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Lectures on Combinatorial and Applied Algebraic Geometry

Erdős Center and HUN-REN Rényi Institute, Budapest

Date and location: Tuesday 10 November 2026, Main Lecture Hall, Rényi Institute

- **9.30 am Chris Eur (Carnegie Mellon):** K-theoretic positivity for matroids
- **11.00 am László Lovász (Rényi Institute) and Márton Borbényi (ELTE):** Limits of matroid sequences
- **2.00 pm Heather Harrington (MPI-CBG Dresden and Oxford):** Kuramoto Oscillators - Dynamical Systems meets Computational Algebraic Geometry (and Topology)
- **3.30 pm Bernd Sturmfels (MPI-MIS Leipzig and Berkeley):** Eigenvector varieties

Chris Eur: *K-theoretic positivity for matroids*

The Hodge theory of matroids by Adiprasito–Huh–Katz resolved outstanding conjectures in matroid theory by establishing positivity properties for Chow rings of matroids. In algebraic geometry, a notion complementary to the Chow ring is the K-ring of a variety. We establish positivity properties for K-rings of matroids. Our results give a new proof of the nonnegativity of the omega invariant of a matroid, in support of Speyer's f-vector conjecture, and resolve the conjecture of Tohaneanu that higher order Orlik–Terao algebras are Cohen–Macaulay.

László Lovász and Márton Borbényi: *Limits of matroid sequences*

In the last 25 years, limit theories for graphs and other combinatorial structures have been worked out, allowing us to approximate very large finite structures by smoother, continuous structures. For graphs, the limit objects are quite well described, and various associated structures (spanning trees, matchings, automorphism groups, spectra), and their convergence to the corresponding structure in the limit, are quite well understood. The matroid of a graph is another associated structure, which carries a lot of information about the graph (spanning trees, connectivity, planarity, etc.). In this talk I sketch some recent results on how to define convergence of a sequence of matroids (or more generally submodular set functions on finite sets), and how to construct an appropriate limit object. This is joint work with Kristóf Bérczi, Márton Borbényi, and László Márton Tóth.

Heather Harrington: *Kuramoto Oscillators - Dynamical Systems meets Computational Algebraic Geometry (and Topology)*

The Kuramoto model describes synchronisation in graphs of coupled oscillators. A central question is which graphs lead to complete synchronisation and which admit other stable equilibria, known as exotic solutions. In this talk, I will review and present tools from computational algebraic geometry to investigate these questions, characterise equilibrium spaces, and classify graphs exhibiting exotic solutions. Time permitting, I will present a topological data analysis perspective on dynamics of Kuramoto oscillators.

Bernd Sturmfels: *Eigenvector varieties*

We discuss the eigenvectors of a square matrix whose entries depend linearly on parameters. This lecture gives an introduction to the eigenvector varieties of linear spaces of matrices. This is joint work with Sandra Di Rocco and Svala Sverrisdottir, and it was motivated by Hamiltonians of quantum systems. Many classical varieties, such as Grassmannians, arise as eigenvector varieties of Lie algebras.