Titles and Abstracts

Martin Bies: Computational Frontiers in Singular Elliptic Fibrations and F-Theory Model Building

Elliptic fibrations with prescribed singularities lie at the heart of F-theory model building, where physical content is encoded in the geometry. While the Kodaira classification guides the study of elliptic surfaces, the four-dimensional fibrations employed in F-theory model building lead to qualitatively new computational challenges. Their resolutions typically involve large sequences of blowups, subtle intersection theory, and an overall complexity far beyond hand computations.

In this talk, I provide an update on FTheoryTools, an OSCAR module designed to automate central tasks in the study of singular elliptic fibrations in F-theory: toric and non-toric blowups, intersection computations, and the systematic management of families of fibrations in a reproducible database framework. Said database employs the MaRDI file format, allowing classical and extreme F-theory geometries from the literature to be loaded (and saved, thus also shared among peers) and modified at the click of a button.

To demonstrate how these tools can help to overcome seemingly hopeless computational tasks, we revisit the most flux-rich F-theory geometry known in the literature (arXiv:1511.03209): a singular hypersurface in a 5-dimensional toric ambient space with 101 rays and 198 maximal cones, defined as the vanishing locus of a polynomial with 355,785 monomials. A known resolution of this singular hypersurface requires 209 toric blowups. In our recent work (arXiv:2506.13849), we systematically studied G_4-fluxes: elements in the middle cohomology $H^{2,2}$ of the resolved hypersurface, subject to physics-inspired conditions. This required computing roughly 14 million intersection numbers. In the case at hand, OSCAR's default approach via Gröbner bases in the cohomology ring (313 variables and 46,547 relations) is hopeless; a specialized Monte Carlo algorithm circumvents this bottleneck. All results are archived in a MaRDI file on Zenodo (https://zenodo.org/records/15548043).

Cecile Gachet: Convex cones in birational geometry

In the late 70ies, the Japanese mathematician Mori introduced and described convex cones naturally associated with complex projective varieties, whose convex properties (extremal rays, symmetries,...) encoded some or all information about the geometry of the corresponding variety (existence of fibrations, symmetrie...). His approach has been furthered over the past fifty years in two major ways: Other cones have been introduced, that capture more geometric information on varieties; the extent of the information to be recovered from cones has been enhanced. In this talk, I first will report on joint work with H.-Y. Lin, I. Stenger and L. Wang comparing different cones attached to Calabi-Yau varieties, which fall beyond the scope of Mori's cone theorem. I will highlight what information is stored in which cone, and roughly explain the equivalence between the movable and the effective cone conjectures under the existence of good minimal models. If time allows, I will conclude by making a case for obtaining both general and explicit/concrete descriptions of these cones, with other recent work in mind.

Linda Hoyer: On the dimensions of correlated equilibria polytopes

Assume that we have two car drivers that meet at an intersection. They both want to get to their destination as quickly as possible, yet if they both started driving at the same time, they'd risk a car crash. This situation is solved by introducing a third, neutral party (a traffic light) that suggests who goes first. When no driver benefits from deviating from the suggestion, the "game" has reached a so called correlated equilibrium.

The set of all correlated equilibria is a polytope P which lies in the probability simplex. Under some mild assumptions, the following seems to hold: Either P is full-dimensional, or there is some smaller game whose correlated equilibria polytope is combinatorially equivalent to P. We report on some recent progress on this conjecture.

This is joint work with Irem Portakal. No previous knowledge on game theory is required.

Andrés Jaramillo Puentes: Motivic Gromov-Witten Invariants

Classical Gromov-Witten invariants of the complex projective plane count the number of curves of a fixed genus and degree passing through a generic configuration of points. Over the real numbers, the naive count of such curves is not invariant under deformations, but Welschinger showed that a signed count yields a well-defined invariant. In $\mathbb{A}^1$-enumerative geometry, one seeks refinements of such invariants over arbitrary fields, capturing richer arithmetic and geometric structures. Motivic Gromov-Witten invariants provide a quadratic enrichment of curve counting, encoding information beyond the classical and real settings. This perspective has led to striking results, including refinements of the Welschinger invariants and new insights into the structure of enumerative invariants over general fields. In this talk, we will introduce the framework of motivic Gromov-Witten invariants, state computational techniques, and discuss recent developments, including their connections to tropical geometry.

Joël Ouaknine: Fragments of Hilbert's Program

Hilbert's dream of mechanising all of mathematics was dealt fatal blows by Gödel, Church, and Turing in the 1930s, almost a hundred years ago. Paradoxically, assisted and automated theorem proving have never been as popular as they are today! Motivated by algorithmic problems in discrete dynamics, non-linear arithmetic, and program analysis, we examine the decidability of various logical theories over the natural numbers, and discuss a range of open questions at the intersection of logic, automata theory, and number theory.

Yue Ren: Tropical homotopies two ways

Polyhedral homotopies, introduced by Huber and Sturmfels 30 years ago, are a powerful method for solving systems of polynomial equations and have since become a cornerstone in numerical algebraic geometry. This talk will begin with a general introduction to polynomial system solving and what makes polyhedral homotopies so efficient.

After a brief introduction to tropical geometry, we then turn to two tropical generalisations: tropical lifting homotopies and tropical intersection homotopies. Combined, they provide a promising alternative to the classical polyhedral homotopies.

At its core, solving a polynomial system amounts to computing the intersection of algebraic hypersurfaces and linear spaces. Building on the work of Leykin and Yu, tropical lifting homotopies are geometric homotopies that compute these algebraic intersections from the intersections of their tropical counterparts. Building on the work of Jensen, tropical intersection homotopies are combinatorial homotopies for computing the necessary tropical intersection in the first place.

Marie Roth: On the unitriangularity of decomposition matrices of finite groups of Lie type of exceptional type

Decomposition matrices encode the link between ordinary and modular representations of finite groups. In 2020, Brunat-Dudas-Taylor showed that the decomposition matrix of the unipotent ℓ-blocks of a finite group G of Lie type in good characteristic has unitriangular shape, answering a conjecture of Geck. Their theorem holds under some conditions on the prime ℓ, in particular when ℓ is good. In this talk, we will discuss how to extend this result, firstly to ℓ bad (for any G simple adjoint) and then to other blocks, namely the isolated blocks (for G simple adjoint of type G2, F4, and E6). We will use this question to illustrate how one can approach the solution to a theoretical problem by combining (even) more abstract theory with the use of a computer algebra system.

Ulrich Thiel will lead a discussion about the future of OSCAR