Sobolev Institute of Mathematics

Novosibirsk State University

Algebras and related groups

International School Conference

April 20–26, 2026

Collection of Abstracts

The conference is supported by Mathematical Center in Akademgorodok under the agreement No. 075-15-2025-349 with the Ministry of Science and Higher Education of the Russian Federation.

Novosibirsk • 2026

Contents

I. Lecture courses

Locally nilpotent derivations and automorphisms of algebraic varieties

I. V. Arzhantsev

The course consists of three parts. The first part is about the algebraic theory of locally nilpotent derivations. In the second part we study automorphisms of affine algebraic varieties using gradings on the algebra of regular functions and describing homogeneous locally nilpotent derivations of such algebras. In the third part we apply these results to study automorphisms of projective varieties. This approach is based on the concept of Cox rings. Among other things, following Demazure, we obtain a description of the automorphism group of a complete toric variety.

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The arithmetics of binary quadratic operads

P. S. Kolesnikov

Operads are combinatorial objects emerging in various fields of mathematics. Formally, an operad is a category with an additional structure (multi-morphisms) that has only one object. On the other hand, an operad may be considered as a governing object for an equational class of algebraic systems (a variety), with generators–operations and relations–identities. In the mini-course, we consider the class of binary quadratic operads (in the sense of V. Ginzburg and M. Kapranov) corresponding to the classes of non-associative algebras defined by quadratic identities (like associative, Lie, Poisson, Novikov algebras, etc.). We will learn how to compute Manin products of such operads (black and white product), discuss Koszul duality of operads, and consider applications of these constructions.

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The $(2,3)$-generated and Hurwitz groups

M. A. Vsemirnov

First, we consider the finite quotients of the famous modular group $\mathrm{PSL}(2,\mathbb{Z})$. For more than a century this problem attracted a lot of interest. Next, we focus on an important subclass of such groups, the so-called Hurwitz groups. We discuss constructive methods, which allow us to build many Hurwitz generators for matrix groups of large rank, and also explain why Hurwitz groups in low dimensions are rather rare. To deal with these obstructions we consider tools from representation theory, like Scott's formula. At the end some open problems and directions of further research will be discussed.

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II. Short talks

δ-Leibniz algebras and related δ-type algebras

Jobir Adashev

The concept of Leibniz algebras, introduced as a non-antisymmetric generalization of Lie algebras, was popularized by Jean-Louis Loday in the 1990s in the framework of Lie dialgebras and continues to attract significant attention. A key feature of Leibniz algebras is that right multiplication by any element acts as a derivation. The notion of derivations plays a fundamental role not only in Leibniz algebras but also in many other algebraic structures, including Lie, Jordan, Novikov, and Poisson algebras.

Recently, the concept of anti-Leibniz algebras has been introduced by replacing derivations with antiderivations (or (-1)-derivations). Anti-Leibniz algebras can be viewed as noncommutative generalizations of Jacobi–Jordan (mock-Lie) algebras.

We study δ-Leibniz algebras, which provide a unified generalization of both Leibniz and anti-Leibniz algebras via the concept of δ-derivations. The idea of δ-type algebras first appeared in the study of Poisson and anti-Poisson algebras and was later extended to Novikov algebras. The notion of a δ-commutator provides a special type of algebra mutation and has been extensively studied for Leibniz and Zinbiel algebras. Related structures such as quasi-associative and quasi-alternative algebras can also be defined via appropriate δ-commutator products.

We introduce δ-Lie algebras and show that almost all of them are 2-step nilpotent, with exceptional behavior occurring at $\delta = -\frac{1}{2}$. We define δ-Lie dialgebras and prove that they are equivalent to 2-step nilpotent algebras or, equivalently, to antiassociative anti-right-commutative algebras. Further investigate these algebras by constructing bases of free algebras and describing identities governing their Koszul dual operads, noting that the first non-2-step nilpotent examples appear in dimension 7.

Moreover, we show that there are no simple anti-Leibniz algebras and that every symmetric anti-Leibniz algebra is a central extension of a Jacobi–Jordan algebra. In addition, we prove that every δ-associative algebra is 3-step nilpotent and characterize commutative δ-Leibniz algebras. Further results generalize known relationships between Leibniz, anti-Leibniz, associative, and antiassociative algebras within the δ-framework. Symmetric δ-Leibniz algebras are shown to be power-associative and, for $\delta \neq \frac{1}{2}$, nilalgebras of nilindex 3.

We also introduce δ-Zinbiel algebras as Koszul duals of δ-Leibniz algebras, classify them in dimension two, and study their nilpotency properties, including bounds on their lengths. Analogues of classical results are established, including the fact that every finite-dimensional anti-Zinbiel algebra is nilpotent.

Finally, we connect Lie-admissible and Jacobi–Jordan admissible algebras through the δ-commutator framework. We characterize symmetric δ-Leibniz admissible algebras and prove that they are nilalgebras whenever $\delta \notin \{\pm 1, \frac{1}{2}\}$. Algebras of δ-biderivation type are shown to form a bridge between biderivation-type and anti-biderivation-type algebras, highlighting the unifying role of δ-biderivations.

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Bounding the derived length of finite solvable groups using character degrees

K. Dastouri

One of the classical results in character theory is a theorem of Taketa, which states that every M-group (a finite group where every ordinary irreducible character is monomial) is solvable. Moreover, his proof yields the inequality $\mathrm{dl}(G) \leq |\operatorname{cd}(G)|$, bounding the derived length of G by the number of its distinct irreducible character degrees. This inspired the famous Isaacs-Seitz conjecture (or Taketa's problem), which asserts that the same inequality $\mathrm{dl}(G) \leq |\operatorname{cd}(G)|$ holds for all finite solvable groups. While this conjecture remains open in general, significant partial results are known, such as Berger's proof for groups of odd order [**4**] and Gluck's general bound $\mathrm{dl}(G) \leq 2|\operatorname{cd}(G)|$ [**3**].

This talk explores an analogue of this theory within the framework of π-partial characters, as developed by Isaacs for π-separable groups. We introduce and study the class of M_π-groups: π-separable groups in which every irreducible Isaacs π-partial character is monomial. We will describe a bound for the derived length of an M_π-group in terms of its π-partial character degrees.

Theorem. Let G be an M_π-group. Then $G/O_{\pi'}(G)$ is solvable and $\mathrm{dl}(G/O_{\pi'}(G)) \leq |\operatorname{cd}_\pi(G)|$.

This generalizes Taketa's inequality and as a corollary, if the π'-core $O_{\pi'}(G)$ is solvable, then G itself is solvable and we obtain an explicit bound for its derived length. In the special case of $M_{p'}$-groups, this yields $\mathrm{dl}(G) \leq |\operatorname{cd}_{p'}(G)| + \mathrm{dl}(O_p(G))$, which implies Gluck's bound $\mathrm{dl}(G) \leq 2|\operatorname{cd}(G)|$ for this class.

Finally, we investigate the Isaacs-Knutson conjecture [**2**] concerning the derived length of a normal subgroup N in relation to the character degrees of G that are non-trivial on N. We extend this to the π-partial setting, proving that if G is an M_π-group with solvable $O_{\pi'}(G)$ and $N \trianglelefteq G$, then $\mathrm{dl}(N) \leq |\operatorname{cd}_\pi(G|N)| + \mathrm{dl}(O_{\pi'}(G))$.

Examples, including $(C_3 \times C_3) \ltimes \mathrm{SL}(2,3)$, will be presented to demonstrate the sharpness of these results and to distinguish M_π-groups from ordinary M-groups. Some of these results are based on joint work [**1**].

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Chiral algebras with abelian conformal part

I. V. Dudin, P. S. Kolesnikov

We study a categorical approach to the concept of varieties of chiral algebras. In particular, chiral Lie algebras are known as vertex algebras; in general, chiral algebras are a generalization of conformal algebras. We prove that the class of chiral algebras of a variety defined by a binary quadratic operad *Var*, whose conformal structure is abelian, coincides with the class of differential algebras of the variety defined by the black Manin product of operads *Var* and *Com*.

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Rota—Baxter operators on finite simple groups

V. Gubarev

Rota—Baxter operators on algebras have been studied since 1960; to date, numerous connections have been discovered between them and such areas as the Yang—Baxter equation, pre- and postalgebras, double Lie algebras, multiple zeta values.

In 2020, L. Guo, H. Lang, Y. Sheng defined [**4**] an analogue of Rota—Baxter operator on a group.

Definition [**4**]. Let G be a group. A map $B\colon G \to G$ is called a Rota—Baxter operator (RB-operator) of weight 1 if

$$B(g)B(h) = B(gB(g)hB(g)^{-1})$$

holds for all $g, h \in G$.

On any group G, one has always trivial RB-operators $B_1\colon g \to e$ and $B_2\colon g \to g^{-1}$. Given an exact factorization $G = HL$, the map $B\colon hl \to l^{-1}$ is a *splitting* Rota—Baxter operator on G. Note that trivial RB-operators are splitting.

The problem of description of RB-operators on finite simple groups was posed in [**1**]. There, it was proved that all RB-operators on sporadic simple groups are splitting.

In [**2**], it was shown that there exist non-spliting RB-operators on simple alternating groups. Let us formulate some conditions for numbers m, q: (i) q is a prime-power; (ii) each prime divisor of m divides $q-1$; (iii) $q \equiv 3 \pmod 4$ and $m \equiv 2 \pmod 4$.

Theorem 1 [**2**]. *Let B be a Rota—Baxter operator on a simple alternating group A_n. B is non-splitting if and only if one of the following holds:*

(*a*) $n = q^m$ *and m, q satisfy the conditions (i)–(iii);*
(*b*) $n = q^m + 1$ *and m, q satisfy the conditions (i)–(iii).*

Moreover, there is a description of all such B.

In [**3**], RB-operators on some classes of simple groups of Lie type were described.

Theorem 2 [**3**]. *All Rota—Baxter operators on finite simple exceptional groups of Lie type are trivial.*

Theorem 3 [**3**]. *All Rota—Baxter operators on* $\mathrm{PSL}_2(\mathrm{q})$ *are splitting.*

The study was supported by a grant from the Russian Science Foundation №23-71-10005, https://rscf.ru/project/23-71-10005/

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Radiant toric varieties

Zeyu Li

The term “radiant toric variety"was named in the article [**1**], but research on it had already begun in [**2**]. This is a cool class of toric varieties which has important distinguishing features that make it attractive for study. It has several equivalent definitions (see [**1**, Theorem A] and the references therein).

Theorem. *Let X be a complete toric variety. The following conditions are equivalent(in which case, we say that X is a* **radiant toric variety***.):*

(1) a maximal unipotent subgroup U of the automorphism group $Aut(X)$ acts on X with an open orbit.

(2) the variety X admits an additive action;

(3) the variety X admits a normalized additive action;

(4) the fan Σ_X is bilateral.

We will review relevant research and further illustrate them with some concrete examples, such as (weighted) projective spaces, Hirzebruch surfaces, and others.

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On recognition by Gruenberg–Kegel graph of finite nonabelian simple groups with orders having prime divisors at most 17

D. D. Lonovenko

The Gruenberg—Kegel graph (or the prime graph) $\Gamma(G)$ of a finite group G is defined as follows. The vertex set of $\Gamma(G)$ is the set of all prime divisors of the order of G. Two distinct primes p and q are adjacent in $\Gamma(G)$ if and only if there exists an element of order pq in G. We say that the problem of recognition by Gruenberg–Kegel graph is solved for a finite group if the number of pairwise non-isomorphic finite groups with the same Gruenberg–Kegel graph as the group under study is known. In 2026, N. V. Maslova and L. G. Nechitailo [**1**] completed solving the problem of recognition by Gruenberg-Kegel graph for all finite nonabelian simple groups with orders having prime divisors at most 13. In this talk we discuss the problem of recognition by Gruenberg-Kegel graph for nonabelian simple groups with orders having prime divisors at most 17.

This is a joint work with K. A. Zhuravlev supervised by N. V. Maslova.

Acknowledgments. The work was performed as part of research conducted in the Ural Mathematical Center with the financial support of the Ministry of Science and Higher Education of the Russian Federation (Agreement number № 075-02-2026-737).

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On the realizability of a simple labeled graph as the Gruenberg-Kegel graph of a finite group

N. V. Maslova

The Gruenberg—Kegel graph (or the prime graph) $\Gamma(G)$ of a finite group G is defined as follows. The vertex set of $\Gamma(G)$ is the set $\pi(G)$ of all prime divisors of the order of G. Two distinct primes p and q are adjacent in $\Gamma(G)$ if and only if there exists an element of order pq in G.

A simple graph Γ is a labelled graph if its vertices are labelled by pairwise distinct primes. We denote by $\pi(\Gamma)$ the set of labels of Γ, and let

$$h(\Gamma) = |\{H \mid H \text{ is a finite group such that } \Gamma(H) = \Gamma\}|.$$

It is clear that $h(\Gamma) \in \{0\} \cup \mathbb{N} \cup \{\infty\}$.

Denote by $S(G)$ the largest normal solvable subgroup of a finite group G. Recall that a finite group G is almost simple if there is a finite nonabelian simple group S such that $S \cong \mathrm{Inn}(S) \trianglelefteq G \leq \mathrm{Aut}(S)$.

Set $F(x) = 500(x+1)(2x+4)^3(26+2x^2+6x(x+1)(2x+3)+7x(x+1)+3(x+1))$.

Continuing the research begun in [**1**], we prove the following theorems.

Theorem 1. *Let Γ be a labelled graph with $\pi(\Gamma) = \{p_1, p_2 \ldots, p_m\}$, where $p_1 < p_2 < \ldots < p_m$. The following statements are equivalent*:

(1) $h(\Gamma) = \infty$;

(2) $h(\Gamma) > F(m)$;

(3) *there is a finite group G such that $\Gamma(G) = \Gamma$ and $|G| > {p_m}^{9p_m^2+p_m+1} + 1$;*

(4) *there is a finite group G such that $\Gamma(G) = \Gamma$ and $S(G) \neq 1$;*

(5) *there is a finite group G such that $\Gamma(G) = \Gamma$ and G is not almost simple.*

Note that using results obtained in [**2**], we can replace $F(x)$ to a polynomial function of degree at most 5.

Theorem 2. *Let $\pi = \{p_1, p_2 \ldots, p_m\}$ be a set of primes. There is a (large) constant $C = C(\pi)$ such that for each labelled disconnected graph Γ such that $\pi(\Gamma) = \pi$ the following statements are equivalent*:

(1) $h(\Gamma) > 0$;

(2) *there is a finite group G such that $\Gamma(G) = \Gamma$ and $|G| < C(\pi)$.*

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Additive actions on projective surfaces with finitely many orbits

A. Yu. Perepechko

An additive action on an algebraic variety is an effective action of the vector group $\mathbb{G}_a^n$ with an open orbit. Such actions arise naturally as equivariant compactifications of affine spaces. Their classification is part of a long-standing research program in the geometry of algebraic group actions, initiated by Brendan Hassett and Yuri Tschinkel in 1999 and still actively pursued today.

In this talk we focus on the two-dimensional case and classify projective surfaces with at most du Val (ADE) singularities that admit a $\mathbb{G}_a^2$-action with only finitely many orbits. The orbit structure of such surfaces resembles that of toric varieties: there is one open orbit, at most three one-dimensional orbits, and exactly one fixed point. A key tool is the bubble space of equivariant blowups of Hirzebruch surfaces, combined with an explicit description of the $\mathbb{G}_a^2$-action in local coordinates near exceptional curves.

A notable outcome is that the blowup of a Hirzebruch surface $\mathbb{F}_r$ $(r \geq 2)$ at two points of a distinguished fiber admits a one-parameter family of pairwise non-isomorphic additive actions — answering a question posed by Hassett and Tschinkel.

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On lattices close to distributive ones

K. V. Selivanov

Definition [1]. A lattice is said to be *close to distributive* one if, for any of its elements x, y, and z, the intervals

$$[(x \wedge z) \vee (y \wedge z); (x \vee y) \wedge z] \text{ and } [(x \wedge y) \vee z; (x \vee z) \wedge (y \vee z)]$$

have length at most 1.

The class of lattices close to distributive ones is a natural extension of the class of distributive lattices.

It is well known that the minimal nondistributive lattices are the diamond and the pentagon. The presence or absence of these lattices as sublattices determines whether a lattice is distributive.

For the class of lattices close to distributive ones, it is natural to consider an analogous problem, namely, to find the minimal lattices that are not close to distributive. In [**2**], the speaker, jointly with A. G. Gein, showed that the class of minimal lattices not close to distributive ones can be divided into two subclasses: the subclass of lattices that are generated by 3 elements of a special kind, and the subclass of lattices that are generated by 4 elements of a special kind.

Both subclasses have been completely described by the speaker. The first subclass contains 5 self-dual lattices and 12 pairs of dual lattices. This subclass was described in [**3**]. The second subclass contains 7 self-dual lattices and 67 pairs of dual lattices. The talk is intended to present the method used to obtain the result for both subclasses. This description makes it possible to obtain, for finite lattices, a criterion for deciding whether a given lattice is close to distributive one.

Theorem. *A finite lattice is close to distributive one if and only if it contains no a minimal lattice that is not close to distributive one as a sublattice.*

Acknowledgments. The work was performed as part of research conducted in the Ural Mathematical Center with the financial support of the Ministry of Science and Higher Education of the Russian Federation (Agreement number № 075-02-2026-737).

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On Christophersen's problem

R. Stasenko

Let A be an abelian local algebra over the field $\mathbb{C}$ of dimension n. In the beginning of 21th centuary Jan Christophersen asked whether the dimension of the group $\mathrm{Aut}(A)$ is more than or equal $n-1$ and the equality should only happen when $A \backsimeq \mathbb{C}[t]/(t^n)$. This problem is still opened nowadays.

In 1996 S. Yau proved, that for graded artinian local algebras the following bound is true:

$$\dim \mathrm{Aut}(A) \geqslant \dim A - \dim \mathrm{Soc}(A).$$

Then in 2013 A. Perepechko gave another lower bound:

$$\dim \mathrm{Aut}(A) \geqslant \dim(\mathfrak{m}/\mathfrak{m}^2) \cdot \dim \mathrm{Soc}(A).$$

Let S be a reductive algebraic group and let $\mathfrak{g}$ be an algebra. The homomorphism $\Phi : S \to \mathrm{Aut}(\mathfrak{g})$ is called the S-structure on the algebra $\mathfrak{g}$. S-structure can be viewed as another type of grading on $\mathfrak{g}$. The algebra $\mathfrak{g}$ is called S-graded in this case.

The aim of the talk is to give some remarks to this problem and, using the upper bounds, prove their analogies for the S-graded local algebras.

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Integro-derivation Dzhumadildaev algebras: from the algebra of polynomials

Naurizbay Uzakbaev

In this talk, we discuss algebras constructed from the algebra of polynomials via derivation and integration operators using a process introduced by Dzhumadildaev. We present some properties of these algebras and describe new classes of infinite-dimensional simple conservative algebras. In particular, we discuss the derivations of these algebras in the cases of ranks 1 and 2.

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On {2,3,5}-groups with conjugacy classes of distinct sizes

Zhou Wei

A finite group is called an *ah*-group if all of its conjugacy classes have distinct sizes. In 1973, F. M. Markel proposed the famous S_3-conjecture, which states that any non-trivial finite *ah*-group is isomorphic to the symmetric group S_3, and he verified it for all supersolvable groups [**2**]. This conjecture was completely resolved for solvable groups in 1994 [**3**] and 1995 [**1**]. However, the general non-solvable cases remain open. In this talk, we present our recent progress toward resolving the conjecture for $\{2, 3, 5\}$-groups.

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