Titles and Abstracts

Systems of Lines: Applications of Algebraic Combinatorics

Very rough draft – please make corrections!

Appleby, Marcus, University of Sydney

Galois symmetries of a SIC-POVM

No abstract

Chaiken, Seth, University at Albany

Resistive networks, linear spaces and Tutte polynomials

No abstract

Chan, Ada, York University

No Title No abstract

Coutinho, Gabriel, University of Waterloo

Lines and covers of graphs

with: Chris Godsil, Hamed Shirazi and Harmony Zhan

The study of the relation between lines and covers of graph dates back to the work of Seidel in 70s. However many questions remain unanswered. In this talk, I will give an overview of what we know, some recent developments and some of the open questions we have.

Dilks, Kevin, University of Minnesota

No Title

No abstract

Duarte, Marco, University of Massachusetts

Parameter Estimation in Compressive Sensing

No abstract

Edman, Robert, University of Minnesota

Monotone Paths on Zonotopes

No abstract

Flammia, Steven, University of Sydney

No Title

No abstract

Grassl, Markus, Universtität Erlangen-Nürnberg & Max Planck Institute for the Science of Light

Unextendible sets of MUBs

In quantum information, Mutually Unbiased Bases (MUBs) correspond to sets of pairwise complementary observables. The maximal number of such bases in a system of dimension d is $d + 1$, and construction of maximal sets achieving this bound are known only if the dimension is a prime power. For other dimensions, we have a lower bound of three bases, and for infinitely many dimensions, we do not know how to improve this lower bound. For specific constructions, we can show that they do not achieve the upper bound. On the other hand, even in prime power dimensions where the maximal number of MUBs can be constructed, there are unextendible sets of smaller size. We will present results of our work in progress on this topic.

Greaves, Gary, Tohoku University
Equiangular lines in Euclidean spaces Given some dimension d, what is the maximum number of lines in $\mathbb{R}^d$ such that the angle between any pair of lines is constant? This classical problem has recently enjoyed a renewed interest due to the current attention the quantum physics community is giving to its complex analogue. I will report on some new developments of the theory of equiangular lines in Euclidean spaces. Among other things, I will present improvements to two long standing upper bounds for equiangular lines in dimensions 14 and 16. This talk is based on joint work with Jack Koolen, Akihiro Munemasa, and Ferenc Szöllősi.

Guo, Krystal, Simon Fraser University
No Title No abstract

Hamzehei, Shermin, University of Massachusetts Amherst
Compressive Parameter Estimation via Approximate Message Passing

with: M. Duarte

The literature on compressive parameter estimation has been mostly focused on the use of sparsity dictionaries that encode a sampling of the parameter space; these dictionaries, however, suffer from coherence issues that must be controlled for successful estimation. We propose the use of statistical parameter estimation methods within the approximate message passing (AMP) algorithm for signal recovery. Our proposed work leverages the recently highlighted connection between statistical denoising methods and the thresholding step commonly used during recovery. As an example, we consider line spectral estimation by leveraging the well-known Root MUSIC algorithm. Numerical experiments show significant improvements in estimation performance.

Ihringer, Ferdinand, Justus Liebig University Giessen
On the Existence of Large Codes in Finite Geometries No abstract

Momihara, Koji, Kumamoto University
Distance sets on circles

with: Masashi Shinohara

An n-point k-distance set on the unit sphere $S^t \subset \mathbb{R}^{t+1}$ is a set X of n points on S^t such that exactly k Euclidean distances occur between two distinct points in X. In this paper,

we treat distance sets on S^1, and show that if k is small enough relative to n, then X lies on a regular polygon. More precisely, we prove that for an n-point k-distance set X on S^1 with $n \geq 4$, if $k < 3t$ or $3t-2$ according as $n = 4t, 4t-1$ or $n = 4t-2, 4t-3$, then X lies on a regular $2k$ or $(2k+1)$-sided polygon. Furthermore, we see that this bound can not be improved any more. Also, we find an application of Kneser's addition theorem to distance sets on circles.

Munemasa, Akihiro, Tohoku University
Complex Hadamard matrices and imprimitive three-class association schemes

with: Takuya Ikuta

No abstract

O'Catháin, Padraig, Monash / Aalto
Almost equiangular lines

Hadamard matrices and pairwise balanced designs can be used to construct sets lines which are almost equiangular. In this talk I will outline a general construction and show how the properties of the system of lines depends on the properties of the designs used in the construction. Finally, I will show how the recent breakthrough results of Keevash on the existence of designs imply strong asymptotic existence results for almost equiangular lines.

Paffenroth, Randy, WPI
compressed sensing

No abstract

Polyanskiy, Yury, MIT
On metric properties of maps between Hamming spaces and related graph homomorphisms

The classical question in coding theory is to find the maximal number of points in the Hamming space with a given lower bound on pairwise distance. The best known upper bound on this number is obtained via Delsarte's linear programming (i.e. by bounding Schrijver ϑ-function).

In this talk the following extension of the coding problem is studied: A mapping of k-bit strings into n-bit strings is called an (α, β)-map if k-bit strings which are more than αk apart are mapped to n-bit strings that are more than βn apart. Equivalently, an (α, β)-map is a graph homomorphism between certain graphs on the hypercube. We develop and apply tools based on Schrijver's ϑ-function for testing when such homomorphisms are possible.

For $n > k$ the non-existence results on (α, β) are proved by invoking the asymptotic results on θ-function of McEliece, Rodemich, Rumsey and Welch (1977), Samorodnitsky (2001) as well as an exact solution of Delsarte's linear program for $d > n/2$. Among other things, these bounds show that for $\beta > 1/2$ and n/k – integer, the repetition map achieving $\alpha = \beta$ is best possible. For $n < k$ a quantitative version of the no-homomorphism lemma is used together with Kleitman's theorem, which precisely characterizes the diameter-volume tradeoff in Hamming space.

Finally, the question of constructing good linear (α, β) maps is shown to be equivalent to finding certain extremal configurations of points in (finite) projective spaces. Consequently, implications of our results for projective geometry over $\mathbb{F}_2$ is given. Time permitting we will also mention how Kneser conjecture shows obstructions to existence of (α, β)-maps."

Romberg, Justin, Georgia Tech

Solving Underdetermined Linear Systems and Overdetermined Quadratic Systems of Equations

Over the past decade, a rich mathematical theory has been developed around the fundamental problem of when a system of underdetermined equations can be meaningfully "inverted". The central message of this body of work is that if a solution has a type of expected structured, it can often be found from many fewer equations from unknowns. Two examples of structure would be if the unknown entity is a vector which is sparse (has only a few "active" entries) or if it is a matrix which is low rank. We discuss some of the applications of this theory in signal processing and statistics.

Next, we will discus how some of these structured recovery results give us new insights into solving systems of quadratic and bilinear equations. In particular, we can derive conditions on when these types of equations can be solved in the context of some common imaging and communications applications.

Rooney, Brendan, University of Waterloo

Vector Colourings of Distance-Regular Graphs

with: Chris Godsil, David Roberson, Robert Samal, Antonios Varvitsiotis

A *vector colouring* of a graph G maps the vertices of G to vectors in $\mathbb{R}^m$. The goal is to map adjacent vertices to vectors that are far apart. We will look at representations of a graph on its least eigenspace as examples of vector colourings. For distance-regular graphs, these colourings are optimal.

Furthermore, by looking at a space of symmetric matrices derived from the representation, we can show that these colourings are unique. This gives us a tool for proving that various classes of distance-regular graphs are cores. We also present some computational work on strongly regular graphs that supplies evidence for a conjecture of Cameron and Kazanidis.

Servatius, Brigitte, WPI

Dimension of a point-line configuration

Given a point-line configuration in the plane, what is the highest dimension it lifts to? We only know the answer for a few classical configurations.

Suda, Sho, Aichi University of Education

Semidefinite programming for complex spherical codes

No abstract

Tamon, Christino, Clarkson University

No Title

No abstract

Tanaka, Hajime, Tohoku University

A semidefinite programming approach to a cross-intersection problem with measures

with: Sho Suda and Norihide Tokushige

We present a semidefinite programming approach to bound the measures of cross-independent pairs in a bipartite graph. This can be viewed as a far-reaching extension of Hoffman's ratio bound on the independence number of a graph. As an application, we solve a problem on the maximum measures of cross-intersecting families of subsets with two different product measures, which is a generalized measure version of the Erdős-Ko-Rado theorem for cross-intersecting families with different uniformities.

Taniguchi, Tetsuji, Hiroshima Institute of Technology

A representation of Hoffman graphs

We introduce a Hoffman graph and its representation. Moreover we talk about some results and problems.

Terwilliger, Paul, University of Wisconsin

Q-polynomial distance-regular graphs and the q-Onsager algebra

For a Q-polynomial distance-regular graph of q-Racah type, the adjacency matrix A and dual adjacency matrix A^* satisfy the q-Dolan/Grady relations. These are the defining relations for the q-Onsager algebra. In this talk we describe how the q-Onsager algebra is related to the positive part of the quantum algebra $U_q(\widehat{\mathfrak{sl}}_2)$.

Waldron, Shayne, University of Auckland

Calculating the symmetries of a tight frame

No abstract

Wilson, Richard M, Caltech

Combinatorial consequences and extensions of a simple inequality for matrices

Let M be a matrix of order n and of rank r. Let s be the number of distinct off-diagonal entries of M and assume that none of these values occur on the diagonal of M. Then

$$n \leq \binom{r+s}{s}.$$

For example, one immediate consequence is that the multiplicity of an eigenvalue $\lambda \neq 1, 0, -1$ of a $(0,1)$-matrix is less than $n - \sqrt{2n} + 2$.

Our talk will discuss applications and generalizations of this inequality. We recover known inequalities on systems of sets with restricted intersections and sets of points with restricted distances. In case the entries of M are integers, we give necessary conditions for equality and, under certain conditions, can reduce the bound for n to

$$n \leq \binom{r+t}{t}$$

with $t < s$.

Yu, Wei-Hsuan, Michigan State University
Equiangular lines and spherical designs

with: Alexander Barg, Takayuki Okuda

We determine the maximum size of equiangular lines in $\mathbb{R}^n$ for $24 \leq n \leq 41$ and $n = 43$. We will discuss the relation between equiangular lines and spherical t-designs.

Zhan, Harmony, University of Waterloo **Equiangular Lines and Covers of the Complete Graph**

with: Chris Godsil, Gabriel Coutinho, Mirhamed Shirazi

No abstract