

## Plenary Lectures

**Rajendra Bhatia**, Indian Statistical Institute, Hans Schneider Prize Speaker, Thursday, 8:00, Hoover 2055

*Another metric, another mean*

### Abstract

The geometric mean of several positive definite matrices has been extensively studied in recent years, and has been much talked about in recent ILAS meetings. This mean is defined as the solution to a least squares problem with respect to a Riemannian metric on the space of positive definite matrices. There is another very interesting metric that gives rise to the Bures-Wasserstein distance much used in quantum information and in optimal transport. We will describe some features of this distance, and the associated two-variable and several-variable mean.

**Hal Caswell**, University of Amsterdam, Tuesday, 13:45, Hoover 2055

*Matrix population models: Connecting individuals and populations*

### Abstract

The dynamics of populations depend on the survival, fertility, development, and movement of individuals. Individuals differ in those processes depending on their age, size, developmental stage, health status, physiological condition, past history, or a host of other variables. Formulating these dynamics as matrix operators has provided a rich framework for theoretical and applied population ecology. Indeed, the Perron-Frobenius theorem may have been invoked more frequently than any other mathematical result in conservation biology.

This talk will survey some recent developments that have opened new perspectives on the connection of individuals and populations, and that may be of interest to fans of linear algebra. These developments have inspired a tighter link between matrix population models and absorbing Markov chains, including Markov chains with rewards. As models for individual development, the results include the moments of lifetime reproductive output, lifetime income, and lifetime experience of health outcomes. One of the conclusions is an increased appreciation for the importance of individual stochasticity and unobserved heterogeneity as sources of variance in demographic outcomes. This research has been supported by ERC Advanced Grant 322989, NWO Project ALWOP.2015.100, and NSF Grant DEB-1257545.

**Chris Godsil**, University of Waterloo, Friday, 10:30, Hoover 2055

*Graph invariants from quantum walks*

### Abstract

Work in quantum computing leads physicists to ask questions about matrices of the form  $\exp(itM)$ , where  $M$  is the adjacency (or Laplacian) matrix of a graph. Such a family of matrices defines what is known as a *continuous quantum walk*. Questions raised by physicists about these walks lead to a number of interesting mathematical problems; the basic goal is to derive properties of the associated quantum system from properties of the underlying graph. In my talk I will discuss some of these problems, but I will actually focus on some new graph invariants that have arisen from

work in this area. (These can be defined without use of the words "physics" or "quantum" but are nonetheless interesting.)

**Stefan Güttel**, The University of Manchester, SIAG-LA Lecturer, Thursday, 14:35, Hoover 2055  
*The Nonlinear Eigenvalue Problem*

**Abstract**

Given a matrix-valued function  $F : \mathbb{C} \supseteq \Omega \rightarrow \mathbb{C}^{n \times n}$ , the basic nonlinear eigenvalue problem consists of finding scalars  $z \in \Omega$  for which  $F(z)$  is singular. Such problems arise in many areas of computational science and engineering, including acoustics, control theory, fluid mechanics, and structural engineering.

In this talk I will discuss some interesting mathematical properties of nonlinear eigenvalue problems and then review recently developed algorithms for their numerical solution. Emphasis will be given to the linear algebra problems to be solved in these algorithms and to the choice of parameters.

**Willem Haemers**, Tilburg University, Thursday, 13:45, Hoover 2055  
*Spectral characterizations of graphs*

**Abstract**

Spectral graph theory deals with the relation between the structure of a graph and the eigenvalues (spectrum) of an associated matrix, such as the adjacency matrix  $A$  and the Laplacian matrix  $L$ . Many results in spectral graph theory give necessary conditions for certain graph properties in terms of the spectrum of  $A$  or  $L$ . Typical examples are spectral bounds for characteristic numbers of a graph, such as the independence number, the chromatic number, and the isoperimetric number. Another type of relations are characterizations. These are conditions in terms of the spectrum of  $A$  or  $L$ , which are necessary and sufficient for certain graph properties. Two famous examples are: (i) a graph is bipartite if and only if the spectrum of  $A$  is invariant under multiplication by  $-1$ , and (ii) the number of connected components of a graph is equal to the multiplicity of the eigenvalue 0 of  $L$ .

In this talk we will survey graph properties that admit such a spectral characterization. In the special case that the graph itself is characterized by the spectrum of  $A$  or  $L$ , we say that the graph is determined by the considered spectrum. Although many graphs are not determined by the spectrum of  $A$  or  $L$  it is conjectured that almost all graphs are determined by their adjacency spectrum (and perhaps also by the Laplacian spectrum). We will report on recent results concerning this conjecture.

**Tamara G. Kolda**, Sandia National Laboratories, Tuesday, 8:00, Hoover 2055  
*Tensor Decomposition: A Mathematical Tool for Data Analysis and Compression*

**Abstract**

Tensors are multiway arrays, and tensor decompositions are powerful tools for data analysis and compression. In this talk, we demonstrate the wide-ranging utility of both the canonical polyadic (CP) and Tucker tensor decompositions with examples in neuroscience, chemical detection, and combustion science. The CP model is extremely useful for interpretation, as we show with an example in neuroscience. However, it can be difficult to fit to real data for a variety of reasons. We present a novel randomized method for fitting the CP decomposition to dense data that is more scalable and robust than the standard techniques. The Tucker model is useful for compression and can guarantee the accuracy of the approximation. We show that it can be used to compress massive data sets by orders of magnitude; this is done by determining the latent low-dimensional multilinear manifolds. Lastly, we consider the modeling assumptions for fitting tensor decompositions to data and explain alternative strategies for different statistical scenarios. This talk features joint

work with Woody Austin (University of Texas), Casey Battaglini (Georgia Tech), Grey Ballard (Wake Forrest), Alicia Klinvex (Sandia), Hemanth Kolla (Sandia), and Alex Williams (Stanford University).

**Miklós Pálfi**, Sungkyunkwan University and MTA-DE “Lendület” Functional Analysis Research Group, Taussky-Todd Lecturer, Tuesday, 8:50, Hoover 2055

*On the recent advances in the multivariable theory of operator monotone functions and means*

**Abstract**

The origins of this talk go back to the fundamental theorem of Loewner in 1934 on operator monotone real functions and also to the hyperbolic geometry of positive matrices. Loewner’s theorem characterizing one variable operator monotone functions has been very influential in matrix analysis and operator theory. Among others it lead to the Kubo-Ando theory of two-variable operator means of positive operators in 1980.

One of the nontrivial means of the Kubo-Ando theory is the non-commutative generalization of the geometric mean which is intimately related to the hyperbolic, non-positively curved Riemannian structure of positive matrices. This geometry provides a key tool to define multivariable generalizations of two-variable operator means. Arguably the most important example of them all is the Karcher mean which is the center of mass on this manifold. This formulation enables us to define this mean for probability measures on the cone of positive definite matrices extending further the multivariable case. Even the infinite dimensional case of positive operators is tractable by abandoning the Riemannian structure in favor of a Banach-Finsler structure provided by Thompson’s part metric on the cone of positive definite operators. This metric enables us to develop a general theory of means of probability measures defined as unique solutions of nonlinear operator equations on the cone, with the help of contractive semigroups of nonlinear operators. The order preserving property of operator means and operator monotone functions are crucial in this theory.

We also introduce the recently established structure theory of multivariable operator monotone functions extending the classical result of Loewner into the non-commutative multivariable realm of free functions, providing theoretically explicit closed formulas for our multivariable operator means.

**Vern Paulsen**, University of Waterloo, Monday, 8:30, Hoover 2055

*Quantum Chromatic Numbers*

**Abstract**

The chromatic number of a graph can be characterized as the minimal  $c$  for which a perfect deterministic strategy exists for a game called the  $c$ -coloring game. If instead of giving deterministic the players use classical random variables to produce their answers then the least  $c$  for which the players can win the  $c$ -coloring game with probability one is still the chromatic number.

However, if they are allowed to use the random outcomes of entangled quantum experiments to produce their answers, then the players can win the  $c$ -coloring game with probability one for values of  $c$  that are much smaller than the chromatic number. The least  $c$  for which one can win this game using such quantum probabilities is called the quantum chromatic number of the graph. Computing this integer reduces to finding systems of projection matrices that satisfy certain combinatorial identities.

Also, there are several possible models for the set of quantum probability densities, whether these are all the same or different is related to conjectures of Connes and Tsirelson. These different models lead to several possible variants of the quantum chromatic number.

In this talk, I will introduce these ideas and introduce a free algebra whose representation theory determines the values of these chromatic numbers.

**Helena Šmigoc**, University College Dublin, LAMA Lecturer, Monday, 9:20, Hoover 2055

*From positive matrices to negative polynomial coefficients*

**Abstract**

The nonnegative inverse eigenvalue problem, the problem of characterising all lists of eigenvalues of entry-wise nonnegative matrices, motivated the construction of matrices with nonnegative entries and a given set of eigenvalues. Constructions based on companion matrices proved to be one of the most fruitful approaches to this problem. We will review several different companion-type constructions, and learn about some extensions of classical results on the roots of polynomials developed in the process. The talk concludes with some related results on the coefficients of power series.

Joint work with Richard Ellard (University College Dublin), Thomas Laffey (University College Dublin) and Raphael Loewy (Technion).

**Raf Vandebril**, KU Leuven, ILAS 30th Anniversary LAA Lecturer, Friday, 11:20, Hoover 2055

*Fast and Stable Roots of Polynomials via Companion Matrices*

**Abstract**

In this talk we present a fast and stable algorithm for computing roots of polynomials. The roots are found by computing the eigenvalues of the associated companion matrix. A companion matrix is an upper Hessenberg matrix that is of unitary-plus-rank-one form, that is, it is the sum of a unitary matrix and a rank-one matrix. When running Francis's implicitly-shifted QR algorithm this property is preserved, and exactly that is exploited here.

To compactly store the matrix we will show that only  $3n - 1$  rotators are required, so the storage space is  $O(n)$ . In fact, these rotators only represent the unitary part, but we will show that we can retrieve the rank-one part from the unitary part with a trick. It is thus not necessary to store the rank-one part explicitly. Francis's algorithm tuned for working on this representation requires only  $O(n)$  flops per iteration and thus  $O(n^2)$  flops in total. The algorithm is normwise backward stable and is shown to be about as accurate as the (slow) Francis QR algorithm applied to the companion matrix without exploiting the structure. It is also faster than other  $O(n^2)$  methods that have been proposed, and its accuracy is comparable or better.

**Van Vu**, Yale University, Monday, 13:45, Hoover 2055

*Perturbation with random noise*

**Abstract**

A fundamental problem in linear algebra is: How much do the eigenvalues and eigenvectors change when the matrix is perturbed?

Classical results such as Weyl's bound and Davis-Kahan's theorem provide sharp answers in the deterministic case.

In this talk, we discuss the case when the perturbation is random. It has turned out that the bounds provided by Weyl and Davis-Kahan can be improved significantly in many basic settings. We will present a collection of these results, the intuition behind them, and new open questions.

**Rachel Ward**, University of Texas, Thursday, 8:50, Hoover 2055

*Learning dynamical systems from highly corrupted measurements*

**Abstract**

We consider the problem of learning the governing equations in a system of ODEs from possibly noisy snapshots of the system in time. Using a combination of tools from ergodic theory and compressive sensing, we show that if the governing equations are polynomial of given maximal degree, then the polynomial coefficients can be recovered exactly – even when most of the snapshots are highly corrupted by noise – under certain ergodicity assumptions. Important in high-dimensional

problems, such coefficients can be exactly recovered even when the number of measurements is smaller than the dimension of the polynomial space, assuming the underlying polynomial expansions are sparse. Finally, we present several numerical results suggesting that L1-minimization based recovery algorithms can exactly recover dynamical systems in a much wider regime.

## Mini-Symposia Summary

### MS-1 Linear Algebra Aspects of Association Schemes (Association Schemes):

*Allen Herman and Bangteng Xu*

**Parallel Session 3** Mon., 16:45–18:15, **Room 294**    **Parallel Session 7** Wed., 13:15–14:45, **Room 294**

**Parallel Session 5** Tue., 14:45–16:15, **Room 294**    **Parallel Session 8** Wed., 15:15–16:45, **Room 294**

### MS-2 Combinatorial Matrix Theory: *Minerva Catral and Louis Deaett*

**Parallel Session 1** Mon., 10:40–12:10, **Room 202**    **Parallel Session 10** Thu., 16:00–17:30, **Room 202**

**Parallel Session 4** Tue., 10:10–12:10, **Room 202**    **Parallel Session 11** Fri., 8:00–10:00, **Room 202**

**Parallel Session 9** Thu., 10:10–12:10, **Room 202**

### MS-3 Compressed sensing and matrix completion (Compressed Sensing):

*Simon Foucart and Namrata Vaswani*

**Parallel Session 3** Mon., 16:45–18:15, **Room 202**    **Parallel Session 10** Thu., 16:00–17:30, **Room 204**

**Parallel Session 8** Wed., 15:15–16:45, **Room 268**    **Parallel Session 11** Fri., 8:00–10:00, **Room 268**

### MS-4 Distance problems in linear algebra, dynamical systems and control

(Distance & Dynamical Systems): *Elias Jarlebring and Wim Michiels*

**Parallel Session 4** Tue., 10:10–12:10, **Room 294**

### MS-5 Distances on networks and its applications (Distances on Networks):

*Angeles Carmona, Andres M. Encinas, and Margarida Mitjana*

**Parallel Session 6** Tue., 16:45–18:15, **Room 202**    **Parallel Session 9** Thu., 10:10–12:10, **Room 204**

### MS-6 Linear Algebra Education (Education): *Rachel Quinlan and Megan Wawro*

**Parallel Session 2** Mon., 14:45–16:15, **Room 274**    **Parallel Session 5** Tue., 14:45–16:15, **Room 202**

**Parallel Session 3** Mon., 16:45–18:15, **Room 274**    **Parallel Session 6** Tue., 16:45–18:15, **Room 274**

### MS-7 Linear Algebra and Geometry (Geometry): *Gabriel Larotonda and Alejandro Varela*

**Parallel Session 4** Tue., 10:10–12:10, **Room 204**    **Parallel Session 11** Fri., 8:30–10:00, **Room 290**

### MS-8 Krylov and filtering methods for eigenvalue problems (Krylov & filtering for eigenvalues):

*Jared Aurentz and Karl Meerbergen*

**Parallel Session 2** Mon., 14:45–16:15, **Room 268**    **Parallel Session 9** Thu., 10:10–11:40, **Room 268**

**Parallel Session 6** Tue., 16:45–18:15, **Room 268**

### MS-9 Linear Algebra and Mathematical Biology (Mathematical Biology):

*Julien Arino and Natalia Komarova*

**Parallel Session 2** Mon., 14:45–16:15, **Room 232**    **Parallel Session 6** Tue., 16:45–18:15, **Room 232**

**Parallel Session 3** Mon., 16:45–18:15, **Room 232**    **Parallel Session 7** Wed., 13:15–14:45, **Room 232**

**Parallel Session 5** Tue., 14:45–16:15, **Room 232**

### MS-10 Matrix Analysis: Inequalities, Means, and Majorization (Matrix Inequalities):

*Fumio Hiai and Yongdo Lim*

**Parallel Session 1** Mon., 10:40–12:10, **Room 305**    **Parallel Session 9** Thu., 10:10–12:10, **Room 305**  
**Parallel Session 2** Mon., 15:15–16:15, **Room 305**    **Parallel Session 10** Thu., 16:00–17:30, **Room 268**  
**Parallel Session 7** Wed., 13:45–14:45, **Room 305**

**MS-11 Matrix Polynomials:** *Froilán Dopico and Paul Van Dooren*

**Parallel Session 3** Mon., 16:45–18:15, **Room 268**    **Parallel Session 8** Wed., 15:15–16:45, **Room 232**  
**Parallel Session 5** Tue., 14:45–16:15, **Room 305**    **Parallel Session 10** Thu., 16:00–17:30, **Room 232**

**MS-12 The Nonnegative Inverse Eigenvalue Problem (Nonnegative Inverse Eigenvalue):**  
*Charles R. Johnson and Pietro Paparella*

**Parallel Session 1** Mon., 10:40 – 12:10, **Room 232**    **Parallel Session 11** Fri., 8:00–10:00, **Room 232**

**MS-13 Recent Advancements in Numerical Methods for Eigenvalue Computation (Numerical Eigenvalue Methods):** *James Vogel, Xin Ye, and Jianlin Xia*

**Parallel Session 1** Mon., 10:40 – 12:10, **Room 204**    **Parallel Session 7** Wed., 13:15–14:45, **Room 274**

**MS-14 Numerical Ranges:** *Patrick X. Rault and Ilya Spitkovsky*

**Parallel Session 1** Mon., 10:40 – 12:10, **Room 268**    **Parallel Session 7** Wed., 13:15–14:45, **Room 282**  
**Parallel Session 4** Tue., 10:10–12:10, **Room 268**

**MS-15 Matrix techniques in operator algebra theory (Operator Algebra):**  
*Vern Paulsen and Hugo Woerdeman*

**Parallel Session 1** Mon., 10:40 – 12:10, **Room 294**    **Parallel Session 10** Thu., 16:00–17:30, **Room 294**

**MS-16 Linear Algebra and Positivity with Applications to Data Science (Positivity with Applications):** *Dominique Guillot, Apoorva Khare, and Bala Rajaratnam*

**Parallel Session 2** Mon., 14:45–16:15, **Room 202**    **Parallel Session 9** Thu., 10:10–12:10, **Room 232**  
**Parallel Session 4** Tue., 10:10–12:10, **Room 305**

**MS-17 Linear Algebra and Quantum Information Science (Quantum Information Science):**

*Chi-Kwong Li, Yiu Tung Poon, and Raymond Nung-Sing Sze*

**Parallel Session 3** Mon., 16:45–18:15, **Room 305**    **Parallel Session 10** Thu., 16:00–17:30, **Room 305**  
**Parallel Session 6** Tue., 16:45–18:15, **Room 305**    **Parallel Session 11** Fri., 8:00–10:00, **Room 305**  
**Parallel Session 8** Wed., 15:15–16:45, **Room 305**

**MS-18 Random matrix theory for networks (Random Matrix Theory):**  
*Dustin Mixon and Rachel Ward*

**Parallel Session 8** Wed., 15:15–16:45, **Room 274**    **Parallel Session 9** Thu., 10:10–12:10, **Room 274**

**MS-19 Representation Theory:** *Jonas Hartwig*

**Parallel Session 1** Mon., 10:40 – 12:10, **Room 274**    **Parallel Session 11** Fri., 8:30–10:00, **Room 274**  
**Parallel Session 4** Tue., 10:40–12:10, **Room 274**

**MS-20 Solving Matrix Equations:** *Qing-Wen Wang and Yang Zhang*

**Parallel Session 1** Mon., 10:40 – 12:10, **Room 282**    **Parallel Session 5** Tue., 14:45–16:15, **Room 268**  
**Parallel Session 2** Mon., 14:45–16:15, **Room 294**    **Parallel Session 7** Wed., 13:15–14:45, **Room 268**

**MS-21 Spectral Graph Theory:** *Nair Abreu and Leonardo de Lima*

**Parallel Session 2** Mon., 14:45–16:15, **Room 204**    **Parallel Session 8** Wed., 15:15–16:45, **Room 204**  
**Parallel Session 5** Tue., 14:45–16:15, **Room 204**    **Parallel Session 11** Fri., 8:00–10:00, **Room 204**  
**Parallel Session 7** Wed., 13:15–14:45, **Room 204**

**MS-22 Matrices, Tensors and Manifold Optimization (Tensors and Manifolds):**

*Daniel Kressner and Bart Vandereycken*

**Parallel Session 9** Thu., 10:10–12:10, **Room 294**    **Parallel Session 11** Fri., 8:00–10:00, **Room 294**

**MS-23 Toeplitz Matrices and Riemann Hilbert Problems (Toeplitz Matrices and RH):**

*Jani Virtanen and György Pal Gehér*

**Parallel Session 6** Tue., 17:15–18:15, **Room 282**    **Parallel Session 10** Thu., 16:00–17:30, **Room 282**

**Parallel Session 9** Thu., 10:10–12:10, **Room 282**    **Parallel Session 11** Fri., 8:00–10:00, **Room 282**

**MS-24 Zero Forcing: Its Variations and Applications (Zero Forcing):**

*Daniela Ferrero, Mary Flagg, and Michael Young*

**Parallel Session 3** Mon., 16:45–18:15, **Room 204**    **Parallel Session 7** Wed., 13:45–14:45, **Room 202**

**Parallel Session 6** Tue., 16:45–18:15, **Room 204**    **Parallel Session 8** Wed., 15:15–16:15, **Room 202**

## Mini-Symposia with Speakers

### *MS-1 Linear Algebra Aspects of Association Schemes*

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 294**

16:45 Christopher French, *Realizations of nonsymmetric hypergroups of rank 4 as association schemes*

17:15 Bangteng Xu, *Pseudo-direct sums and wreath products of loose-coherent algebras with applications to coherent configurations*

17:45 Siwaporn Mamart, *Merging in bipartite distance-regular graphs*

**Parallel Session 5** Tuesday, July 25, 14:45 – 16:15, **Room 294**

14:45 Brian Curtin, *Co-split Leonard systems*

15:15 Supalak Sumalroj, *The nonexistence of a distance-regular graph with intersection array  $\{22, 16, 5; 1, 2, 20\}$*

15:45 Paul Terwilliger, *Leonard triples of  $q$ -Racah type and their pseudo intertwiners*

**Parallel Session 7** Wednesday, July 26, 13:15 – 14:45, **Room 294**

13:15 Mitsugu Hirasaka, *On meta-thin association schemes with certain conditions*

13:45 Alyssa Sankey, *Covering configurations derived from weighted coherent configurations*

14:15 Gurmail Singh,  *$C$ -algebras arising from integral Fourier matrices*

**Parallel Session 8** Wednesday, July 26, 15:15 – 16:45, **Room 294**

15:15 Harvey Blau, *Reality-based algebras with a 2-dimensional representation*

15:45 Jason Williford,  *$Q$ -polynomial association schemes with at most 5 classes*

16:15 Sung Yell Song, *Partial geometric designs obtained from association schemes*

### *MS-2 Combinatorial Matrix Theory*

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 202**

10:40 Bryan Shader, *A Matrix Rank Identity with Applications to Combinatorial Matrices*

11:10 Shahla Nasserar, *Distinct eigenvalues of graphs*

11:40 Polona Oblak, *The maximum of the minimal multiplicity of eigenvalues of symmetric matrices whose pattern is constrained by a graph*

**Parallel Session 4** Tuesday, July 25, 10:10 – 12:10, **Room 202**

- 10:10 Ravindra Bapat, *Squared distance matrix of a weighted tree*  
 10:40 Stephen Kirkland, *(0,1) Matrices and the Analysis of Social Networks*  
 11:10 Jane Breen, *Minimising the largest mean first passage time of a Markov chain and the influence of directed graphs*  
 11:40 M<sup>a</sup> José Jiménez, *Triangular matrices and combinatorial recurrences*

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 202**

- 10:10 Richard A Brualdi, *The Permutation and Alternating Sign Matrix Rational Cones*  
 10:40 Louis Deaett, *Matroids and the minimum rank problem for zero-nonzero patterns*  
 11:10 Franklin Kenter, *Computational Approaches for Minimum Rank Problems and their Variations*  
 11:40 Xiaohong Zhang, *Hadamard diagonalizable graphs used to transfer quantum information*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 202**

- 16:00 Judi McDonald, *Spectrally Arbitrary Patterns over Different Fields*  
 16:30 Colin Garnett, *Combinatorial and Algebraic Conditions that preclude SAPpiness*  
 17:00 Kevin Vander Meulen, *Recursive constructions for spectrally arbitrary patterns*

**Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 202**

- 8:00 Zhongshan Li, *Sign patterns that allow diagonalizability*  
 8:30 Wei Gao, *Tree Sign Patterns that Require  $\mathbb{H}_n$*   
 9:00 Xavier Martinez-Rivera, *The signed epr-sequence*  
 9:30 Mohsen Aliabadi, *On matching in groups and vector spaces*

**MS-3 Compressed sensing and matrix completion**

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 202**

- 16:45 Waheed Bajwa, *Collaborative dictionary learning from big, distributed data*  
 17:15 Arian Maleki, *On The Asymptotic Performance of  $\ell_q$ -regularized Least Squares*  
 17:45 Dustin Mixon, *Explicit Restricted Isometries*

**Parallel Session 8** Wednesday, July 26, 15:15 – 16:45, **Room 268**

- 15:15 Hassan Mansour, *A Kaczmarz Method for Low Rank Matrix Recovery*  
 15:45 Rob Nowak, *Low Rank Matrix Completion and Beyond*  
 16:15 Simon Foucart, *Concave Mirsky Inequality and Low-Rank Recovery*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 204**

- 16:00 Paul Hand, *Compressed Sensing from Phaseless Gaussian Measurements via Linear Programming in the Natural Parameter Space*  
 16:30 Rayan Saab, *Phase retrieval from local measurements*  
 17:00 Chinmay Hegde, *Stable inversion of (certain) random periodic feature maps*

**Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 268**

- 8:00 Yuxin Chen, *The Projected Power Method: A Nonconvex Algorithm for Joint Alignment*  
 8:30 Second Speakername, *Second speaker title*  
 9:00 Yuejie Chi, *Provably robust and fast low-rank matrix recovery with outliers*  
 9:30 Namrata Vaswani, *New Results for Provably Correct Dynamic Robust Principal Components Analysis (PCA)*

**MS-4 Distance problems in linear algebra, dynamical systems and control**

**Parallel Session 4** Tuesday, July 25, 10:10 – 12:10, **Room 294**



10:10 Francesco Borgioli, *An iterative algorithm to compute the pseudospectral abscissa for real perturbations of a nonlinear eigenvalue problem*

10:40 Mert Gurbuzbalaban, *Approximating the real structured stability radius with Frobenius norm bounded perturbations*

11:10 Emre Mengi, *Subspace procedures for large-scale stability radius problems*

11:40 Bart Vandereycken, *Subspace acceleration for computing the Crawford number*

**MS-5 Distances on networks and its applications**

**Parallel Session 6** Tuesday, July 25, 16:45 – 18:15, **Room 202**

16:45 Douglas J. Klein, *Intrinsic Metrics on Graphs and Applications*

17:15 Ángeles Carmona, *Matrix Tree Theorem for Schrödinger operators on networks*

17:45 Milan Randić, *Graphical Bioinformatics: The Exact Solution to the Protein Alignment Problem*

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 204**

10:10 Yujun Yang, *A recursion formula for resistance distances and its applications*

10:40 Jiang Zhou, *Resistance distance and resistance matrix of graphs*

11:10 Enric Monsó, *Green's kernel of Schrödinger operators on generalized subdivision networks*

11:40 Andrés M. Encinas, *The effective resistance of extended or contracted networks*

**MS-6 Linear Algebra Education**

**Parallel Session 2** Monday, July 24, 14:45 – 16:15, **Room 274**

14:45 Sepideh Stewart, *Embodied, symbolic and formal worlds: A basis for the vector space of mathematical thinking.*

15:15 Carlos Nicolas, *Teaching combinatorial convexity applications in an undergraduate linear algebra class.*

15:45 Megan Wawro, *Inquiry-Oriented Linear Algebra: An overview and an example.*

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 274**

16:45 Ana Paulina Figueroa, *Multiplying Matrices: an activity based approach.*

17:15 Cathrine Kazunga, *A Rasch Analysis for Teaching linear algebra concepts for the test or setting up students for failure: A case study of a university in a developing country.*

17:45 Damjan Kobal, *Visualizations and the Concept of Proof in Basic Linear Algebra Teaching.*

**Parallel Session 5** Tuesday, July 25, 14:45 – 16:15, **Room 202**

14:45 David Strong, *Motivating Examples, Meaning and Context in Teaching Linear Algebra.*

15:15 Maria Trigueros, *Students learning through a modeling course on elementary Linear Algebra.*

15:45 Christine Andrews-Larson, *Solving Linear Systems: Reconstructing Unknowns to Interpret Row Reduced Matrices.*

**Parallel Session 6** Tuesday, July 25, 16:45 – 18:15, **Room 274**

16:45 Guershon Harel, *The Learning and Teaching of Linear Algebra Through the Lenses of DNR-Based Instruction in Mathematics.*

17:15 Hamide Dogan, *Multi-Faceted Nature of Matrices.*

17:45 Helena Šmigoc, *Using Nonnegative Matrix Factorization to Analyze a Set of Documents.*

**MS-7 Linear Algebra and Geometry**

**Parallel Session 4** Tuesday, July 25, 10:10 – 12:10, **Room 204**

10:10 György Gehér, *Symmetry transformations on Grassmann spaces*

- 10:40 Tin-Yau Tam, *Geometry and unitarily similarity orbit of a matrix*  
 11:10 Eduardo Chiumiento, *Approximation by partial isometries and symmetric approximation of finite frames*

**Parallel Session 11** Friday, July 28, 8:30 – 9:30, **Room 290**

- 8:30 Alejandro Varela, *Short curves in orbits of unitary subgroups*  
 9:00 Martin Argerami, *Matricial and numerical ranges in the classification of small-dimension operator systems*

**MS-8 Krylov and filtering methods for eigenvalue problems**

**Parallel Session 2** Monday, July 24, 14:45 – 16:15, **Room 268**

- 14:45 Yasunori Futamura, *A real-valued method for improving efficiency of a contour integral eigenvalue solver*  
 15:15 Brendan Gavin, *The FEAST Eigenvalue Algorithm with Inexact Solves*  
 15:45 Anthony Austin, *Estimating Eigenvalue Distributions*

**Parallel Session 6** Tuesday, July 25, 16:45 – 18:15, **Room 268**

- 16:45 Vassilis Kalantzis, *Rational filtering Schur complement techniques for the solution of large-scale generalized symmetric eigenvalue problems*  
 17:15 Yousef Saad, *Rational and polynomial filtering, spectrum slicing, and the EVSL package*  
 17:45 Roel van Beeumen, *A rational filtering connection between contour integration and rational Krylov methods for large scale eigenvalue problems*

**Parallel Session 9** Thursday, July 27, 10:10 – 11:40, **Room 268**

- 10:10 Thomas Mach, *Inverse Free Rational Krylov Subspaces for Computing Matrix Functions*  
 10:40 Daan Camps, *On the implicit restart of the rational Krylov method*  
 11:10 Vjieran Hari, *On Element-wise and Block-wise Jacobi Methods for PGEP*

**MS-9 Linear Algebra and Mathematical Biology**

**Parallel Session 2** Monday, July 24, 14:45 – 16:15, **Room 232**

- 14:45 Marc Feldman, *Reduction Principle for recombination, mutation and migration*  
 15:15 Evan Milliken, *A technique to approximate the probability of partial extinction events in metapopulations.*  
 15:45 Jim Cushing, *Some Matrix Population Models with Imprimitve Projection Matrices*

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 232**

- 16:45 Pauline van den Driessche, *Inequalities on Spectral Bounds for Matrices in a Stage-Structured Population Model*  
 17:15 Joe Tien, *Disease spread on networks: integrating structure and dynamics through a generalized inverse*  
 17:45 Gleb Pogudin, *Elimination for nonlinear ODEs arising in biology*

**Parallel Session 5** Tuesday, July 25, 14:45 – 16:15, **Room 232**

- 14:45 Lee Altenberg, *"Error Catastrophes" and the Information Content of the Perron vector in Quasispecies Models of Evolution*  
 15:15 Zhijun Wu, *Computing Dense versus Sparse Equilibrium States for Evolutionary Games*  
 15:45 Natalia Komarova, *Stability of control networks in stem cell lineages*

**Parallel Session 6** Tuesday, July 25, 16:45 – 18:15, **Room 232**

- 16:45 Patrick De Leenheer, *The population dynamics of a fish species subject to environmental stochasticity*

- 17:15 Julien Arino, *The population dynamics of a fish species subject to environmental stochasticity*  
 17:45 Mark Artzrouni, *A Leslie matrix model for Sicyopterus lagocephalus in La Reunion: sensitivity, uncertainty and research prioritization*

**Parallel Session 7** Wednesday, July 26, 13:15 – 14:45, **Room 232**

- 13:15 Jonathan Smith, *Virtual species and matrix solution of Eigen's equations*  
 13:45 Vladimir Protasov, *How to find the closest stable nonnegative matrix?*  
 14:15 Bruce Ayati, *Mathematics for Musculoskeletal Diseases*

**MS-10 Matrix Analysis: Inequalities, Means, and Majorization**

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 305**

- 10:40 Jimmie Lawson, *The Karcher Barycentric Map for Positive Operator Probability Measures on Hilbert Space*  
 11:10 Sejong Kim, *An order inequality characterizing Cartan barycenters of positive definite matrices*  
 11:40 Takeaki Yamazaki, *Properties of weighted operator means via generalized relative operator entropy*

**Parallel Session 2** Monday, July 24, 15:15 – 16:15, **Room 305**

- 15:15 Yongdo Lim, *Multiplicative Geometric Means*  
 15:45 Masatoshi Ito, *Estimations of power difference mean by Heron mean*

**Parallel Session 7** Wednesday, July 26, 13:45 – 14:45, **Room 305**

- 13:45 Man-Duen Choi, *Some assorted inequalities for positive linear maps*  
 14:15 Fuad Kittaneh, *A generalization of the Ando-Hiai-Okubo trace inequalities*

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 305**

- 10:10 Lajos Molnar, *Order automorphisms in matrix algebras and in operator algebras and their applications*  
 10:40 Douglas Farenick, *Isometries and contractions of density operators relative to the Bures metric*  
 11:10 Frank Hansen, *Peierls-Bogolyubov's inequality for deformed exponentials*  
 11:40 Seung-Hyeok Kye, *Separability of three qubit X-states*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 268**

- 16:00 Pingping Zhang, *Remarks on two determinantal inequalities*  
 16:30 Takashi Sano, *On classes of non-normal matrices/operators*  
 17:00 Fumio Hiai, *Log-majorization and Lie-Trotter formula for the Cartan barycenter*

**MS-11 Matrix Polynomials**

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 268**

- 16:45 Volker Mehrmann, *Port-Hamiltonian linearizations and stability radii for systems arising in acoustic field computation.*  
 17:15 María Isabel Bueno, *A unified approach to Fiedler-like pencils via strong block minimal bases pencils.*  
 17:45 Philip Saltenberger, *Block Kronecker ansatz spaces for matrix polynomials.*

**Parallel Session 5** Tuesday, July 25, 14:45 – 16:15, **Room 305**

- 14:45 Marc Van Barel, *Solving polynomial eigenvalue problems by a scaled block companion linearization.*  
 15:15 Javier Pérez, *Structured backward error analyses of linearized polynomial eigenvalue problems.*

15:45 Leonardo Robol, *Fast and backward stable computation of the eigenvalues of matrix polynomials.*

**Parallel Session 8** Wednesday, July 26, 15:15 – 16:45, **Room 232**

15:15 Steve Mackey, *Majorization and matrix polynomials.*

15:45 Elias Jarlebring, *The infinite bi-Lanczos method for nonlinear eigenvalue problems.*

16:15 Andrii Dmytryshyn, *Generic matrix polynomials with fixed rank and fixed degree.*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 232**

16:00 Paul Van Dooren, *Robustness and perturbations of minimal bases.*

16:30 Silvia Marcaida, *Extended spectral equivalence.*

17:00 Froilán Dopico, *Paul Van Dooren's Index Sum Theorem and the solution of the inverse rational eigenvalue problem.*

**MS-12 The Nonnegative Inverse Eigenvalue Problem**

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 232**

10:40 Elvis Valero, *A recursive condition for "The symmetric nonnegative inverse eigenvalue problem"*

11:10 Pietro Paparella, *A matricial view of the Karpelevič Theorem*

11:40 Carlos Marijuán, *On Symmetric Nonnegative Realizability*

**Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 232**

8:00 Sasmita Barik, *On the spectra of multi-directed bipartite graphs*

8:30 Ricardo Soto, *Structured nonnegative inverse elementary divisors problem*

9:00 Miriam Pisonero, *5-Spectra of Symmetric Nonnegative Matrices*

9:30 Raphael Loewy, *A new necessary condition for the spectrum of nonnegative symmetric  $5 \times 5$  matrices*

**MS-13 Recent Advancements in Numerical Methods for Eigenvalue Computation**

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 204**

10:40 Jonathan Moussa, *Local reduction of Hermitian eigenproblems*

11:10 James Vogel, *A Superfast Multi-Rank Eigenvalue Update: Algorithm, Analysis, and Applications*

11:40 Enyinda Onunwor, *On the Computation of a Truncated SVD of a Large Linear Discrete Ill-Posed Problem*

**Parallel Session 7** Wednesday, July 26, 13:15 – 14:45, **Room 274**

13:15 Tetsuya Sakurai, *Nonlinear Sakurai-Sagiura method for electronic transport calculation*

13:45 James Kestyn, *New Functionality in the FEAST Eigenvalue Solver*

14:15 Guojian Yin, *A FEAST Algorithm with oblique projection for generalized eigenvalue problems*

**MS-14 Numerical Ranges**

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 268**

10:40 Kristin Camenga, *The Gau-Wu number for  $4 \times 4$  matrices.*

11:10 Brian Lins, *Eigenvalue crossings in Hermitian pencils and the boundary of the numerical range*

11:40 Hiroshi Nakazato, *Singular points of the Kippenhahn curves for unitary bordering matrices*

**Parallel Session 4** Tuesday, July 25, 10:10 – 12:10, **Room 268**

10:10 Cesar Palencia, *The numerical range as a spectral set*

- 10:40 Linda Patton, *Numerical ranges with rotational symmetry*  
 11:10 Peng-Ruei Huang, *Cyclic weighted shift matrix with reversible weights*  
 11:40 Patrick Rault, *Numerical ranges over finite fields*

**Parallel Session 7** Wednesday, July 26, 1:15 – 2:45, **Room 282**

- 13:15 Göran Bergqvist, *Curves and envelopes that bound the spectrum of a matrix*  
 13:45 Pan Shun Lau, *The star-shapedness of a generalized numerical range*  
 14:15 Farshid Abdollahi, *Some results on the numerical range of a class of composition operators*

**MS-15 Matrix techniques in operator algebra theory**

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 294**

- 10:40 Lawrence Fialkow, *The core variety and representing measures in multivariable moment problems*  
 11:10 Scott McCullough, *Matrix convex sets defined by non-commutative polynomials*  
 11:40 Hugo J. Woerdeman, *Complete spectral sets and numerical range*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 294**

- 16:00 Radu Balan, *On a Feichtinger Problem for trace-class operators*  
 16:30 John Haas, *Constructions of optimal like packings with DFT matrices*  
 17:00 Eric Weber, *Boundary Representations of Reproducing Kernels in the Hardy Space*

**MS-16 Linear Algebra and Positivity with Applications to Data Science**

**Parallel Session 2** Monday, July 24, 14:45 – 16:15, **Room 202**

- 14:45 Mahya Ghandehari, *Geometric graphs and uniform embeddings*  
 15:15 Alfred Hero, *Continuum limits for shortest paths*  
 15:45 Peter Diao, *Distribution-Free Consistency of Graph Clustering*

**Parallel Session 4** Tuesday, July 25, 10:10 – 12:10, **Room 305**

- 10:10 Nikolas Stott, *Minimal upper bounds in the Loewner order: characterizations and parametrization*  
 10:40 Tanvi Jain, *Hadamard powers of two classes of positive matrices*  
 11:10 Shaun Fallat, *Hadamard Powers, Critical Exponents, and Total Positivity*  
 11:40 Alexander Belton, *A quantitative form of Schoenberg’s theorem in fixed dimension*

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 232**

- 10:10 Ilse Ipsen, *Randomized matrix-free trace and log-determinant estimators*  
 10:40 Helene Massam, *Precision matrix estimation and sampling in coloured graphical Gaussian models*  
 11:10 Caroline Uhler, *Your dreams may come true with MTP2*  
 11:40 Cynthia Vinzant, *Hyperbolicity and reciprocal linear spaces*

**MS-17 Linear Algebra and Quantum Information Science**

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 305**

- 16:45 Nathaniel Johnston, *Quantum Coherence and Quantum Entanglement*  
 17:15 Shmuel Friedland, *Entanglement of Boson quantum states*  
 17:45 Michael Nathanson, *An equivalence between local state discrimination and state transformation in multipartite systems*

**Parallel Session 6** Tuesday, July 25, 16:45 – 18:15, **Room 305**

- 16:45 Dariusz Chruściński, *Positive maps from mutually unbiased bases*

- 17:15 Wai Shing Tang, *Some aspects of 2-positive linear maps on matrix algebras*  
 17:45 Dániel Virosztek, *Quantum  $f$ -divergence preserving maps on positive semidefinite operators acting on finite dimensional Hilbert spaces*

**Parallel Session 8** Wednesday, July 26, 15:15 – 16:45, **Room 305**

- 15:15 Jinchuan Hou, *Entropy exchange for infinite-dimensional systems*  
 15:45 Rajesh Pereira, *The Classical Mathematics Behind Some Concepts in Quantum Information*  
 16:15 Xiaofei Qi, *Measurement-Induced Nonlocality of Gaussian version*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 305**

- 16:00 Schulte-Herbrüggen, *Quantum Systems Theory as Reflected by Numerical Ranges*  
 16:30 Stephan Weis, *A new signature of quantum phase transitions from the numerical range*  
 17:00 Chi-Kwong Li, *Numerical range techniques in quantum information science*

**Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 305**

- 8:00 Jianxin Chen, *Quantum algorithm for multivariate polynomial interpolation*  
 8:30 Debbie Leung, *From embezzlement (of entanglement) to breaking any (conservation) law*  
 9:00 Sarah Plosker, *Quantum state transfer via Hadamard diagonalizable graphs*  
 9:30 Diane Christine Pelejo, *On the Rank of Bipartite States with Prescribed Reduced States*

**MS-18 Random matrix theory for networks**

**Parallel Session 8** Wednesday, July 26, 15:15 – 16:45, **Room 274**

- 15:15 Sam Cole, *A simple algorithm for spectral clustering of random graphs*  
 15:45 Soledad Villar, *Clustering subgaussian mixtures by semidefinite programming*  
 16:15 Amelia Perry, *Message passing algorithms for synchronization problems*

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 274**

- 10:10 Thang Huynh, *Phase Retrieval with Noise and Outliers*  
 10:40 Shuyang Ling, *Fast joint blind deconvolution and demixing via nonconvex optimization*  
 11:10 Hamidreza Hakim Javadi, *Non-negative Matrix Factorization Revisited*  
 11:40 Tingran Gao, *Manifold Learning on Fibre Bundles*

**MS-19 Representation Theory**

**Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 274**

- 10:40 Apoorva Khare, *Generalized nil-Coxeter algebras over complex reflection groups*  
 11:10 Akaki Tikaradze, *On the isomorphism problem of certain algebraic quantizations*  
 11:40 Lisa Schneider, *Multiplicities of Demazure flags*

**Parallel Session 4** Tuesday, July 25, 10:40 – 12:10, **Room 274**

- 10:40 Kayla Murray, *Graded representations of current algebras*  
 11:10 Matthew Lee, *Global Weyl modules for non standard maximal parabolics of twisted affine Lie algebras*  
 11:40 Mark Colarusso, *The Gelfand-Zeitlin integrable system for complex orthogonal Lie algebras*

**Parallel Session 11** Friday, July 28, 8:30 – 10:00, **Room 274**

- 8:30 Miodrag Iovanov, *On incidence algebras and their representations*  
 9:00 Sarah Bockting-Conrad, *Some linear transformations associated with a tridiagonal pair of  $q$ -Racah type*  
 9:30 John Dusel, *Combinatorial generation of multi-highest-weight crystals*

### **MS-20 Solving Matrix Equations**

#### **Parallel Session 1** Monday, July 24, 10:40 – 12:10, **Room 282**

10:40 Eric King-wah Chu, *Projection Methods for Riccati Equations*

11:10 Yan-Fei Jing, *Recent Progress on Block Krylov Subspace Methods for Linear Systems with Multiple Right-hand Sides*

11:40 Jin Liang, *Monotonicity of certain maps of positive definite matrices*

#### **Parallel Session 2** Monday, July 24, 14:45 – 16:15, **Room 294**

14:45 Qing-Wen Wang, *A System of Matrix Equations over the Quaternion Algebra with Applications*

15:15 David Imberti, *Condition Number of Krylov Matrices and Subspaces via Kronecker Product Structure*

15:45 Volha Kushel, *Matrix Scalings and Submatrices*

#### **Parallel Session 5** Tuesday, July 25, 14:45 – 16:15, **Room 268**

14:45 Xingping Sheng, *A relaxed gradient based algorithm for solving generalized coupled Sylvester matrix equations*

15:15 Özlem Esen, *On the Diagonal Stability of Metzler Matrices*

15:45 Lizhu Sun, *Solutions of multilinear systems and characterizations for spectral radius of tensors*

#### **Parallel Session 7** Wednesday, July 26, 13:15 – 14:45, **Room 268**

13:15 Caiqin Song, *On solutions to the matrix equations  $XB - AX = CY$  and  $XB - A\hat{X} = CY$*

13:45 Yang Zhang, *Solving Ore matrix equations*

14:15 Guihai Yu, *The single-Hook immanants of adjacency and Laplacian matrices for complete graph and cycle*

### **MS-21 Spectral Graph Theory**

#### **Parallel Session 2** Monday, July 24, 14:45 – 16:15, **Room 204**

14:45 Domingos Cardoso, *Lexicographic polynomials of graphs and their spectra*

15:15 Mike Tait, *The spectral radius of a graph with no induced  $K_{s,t}$*

15:45 Vilmar Trevisan, *Ordering starlike trees by their indices*

#### **Parallel Session 5** Tuesday, July 25, 14:45 – 16:15, **Room 204**

14:45 Geir Dahl, *Laplacian energy, threshold graphs and majorization*

15:15 Enide Andrade, *A lower bound for the energy of symmetric matrices and graphs*

15:45 María Robbiano,  *$\alpha$ -Adjacency spectra of a compound graph of weighted Bethe trees*

#### **Parallel Session 7** Wednesday, July 26, 13:15 – 14:45, **Room 204**

13:15 Carlos Hoppen, *Eigenvalue location for graphs of small clique-width*

13:45 Aida Abiad, *An application of Hoffman graphs for spectral characterizations of graphs*

14:15 Margarida Mitjana, *Spectra of the generalized subdivision and other extensions of a network*

#### **Parallel Session 8** Wednesday, July 26, 15:15 – 16:45, **Room 204**

15:15 Sebastian Cioaba, *Maximizing the order of a regular graph with given valency and second eigenvalue*

15:45 Leonardo de Lima, *Graphs with all but two eigenvalues in  $[-2, 0]$*

16:15 Suil Oh, *The second largest eigenvalue and vertex-connectivity in regular graphs*

#### **Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 204**

8:00 Gabriel Coutinho, *Quantum walks on trees*

- 8:30 Krystal Guo, *Quantum walks and graph isomorphism*  
 9:00 Jephian C.-H Lin, *Note on von Neumann and Rényi entropies of a graph*  
 9:30 Carolyn Reinhart, *Results on the minimum number of distinct eigenvalues of graphs*

**MS-22 Matrices, Tensors and Manifold Optimization**

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 294**

- 10:10 Nicolas Boumal, *Semidefinite programs with a dash of smoothness: Why and when the low-rank approach Works*  
 10:40 Ju Sun, *When are nonconvex optimization problems not scary?*  
 11:10 Ke Wei, *Guarantees of Riemannian optimization for low rank matrix reconstruction*  
 11:40 Ivan Oseledets, *Optimization over low-rank manifold: new results and applications*

**Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 294**

- 8:00 Alex Gorodetsky, *Low-rank functional decompositions with applications to stochastic optimal control*  
 8:30 Ke Ye, *Tensor network ranks*  
 9:00 Wen Huang, *Intrinsic representation of tangent vectors and vector transport on matrix manifolds*  
 9:30 Sutanoy Dasgupta, *A Geometric framework for density modeling*

**MS-23 Toeplitz Matrices and Riemann Hilbert Problems**

**Parallel Session 6** Tuesday, July 25, 17:15 – 18:15, **Room 282**

- 17:15 Joao Serra, *On the Riemann-Hilbert approach to Einstein's field equations*  
 17:45 Stefano Massei *Computations with semi-infinite quasi-Toeplitz matrices*

**Parallel Session 9** Thursday, July 27, 10:10 – 12:10, **Room 282**

- 10:10 Josh Israelowitz, *Compactness of operators on Bergman and Fock spaces*  
 10:40 Aamena Alqabani, *Fredholm Properties of Toeplitz Operators on Fock Spaces*  
 11:10 Richard Ferro, *A Note on Structured Pseudospectra of Block Matrices*  
 11:40 Santeri Miihkinen, *Strict singularity of a Volterra-type integral operator on  $H^p$*

**Parallel Session 10** Thursday, July 27, 16:00 – 17:30, **Room 282**

- 16:00 Cristina Camara, *Truncated Toeplitz operators and their spectra*  
 16:30 Christophe Charlier, *Thinning and conditioning of the Circular Unitary Ensemble*  
 17:00 Jongrak Lee, *Hyponormality of block Toeplitz operators with circulant matrix function symbols*

**Parallel Session 11** Friday, July 28, 8:00 – 10:00, **Room 282**

- 8:00 Estelle Basor, *Asymptotics of determinants of block Toeplitz matrices*  
 8:30 Robert Buckingham, *Nonintersecting Brownian motions on the unit circle with drift*  
 9:00 Roozbeh Gharakhloo, *On the asymptotic analysis of Toeplitz + Hankel determinants*  
 9:30 Jani Virtanen, *Transition asymptotics of Toeplitz determinants and their applications*

**MS-24 Zero Forcing: Its Variations and Applications**

**Parallel Session 3** Monday, July 24, 16:45 – 18:15, **Room 204**

- 16:45 Chassidy Bozeman, *Zero forcing and power domination*  
 17:15 Boris Brimkov, *Connected zero forcing*  
 17:45 Veronika Furst, *Zero forcing and power domination for tensor products of graphs*

**Parallel Session 6** Tuesday, July 25, 16:45 – 18:15, **Room 204**



16:45 Tracy Hall, *Maehara's Conjecture, the Delta Theorem, and the greedegree of a graph*

17:15 Seth Meyer, *Z sharp forcing*

17:45 Steve Butler, *The  $Z_q$  variation of zero forcing*

**Parallel Session 7** Wednesday, July 26, 13:45 – 14:45, **Room 202**

13:45 Daniela Ferrero, *Power domination and zero forcing in iterated line digraphs*

14:15 Joshua Carlson, *Throttling for variants of zero forcing*

**Parallel Session 8** Wednesday, July 26, 15:15 – 16:15, **Room 202**

15:15 Randy Davila, *Total forcing sets in graphs*

15:45 Mary Flagg, *Nordhaus-Gaddum bounds for power domination*

**Contributed Talks**

*Mohammad Adm*, Recent Applications of the Cauchon Algorithm to the Totally Nonnegative Matrices, Wed. 13:15, Room 290

*Kensuke Aihara*, Numerical study on combining the CGS-type methods and the residual smoothing technique, Tue. 14:45, Room 282

*Changjiang Bu*, Some combinatorial analysis of tensors, Tue. 15:15, Room 274

*Minerva Catral*, Spectral study of  $\{R, s + 1\}$ -potent matrices, Mon. 14:45, Room 290

*Manami Chatterjee*, Inequalities regarding group invertible  $H$  matrices, Mon. 15:45, Room 282

*Chunli Deng*, Minc-type bound eigenvalue inclusion sets of general product of tensors, Tue. 10:10, Room 282

*Hamide Dogan*, Ideals of Lower Triangular Toeplitz Matrices, Mon. 16:45, Room 282

*Kenneth Driessel*, Schwartz's Model of Business Cycles, Mon. 10:40, Room 290

*Jillian Glassett*, Spectrally Arbitrary Zero-Nonzero Patterns over Rings with Unity., Mon. 15:15, Room 290

*Xinqi Gong*, Singular value decomposition based deep learning architecture for functional motion prediction of super-large protein complexes, Mon. 11:10, Room 290

*Gary Greaves*, Equiangular line systems in Euclidean space, Mon. 17:15, Room 282

*Gennadij Heidel*, Second Order Riemannian Methods Low-Rank Tensor Completion, Tue. 10:40, Room 282

*Bokhee Im*, Approximate Latin squares and triply stochastic cubic tensors, Tue. 15:45, Room 274

*Tianpei Jiang*, The operator monotonicity of  $k$ -isotropic functions, Wed. 15:45, Room 290

*Sivakumar K.C.*, Singular  $M$ -matrices: Some Recent Results, Tue. 10:40, Room 232

*Hana Kim*, Riordan matrices related to the Mertens function, Mon. 14:45, Room 282

*Nikolai Krivulin*, Methods of tropical optimization in rank-one approximation of positive matrices, Thu. 16:00, Room 290

*Hiroshi Kurata*, Some Theorems on Core Inverse of Matrices & Core Partial Ordering, Tue. 11:10, Room 232

*Ivan Kyrchei*, Determinantal Representations of the Quaternion Weighted Moore-Penrose Inverse Using Its Weighted Singular Value Decomposition., Tue. 11:40, Room 232

*Hai Feng Li*, Principal eigenvectors and spectral radii of uniform hypergraphs, Thu. 10:40, Room 290

*Sirani M. Perera*, Self Recursive Radix-2 Fast DCT Algorithms, Wed. 15:15, Room 290

*Jose Marin*, A Preconditioning technique for Rank Deficient Least Squares Problems, Tue. 15:15, Room 282

*Rachid Marsli*, Bounds for Smallest & Largest Eigenvalues of Hermitian Matrices, Mon. 17:45, Room 282

*Little Hermie Monterde*, On the sum of strictly  $k$ -zero matrices, Mon. 15:15, Room 282  
*Keiichi Morikuni*, Contour integral methods for rectangular eigenproblems, Thu. 16:00, Room 274  
*Projesh Nath Choudhury*, Matrices whose hermitian part is positive semidefinite., Wed. 13:45, Room 290  
*Evelyn Nitch-Griffin*, Backwards Stability of the Schur Canonical Form, Thu. 16:30, Room 290  
*Vadim Olshevsky*, Lipschitz stability of Jordan bases of general and  $H$ -selfadjoint matrices under small perturbations, Tue. 15:45, Room 282  
*Marko Orel*, Connections between preserver problems, graph theory, & finite geometry, Tue. 14:45, Room 274  
*Vasilije Perovic*,  $T$ -even Nonlinear Eigenvalue Problems and Structure-Preserving Interpolation, Thu. 17:00, Room 274  
*Travis Peters*, LIGHTS OUT! on Cartesian Products, Thu. 10:10, Room 290  
*Rachel Quinlan*, Counting matrices over finite fields, Wed. 14:15, Room 290  
*Alicia Roca*, On the minimal partial realizations of a sequence of vectors, Thu. 17:00, Room 290  
*Adam Rutkowski*, Merging of positive maps: a construction of various classes of positive maps on matrix algebras, Wed. 16:15, Room 290  
*Abbas Salemi Parizi*, On the convergence rate of the DGMRES method by using the polynomial numerical hulls of matrices, Wed. 15:15, Room 282  
*Khalid Shebrawi*, Bounds for zeros of polynomials from numerical radius inequalities, Wed. 15:45, Room 282  
*Jeffrey Stuart*, Sign and ray  $k$ -potent sign and ray patterns that admit  $k$ -potence, Mon. 15:45, Room 290  
*Simon Telen*, Polynomial system solving and numerical linear algebra, Thu. 16:30, Room 274  
*Jihad Titi*, Fast Determination of the Tensorial and Simplicial Bernstein Enclosure, Tue. 11:10, Room 282  
*Konstantin Usevich*, Global convergence of Jacobi-type algorithms for symmetric tensor diagonalization, Tue. 11:40, Room 282  
*Enzo Wendler*, A generalization of skew adjacency matrices and spectra, Thu. 11:10, Room 290  
*Mohsen Zahraei*, Results on generalized joint numerical ranges rectangular matrices, Wed. 16:15, Room 282

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