Daniele Agostini

Heptagons, quartics and theta characteristics

Abstract: A construction of Wachspress associates to a heptagon a plane quartic curve. This has been recently reinterpreted from the point of view of real algebraic geometry, and numerical computations suggest that a general plane quartic arises from precisely 864 heptagons. We prove this rigorously, via theta characteristics and the finite group PSL(2,7). This is joint work with Daniel Plaumann, Rainer Sinn and Jannik Weisner.

Laurent Bartholdi

Property (T)

Abstract: I will explain several recent advances concerning Kazhdan's property (T) and its algorithmic consequences, in particular to generation of random elements in finitely generated groups. This property has been demonstrated for several remarkable examples of groups, notably the automorphism group of a free group of rank at least four (with the assistance of a computer) and the group generated by elementary matrices of size at least three over any finite-type ring. I will outline the new tools: an interpretation of (T) in terms of conic programming and a notion of „angle" between subgroups.

Martin Bies

F-Theory: Exemplifying `OSCAR`'s Pursuit for Multidisciplinary Excellence

Abstract: String Theory, a leading contender for a unified theory of quantum gravity, aims to address fundamental questions about our physical reality, such as the nature of particles observed at CERN and the behavior within black holes. This pursuit, often called the holy grail of string phenomenology, poses a significant challenge due to the vast number of solutions to string theory and has been my academic inspiration. F-theory, a subset of String Theory, elegantly encodes physics using geometry. Hence, we employ advanced geometric tools to investigate F-Theory solutions, following the following typical workflow:

1. Selection of a Lie group, e.g. $G = SU(3) \times SU(2) \times U(1)$.
2. Definition of a singular elliptic fibration Y with a 3-dimensional base B

   We require that the fibers become singular over a chosen codimension-1 locus $\Delta \subset B$ and that the singularities correspond to the Lie group G.
3. Finding a crepant resolution $\widehat{Y}$ of Y.

   Post-resolution, the resolved fibers over certain curves in the base B encapsulate representations of the chosen Lie group G ($\leftrightarrow$ particles).
4. Computation of geometric properties of $\widehat{Y}$ to understand the physics:

   Such quantities include topological intersection numbers, the Mordell-Weil group, Deligne cohomology, root bundles and much more.

F-Theory employs Lie groups and their representation theory. Toric geometry is frequently used to facilitate the crepant resolution as well as finding the desired physical/geometric quantities of $\widehat{Y}$. Modern approaches and technqiues include non-toric blowup centers as well as weighted blowups, which necessitates full-fledged algebraic geometry techniques. Furthermore, over the last couple of years, F-theory send me on a journey to study Brill-Noether theory of root bundles on nodal curves – a topic that may well have interesting applications within number theory. Consequently, F-Theory engages with all pillars of `OSCAR`, establishing it as a compelling interdisciplinary application for the `SFB TRR 195`.

My talk will shed light on the captivating prospects within this field.

Yassine El Maazouz
A non-archimedean version of Kostlan's theorem
Abstract: We prove that when $p > d$ is a prime number, there is a unique gaussian distribution (in the sense of Evans) on the space $\mathbb{Q}_p[x_1, \ldots, x_n](d)$ which is invariant under the action of $\mathrm{GL}(n, \mathbb{Z}_p)$ by change of variables. This gives the non-archimedean counterpart of Kostlan's Theorem on the classification of orthogonally (respectively unitarily) invariant gaussian measures on the space $R[x_1, \ldots, x_n](d)$ (respectively $C[x_1, \ldots, x_n](d)$). More generally, if V is an n-dimensional vector space over a non-archimedean local field K with ring of integers R, and given a partition of a positive integer d, we study the problem of determining the invariant lattices in the Schur module $S(V)$ under the action of the group $\mathrm{GL}(n, R)$ associated to that partition. This is joint work with Antonio Lerario.

Xin Fang
Seshadri stratification and semi-toric degeneration
Abstract: In this talk I will introduce the notion of a Seshadri stratification on an embedded projective variety. Such a structure allows us to construct
(1) a Newton-Okounkov simplicial complex with an extra integral structure;
(2) a flat degeneration of the variety into a reduced union of toric varieties.
For Schubert varieties, Lakshmibai-Seshadri paths got interpretation as successive vanishing orders of certain regular functions within this framework. This talk bases on joint works with Rocco Chirivì and Peter Littelmann.

Malte Gerhold
Cohomology of free unitary quantum groups
Abstract: In the talk, we will discuss the free unitary quantum groups (also known as 'universal quantum groups') of Wang and van Daele from a (co)homological perspective. After a short introduction to compact quantum groups - with an emphasis on free orthogonal and free unitary quantum groups - we will focus on finding a *free resolution of the counit*, a versatile tool which helps to compute cohomological data such as Hochschild cohomology or bialgebra cohomology of the associated Hopf algebras. For free orthogonal quantum groups, such resolutions have been found by Collins, Härtel, and Thom (in the Kac-case) and Bichon (in the general case), and they will serve as our starting point for finding resolutions for free unitary quantum groups.
Joint work with Isabelle Baraquin, Uwe Franz, Mariusz Tobolski and Anna Kula.

Jonas Hetz
On the character tables of finite reductive groups
Abstract: The character theory of finite groups is a very rich and highly active area of current research, as it constitutes an important tool for studying these groups. One of the fundamental tasks in this context is the determination of the character table of a given finite group G. As the classification of finite simple groups shows, the main difficulties occur for the finite reductive groups $G = \mathbf{G}(q)$ consisting of the $\mathbb{F}_q$-rational points of connected reductive groups $\mathbf{G}$ over fields of positive characteristic. In order to generically determine the character tables of these $\mathbf{G}(q)$, Lusztig founded the theory of character sheaves on $\mathbf{G}$ in the 1980s. The subsequent work of Lusztig and Shoji allows a reformulation of our task, which in principle reduces it to determining certain roots of unity. We report on recent progress on how this problem can be tackled.

Max Horn, Claus Fieker
The state of OSCAR
Abstract: We discuss developments in OSCAR during the past year, highlighting both improvements in functionality as well as in usability and consistency. We will demonstrate some of these changes, and then discuss what we our plans are for the coming months. Input from the audience for desirable features is of course always welcome (before, during and after the talk).

Michael Joswig
A FAIR File Format for Mathematical Software
Abstract: We describe a generic JSON based file format which is suitable for computations in computer algebra. This is implemented in the computer algebra system OSCAR, but we also indicate how it can be used in a different context. Joint work with Antony Della Vecchia and Benjamin Lorenz.

Vladimir Lazić
Geometry of varieties with nef anticanonical class
Abstract: I will talk about recent results on the birational geometry of varieties with nef anticanonical class: these sit between varieties with trivial canonical class (Calabi-Yau varieties) and varieties with ample anticanonical class (Fano varieties). Then I will speculate about further intriguing connections to the geometry of Calabi-Yau varieties, prompted by a recent detailed analysis of an important special case.

Erik Paemurru
Log canonical thresholds of high multiplicity plane curves
Abstract: We classify log canonical thresholds at points of multiplicity $d-1$ for plane curves of degree d. As a consequence, we describe all possible values of log canonical threshold that are less than $2/(d-1)$ for plane curves of degree d. In addition, we compute log canonical thresholds for all plane curves of degree less than 6.

Daniel Robertz
Polynomial Identities of Algebras
Abstract: A PI algebra is an algebra for which a non-zero (non-commutative) polynomial in several variables exists that is satisfied by all tuples of elements of the algebra. An example is given by commutative algebras which satisfy the polynomial identity $xy - yx$. This concept sparked a fruitful research direction several decades ago already. In ring theory the above property may be considered as a kind of finiteness condition on algebras. It also suggests a kind of noncommutative geometry. For example, the Specht problem asked whether the vanishing ideal of a variety of algebras is finitely generated. Kemer proved the affirmative answer in the case of associative algebras in characteristic zero in the 1980s. This talk reviews the most important results about PI algebras and discusses new trends in this area.

Felix Röhrle
Towards a computation of the degree of the tropical Prym-Torelli morphism
Abstract: The construction of the Prym variety can be understood as a morphism from the moduli space of unramified double covers to the moduli space of abelian varieties. This is the so-called Prym-Torelli morphism. In the algebro geometric formulation, the degree of this morphism in genus 6 is known to be 27. In ongoing joint work with Dmitry Zakharov, we are working towards a computation of this degree in the tropical analogue of the story. I explain tropical Prym varieties and

then focus on recent insights that were discovered via a computer search

Pascal Schweitzer
Isomorphisms, Canonization, and Normalizers – recent results in computational permutation group theory
Abstract: The Graph Isomorphism Problem is the task of computing isomorphisms between two given finite graphs and it is closely related to the task of detecting symmetries. Indeed, these two task are known to be equivalent both in a practical and a theoretical sense. Both of these tasks reduce to the problem of computing set stabilizers in permutation groups.
In my talk I will give a gentle introduction to all of these problems and then survey recent advances falling into the area of algorithmic permutation group theory. Specifically, I will describe new theoretical and practical algorithms for symmetry detection and the graph isomorphism problem. I will also hint at new insights regarding the structure of automorphism groups of graphs subject to various restrictions. Finally, I will relate canonization algorithms of general combinatorial objects to canonization of graphs and describe new algorithms for this problem. This approach also turns out to be fruitful for computing normalizers in permutation groups.

Ulrich Thiel
Computational aspects of Calogero-Moser spaces
Abstract: Calogero-Moser spaces are Poisson deformations of varieties of the form $(V \times V^*)/W$, where W is a finite complex reflection group acting on a vector space V. These varieties are interesting because they are examples of symplectic singularities (introduced by Beauville) and there is a fascinating interplay between geometry and representation theory. I will give a gentle introduction to these objects focusing on computational aspects.