertices joined by three edges.) This immediately leads to two problems: characterize θ-free (likewise, K4-free) matching covered graphs. A characterization of planar K4-free matching covered graphs was obtained by Kothari and Murty [J. Graph Theory, 82 (1), 2016]; the nonplanar case is still open. We provide a characterization of θ-free matching covered graphs that immediately implies a poly-time algorithm for the corresponding decision problem. Our charac- terization relies heavily on a seminal result due to Edmonds, Lovász and Pulleyblank [Combinatorica, 2, 1982] pertaining to the tight cut decomposition theory of matching covered graphs. We also provide two upper bounds on the size of a θ-free graph, namely, $m \leq 2n-1$ and $m \leq 3n/2+b-1$, where b denotes the number of bricks obtained in any tight cut decomposition of the graph; for each bound, we provide a characterization of the extremal. The Petersen graph as well as K4 play a key role in our results.

Sara Ban Martinović
University Of Rijeka, Faculty Of Mathematics

Construction Of Extremal Type II $\mathbb{Z}_8$***-Codes***

Abstract

The subject of this talk is a construction of new extremal Type II $\mathbb{Z}_8$-codes using doubling method.

Extremal Type II $\mathbb{Z}_8$-codes are a class of self-dual $\mathbb{Z}_8$-codes with Euclidean weights divisible by 16 and the largest possible minimum Euclidean weight for a given length.

We introduce a doubling method for constructing a Type II $\mathbb{Z}_{2k}$-code of length n from a known Type II $\mathbb{Z}_{2k}$-code of length n. Based on this method, we develop an algorithm to construct new extremal Type II $\mathbb{Z}_8$-codes starting from an extremal Type II $\mathbb{Z}_8$-code of type $(\frac{n}{2}, 0, 0)$ with an extremal $\mathbb{Z}_4$-residue code and length $24, 32$ or 40.

We construct at least ten new extremal Type II $\mathbb{Z}_8$-codes of length 32 and type $(15, 1, 1)$. Extremal Type II $\mathbb{Z}_8$-codes of length 32 of this type were not known before. Moreover, the binary residue codes of the constructed extremal $\mathbb{Z}_8$-codes are optimal $[32, 15]$ binary codes.

This is joint work with Sanja Rukavina.

Sergey Kitaev
University of Strathclyde, UK

Naturally labelled posets and a hierarchy related to interval orders

Abstract

A partially ordered set (poset) $(P, \leq_P)$ is naturally labelled by numbers in $\{1, 2, \ldots, n\}$ if $x <_P y$ implies $x < y$. Naturally labelled posets are in one-to-one correspondence with certain lower triangular binary matrices called poset matrices.

By restricting naturally labelled posets – such as considering $(2+2)$-free, k-free, $(3+1)$-free, N-free, and similar classes of posets – we obtain combinatorial objects that fit nicely into a hierarchy related to interval orders. This hierarchy includes, for example, Fishburn matrices, factorial posets, ascent sequences, pattern-avoiding permutations, and many other structures. In particular, it turns out that (2+2,3)-free naturally labelled posets are in one-to-one correspondence with permutations avoiding the vincular pattern $12-34$.

In my presentation, I will introduce these objects and discuss the hierarchy, along with open (embedding) problems.

This is joint work with David Bevan and Gi-Sang Cheon.

Silvia Pagani
Università Cattolica Del Sacro Cuore, Brescia (Italy)
Heffter Arrays From A Discrete Tomography Perspective

Abstract

Heffter arrays have received a lot of attention in the last decade, not only for being interesting combinatorial objects in themselves, but also for their connections to several other areas, such as graph decomposition and design theory. They are (partially) filled matrices whose entries are in a cyclic group and satisfy some additional constraints. Each Heffter array may be seen as the displacement of two orthogonal Heffter systems. One of the main features of an integer Heffter array is that all its rows and columns sum to zero (in $\mathbb{Z}$), so they may be interpreted as ghosts in discrete tomography.

In this talk we exploit classical constructions for tomographic ghosts to obtain integer Heffter arrays and, more generally, r mutually orthogonal Heffter systems for any positive integer r. We will discuss similarities and possible generalizations.

This is a joint work with Paolo Dulio (Politecnico di Milano).

Subbarao Venkatesh Guggilam
UiT - The Arctic University Of Norway, TromsØ

A Formal Power Series Approach To Multiplicative Dynamic Feedback Interconnection

Abstract

The goal of the paper is multi-fold. First, an explicit formula is derived to compute the non-commutative generating series of a closed-loop system when a (multi-input, multi-output) plant, given in Chen–Fliess series description is in multiplicative output feedback interconnection with another system, also given as Chen–Fliess series. Furthermore, it is shown that the multiplicative dynamic output feedback connection has a natural interpretation as a transformation group acting on the plant. A computational framework for computing the generating series for multiplicative dynamic output feedback is devised utilizing the Hopf algebras of the coordinate functions corresponding to the shuffle group and the multiplicative feedback group. The pre–Lie algebra in multiplicative feedback is shown to be an example of Foissy's com-pre-Lie algebras indexed by matrices with certain structure.

Sudhir R. Ghorpade
Indian Institute Of Technology Bombay, India

Determinantal Varieties, Linear Codes, And Rook Placements

Abstract

Algebraic varieties defined by the vanishing of all the minors of a fixed size of a generic matrix, that is, a rectangular matrix whose entries are independent indeterminates over a base field, are known determinantal varieties. These are classical objects that arise in many parts of mathematics, including algebraic geometry, invariant theory, combinatorics and representation theory. It turns out that when the base field is finite, these varieties give rise to an interesting class of linear error correcting codes.

We will discuss a number of results and conjectures concerning fundamental parameters of these linear codes and some recent progress. We will also outline connections of some of these fundamental parameters with the number of nonattacking rook placements on a chessboard of arbitrary width.

This is a joint work with Mahir Bilen Can, and it builds upon prior joint work with Peter Beelen and Sartaj Ul Hasan.

Sylwia Cichacz-Przeniosło
AGH Unbiversity
Magic Squares On Abelian Groups

Abstract

Let $(\Gamma, +)$ be an Abelian group of order n^2 and $GM_\Gamma(n)$ be an $n \times n$ array whose entries are all elements of Γ. Then $GM_\Gamma(n)$ is a Γ-magic square if all row, column, main and backward main diagonal sums are equal to the same element $\mu \in \Gamma$. In this talk we will show a construction of $GM_\Gamma(n)$ for any Abelian group Γ of order n^2, $n > 2$, that is based on complete mappings of Γ.

Trygve Johnsen
UiT - The Arctic University Of Norway
Evaluation Codes From G-Invariant Polynomials

Abstract

Abstract: Several papers have appeared recently, describing how one can produce codes by evaluating linear systems of G-invariant polynomials in n variables (and coefficients in a finite field F), at so-called distinguished points in n-space over F (meaning that all n coordinates are different), where G is a subgroup of the symmetric group in n variables. The group G is typically the full symmetric group or the alternating group . We will present some techniques for determining parameters for such codes, and derived codes, and give an assessment of the properties of the codes.

Tuomo Valtonen
Aalto University

Novel Non-Affine Families Of 8x8 Complex Hadamard Matrices

Abstract

Six non-affine 3-parameter families of 8×8 complex Hadamard matrices are presented. The families are mutually inequivalent as well as inequivalent to any previously known families in the literature. Each family arises from uni- modular points of an algebraic variety defined by palindromic polynomials. For five of the families, the corresponding system of polynomials is solved, and bounds that guarantee unimodularity of the solutions are established.