

**GROUPS AND GROUP RINGS XI**  
**BĘDLEWO (near POZNAŃ), POLAND**  
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**ABSTRACTS**

## 2-Generation of some finite simple groups

Ali Reza Ashrafi

Let  $G$  be a finite group and  $nX$  a conjugacy class of elements of order  $n$  in  $G$ .  $G$  is called  $nX$ -complementary generated if, for every  $x \in G - \{1\}$ , there is a  $y \in nX$  such that  $G = \langle x, y \rangle$ .

In [5] the question of finding all positive integers  $n$  such that a given non-abelian finite simple group  $G$  is  $nX$ -complementary generated was posed. In this talk we report on the latest results on this question.

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## Computations with polycyclic groups

Bjoern Assmann

A group is called polycyclic if it has a finite subnormal series with cyclic factors. The investigation of polycyclic groups was started in the 1930s by Hirsch and was later continued by Baer, Mal'cev and Hall among others.

Every polycyclic group can be finitely presented by a so called polycyclic presentation, which is a relatively easily manageable representation for a computer. Finite solvable groups are polycyclic and algorithms for them were developed in the 1980s by Laue, Neubüser and Schoenwaelder. More recently computations with infinite polycyclic groups have been shown to be practical.

In this talk I want to give some examples that show that polycyclic groups are interesting objects to study. Further I want to report on recent implementations of algorithms in this area in the computer algebra system GAP such as the computation of a nilpotent almost supplement to the Fitting subgroup of a polycyclic group.

## On $p$ -power structure of group of units of modular group algebras

Zsolt Balogh

Let  $\mathbb{F}_p$  be the field of  $p$  elements ( $p$  is a prime) and  $G$  a finite  $p$ -group. Denote by  $\mathbb{F}_p G$  the group algebra of group  $G$  over the field  $\mathbb{F}_p$ . The question, originally raised by S. D. Berman, whether for finite  $p$ -groups  $G$  and  $H$  the isomorphism of group of normalized units  $V(\mathbb{F}_p G)$  and  $V(\mathbb{F}_p H)$  implies the isomorphism of the groups  $G$  and  $H$ .

We investigated the 2-power structure of  $V(\mathbb{F}_2 G)$ , where  $G$  is a group of maximal class of order  $2^n$ , that is, its nilpotency class is  $n - 1$ . We described the structure of the elements of order two of  $V(\mathbb{F}_2 G)$ , and gave their numbers. An interesting consequence of our results above is that the Berman's question is true for 2-groups of maximal class.

Let  $G$  be a group with commutator subgroup  $G'$  of order  $p$ . Bagiński, Shalev and Mann proved that the nilpotency class of the group of normalized units is  $p$  if and only if  $G'$  is of order  $p$ . In this case we examined the  $p$ -power structure of  $V(\mathbb{F}_p G)$ . We verified that the nilpotency class of  $V(\mathbb{F}_p G)$  is  $p$  if and only if  $V(\mathbb{F}_p G)^p$  is a central subgroup of the normalized group of units, consequently the further powers can be easily determined. Moreover, if the Frattini subgroup of  $G$  is of order  $p$  then we can describe the structure of the group  $V(\mathbb{F}_p G)^p$ .

By virtue of the previous results on the  $p$ -power structure, we proved that if  $G$  is a  $p$ -group with Frattini subgroup of order  $p$  ( $p > 2$ ) then the  $p$ th power of the group  $G$  coincides with the intersection of the  $p$ th power of the normalized group of units  $V(\mathbb{F}_p G)$  and the group  $G$ .

By the help of  $p$ -power structure of group of normalized units we proved that the isomorphism class of the group  $V(\mathbb{F}_p G)$  determines the isomorphism class of the group  $G$  if  $G$  is a group of cyclic Frattini subgroup and  $p > 2$ .

## On indecomposable projective representations of direct products of finite groups over a complete discrete valuation ring

Leonid F. Barannyk

In this talk, we continue the investigations of the papers [1], [2].

Let  $F$  be a field of characteristic  $p > 0$ ,  $S = F[[X]]$  the ring of formal power series in the indeterminate  $X$  with coefficients in the field  $F$ ,  $S^*$  the multiplicative group of  $S$ ,  $T$  the quotient field of  $S$ , and  $G$  a finite group. Denote by  $Z^2(G, S^*)$  the group of all  $S^*$ -valued normalized 2-cocycles of the group  $G$  that acts trivially on  $S^*$ . Assume that  $p \nmid |G|$  and  $G = G_p \times B$ , where  $G_p$  is a  $p$ -subgroup and  $B$  is a  $p'$ -subgroup. If every indecomposable projective  $S$ -representation of  $G$  is equivalent to an outer tensor product of an indecomposable projective  $S$ -representation of  $G_p$  and an irreducible projective  $S$ -representation of  $B$ , then we will say that the group  $G$  satisfies the *TPIPR* (Tensor Product of Indecomposable Projective Representations) condition over  $S$ . The group  $G_p$  is defined to be of bounded projective  $S$ -representation type if the set of degrees of all indecomposable projective  $S$ -representations of  $G_p$  with 2-cocycle  $\lambda$  is finite for each  $\lambda \in Z^2(G_p, S^*)$ . A projective  $T$ -representation of the group  $B$  with 2-cocycle  $\lambda \in Z^2(G, S^*)$  is called a projective  $(T, S^*)$ -representation of  $B$ .

**Theorem.** *Let  $p \nmid |G|$  and  $G = G_p \times B$ . The group  $G$  satisfies the *TPIPR* condition over  $S$  if and only if either  $|G_p| = 2$  or any irreducible projective  $(T, S^*)$ -representation of  $B$  is absolutely irreducible.*

**Corollary.** *Let  $p \nmid |G|$  and  $G = G_p \times B$ . The group  $G$  satisfies the *TPIPR* condition over  $S$  if and only if either  $G_p$  is of bounded projective  $S$ -representation type or any irreducible projective  $(T, S^*)$ -representation of  $B$  is absolutely irreducible.*

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## On the orders of conjugacy classes in modular group algebras of $p$ -groups

Adalbert Bovdi

Let  $FG$  be the group algebra of a finite  $p$ -group  $G$  over the field  $F$  with  $p^n$  elements. As is well known that the group of normalized units

$$V = V(FG) = \left\{ \sum_{g \in G} a_g g \mid a_g \in F, \sum_{g \in G} a_g = 1 \right\}$$

is of order  $p^{n(|G|-1)}$ . The structure of such groups  $V$  is one of the interesting questions in the theory of modular group algebras. What is the connection of the class of these groups with other classes of finite  $p$ -groups? Explicit calculations in  $V(FG)$  are usually extremely difficult, even when  $G$  is fairly small, so examples are very hard to come by.

We continue an investigation, begun in [1], exploring *what numbers can occur as cardinalities of conjugacy classes of elements of  $V$* . Only powers of  $p^l$  come into consideration, because the cardinality of the conjugacy class of an element  $v$  is the index of the centralizer  $C_V(v)$  while  $C_V(v) = \{1 + a \mid a \in C_A(v)\}$  where  $A$  is the augmentation ideal of  $FG$  and  $C_A(v)$  is an  $F$ -subspace, so in fact

$$|V : C_V(v)| = p^{n(|G|-1-\dim C_A(v))} = p^{n(|G|-\dim C_{FG}(v))}.$$

It was shown in [1] that 1 cannot occur as such a codimension, but 2 always does if  $G$  has a nonabelian quotient in which the index of the center is  $p^2$ . Of course, then 2 is the smallest positive codimension, and the commutator subgroup of the quotient in question has order  $p$ . Every finite nonabelian  $p$ -group  $G$  has quotients with commutator subgroups of order  $p$ ; let  $p^k$  be the index of the center in such a quotient. Our main result [2]:

**Theorem.** *Let  $F$  be a field of  $p^n$  elements and  $G$  a finite  $p$ -group. If  $G$  has a quotient with commutator subgroup of order  $p$  and center of index  $p^k$ , then the group of normalized units of  $FG$  has a conjugacy class of  $p^{nk}$  elements.*

**Question.** If  $k$  is chosen minimal for  $G$ , is  $p^{kn}$  minimal among the cardinalities of the conjugacy classes of noncentral elements?

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## Lie nilpotency indices of modular group algebras

Victor Bovdi

Let  $R$  be an associative algebra with identity. The algebra  $R$  can be regarded as a Lie algebra, called the associated Lie algebra of  $R$ , via the Lie commutator  $[x, y] = xy - yx$ , for every  $x, y \in R$ . Set  $[x_1, \dots, x_n] = [[x_1, \dots, x_{n-1}], x_n]$ , where  $x_1, \dots, x_n \in R$ . The  $n$ -th lower Lie power  $R^{[n]}$  of  $R$  is the associative ideal generated by all the Lie commutators  $[x_1, \dots, x_n]$ , where  $R^{[1]} = R$  and  $x_1, \dots, x_n \in R$ . By induction, we define the  $n$ -th upper Lie power  $R^{(n)}$  of  $R$  as the associative ideal generated by all the Lie commutators  $[x, y]$ , where  $R^{(1)} = R$  and  $x \in R^{(n-1)}$ ,  $y \in R$ .

The algebra  $R$  is called Lie nilpotent (respectively upper Lie nilpotent) if there exists  $m$  such that  $R^{[m]} = 0$  ( $R^{(m)} = 0$ ). The minimal integers  $m, n$  such that  $R^{[m]} = 0$  and  $R^{(n)} = 0$  are called the Lie nilpotency index and the upper Lie nilpotency index of  $R$  and they are denoted by  $t_L(R)$  and  $t^L(R)$ , respectively.

Let  $U(KG)$  be the group of units of a group algebra  $KG$ . For the noncommutative modular group algebra  $KG$  the following Theorem is well known: The following statements are equivalent: (a)  $KG$  is Lie nilpotent (b)  $KG$  is Lie hypercentral; (c)  $KG$  is strongly Lie nilpotent (d)  $U(KG)$  is nilpotent; (e)  $\text{char}(K) = p > 0$ ,  $G$  is nilpotent and its commutator subgroup  $G'$  is a finite  $p$ -group.

Let  $K$  be a field of positive characteristic  $p$  and  $KG$  the group algebra of a group  $G$ . It is known that if  $KG$  is Lie nilpotent then its upper (or lower) Lie nilpotency index is at most  $|G'| + 1$ , where  $|G'|$  is the order of the commutator subgroup. Previously in [?, ?] was determined the groups  $G$  for which this index is maximal. Now we determine the groups  $G$  for which its upper (or lower) Lie nilpotency index have next highest possible values.

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## Linear groups and group rings

Jairo Zacarias Goncalves

Let  $ZG$  be the integral group ring of the finite group  $G$ . We show that if  $G$  is nonabelian of order prime to 6, then  $ZG$  contains two Bass cyclic units that generate a nonabelian free group. This is a joint work with Professor Don Passman.

## Modular group algebras and isomorphisms of small group rings

Martin Hertweck

Fix a commutative ring  $R$  as domain of coefficients. The isomorphism problem asks in general whether a given group  $G$  is determined (up to isomorphism) by the structure of its group algebra  $RG$ . Remarkably, for finite groups, there is essentially only one instance of this problem that is still (wide) open, the so-called modular isomorphism problem: is an arbitrary  $p$ -group determined by its modular group algebra over the prime field  $k$  with  $p$  elements?

I will report on some (modest) recent progress on this problem. In particular, I will report on joint work with Marcos Soriano, University of Hannover, on small group rings:

Let  $H$  be a fixed finite  $p$ -group. Call a  $p$ -group  $E$  with a central, elementary abelian subgroup  $V$  contained in the  $\text{Fh}(p)$ -group

## Groups of infinite matrices

Waldemar Hołubowski

In our talk we give an account of the theory of groups of infinite matrices. A number of articles and few books mention algebraic aspects of infinite matrices. However they do so with very different backgrounds, for example we mention here associative rings, algebraic  $K$ -theory, Lie algebras, infinite group theory, functional and elementary analysis, representation theory, model theory, infinite combinatorics, probability. We collect foundational material on the infinite-dimensional linear groups and propose a uniform treatment of the most important structures.

## On the unit group of group rings

Edson Ryoji Okamoto Iwaki

We investigate the hypercentre of the unit group  $\mathcal{U}(\mathbb{Z}G)$  of the integral group ring  $\mathbb{Z}G$  of an arbitrary group  $G$ . We prove that the hypercentre is contained in the normalizer of  $G$  and that, if  $G$  has non-normal torsion, the hypercentre is also contained in the finite conjugacy centre of the unit group. We apply these results to integral group rings of torsion generated groups, simple groups, Frobenius groups, nilpotent groups and other groups.

We also investigate other properties of the unit group of group rings.

## Quadratic algebras and groups of I-type

Eric Jespers

In joint work with J. Okninski the problem of characterizing Noetherian semigroup algebras  $K[S]$  is investigated. In this talk we present recent results when  $S$  has a presentation defined via homogeneous quadratic relations.

A monoid  $S$  generated by  $\{x_1, \dots, x_n\}$  is said to be of (left)  $I$ -type if there exists a map  $v$  from the free abelian monoid  $FaM_n$  of rank  $n$  generated by  $\{u_1, \dots, u_n\}$  to  $S$  so that for all  $a \in FaM_n$  one has  $\{v(u_1a), \dots, v(u_na)\} = \{x_1v(a), \dots, x_nv(a)\}$ . Then  $S$  has a solvable Bieberbach group of fractions, which is called a group of (left)  $I$ -type. These monoids first appeared in the work of Gateva-Ivanova and Van den Bergh (inspired by earlier work of Tate and Van den Bergh) and Etingof, Schedler and Soloviev. They have presentations with  $n$  generators  $x_1, \dots, x_n$  and  $\binom{n}{2}$  quadratic homogeneous equations so that each pair  $x_i x_j$  appears in at most one defining relation (if these relations are square free then we say  $S$  is a semigroup of skew type). Furthermore these monoids are non-degenerate set theoretic solutions of the quantum Yang-Baxter equation

We describe these monoids as natural submonoids of semidirect products of the free abelian group of rank  $n$  with the symmetric group of degree  $n$ . As a consequence we describe a rich algebraic structure of such monoids and their algebras. In particular, a monoid is of left  $I$ -type if and only if it is of right  $I$ -type. We simply call them monoids of  $I$ -type. A recent result of Rump and Gateva-Ivanova, confirming a conjecture of Gateva-Ivanova, is then easily reproved: if the defining relations are square free then any non-abelian monoid of  $I$ -type is binomial and it is a product of monoids of  $I$ -type but on less generators. Further it is shown that many groups of  $I$ -type are poly-infinite cyclic and submonoids of such groups that yield left or right Noetherian algebras are described. We show that these groups are not necessarily unique product groups. It turns out that  $K[S]$  is a Noetherian domain that satisfies a polynomial identity and it is a maximal order. The minimal prime ideals are described and it follows that the homogeneous normalizing class group is trivial. Further, via left-right divisibility, we show that all semiprime ideals of  $S$  can be described. The latter yields an ideal chain of  $S$  with factors that are semigroups of matrix type over cancellative semigroups.

It is also shown that the algebraic structure of the algebras  $K[S]$  of the much wider class of monoids  $S$  of skew type is very rich. However some fundamental differences with monoids of  $I$ -type appear. For example, there exist monoids  $S$  of skew type generated by  $4^m$  elements such that the Gelfand-Kirillov dimension of  $K[S]$  is one and so that  $K[S]$  is semiprime, Noetherian and satisfies a polynomial identity.

## On the derived length of Lie soluble group algebras

Tibor Juhasz

Let  $G$  be a nilpotent group with cyclic commutator subgroup of order  $p^n$  and  $F$  a field of characteristic  $p$ . We investigate the Lie derived length of the group algebra  $FG$ .

## Decidability of the elementary theory of a free group

Olga Kharlampovich

Several years ago I proved together with A. Myasnikov the Tarski conjecture about the decidability of the elementary theory of a free group of finite rank. I will discuss the algorithmic results involved in the proof, in particular, the solution of many algorithmic problems for f.g. fully residually free groups. I will also describe the decision procedure for EA-sentences.

## Around torsion units of group rings

Wolfgang Kimmerle

Let  $G$  be a finite group. Denote by  $V(\mathbb{Z}G)$  the units with augmentation 1 of its integral group ring  $\mathbb{Z}G$  and let  $H$  be a finite subgroup of  $V(\mathbb{Z}G)$ . Object of the talk are the two cases when  $H$  is a group basis and when  $H$  is a cyclic subgroup which is not contained in a group basis.

The first case leads to the isomorphism problem of integral group rings. The aim is to show that this question is after M.Hertwecks well known counterexample still a question of fundamental interest for the structure theory of the unit group of an integral group ring. The so-called  $F^*$ -theorem and the status of its proof available in print is presented. Resulting interesting questions for the principal  $p$ -block of a general finite group are discussed.

The second part deals with the first Zassenhaus conjecture, the corresponding conjecture of A.Bovdi and related weaker problems. In contrast to the other conjectures of Zassenhaus concerning units of integral group rings this conjecture is still wide open. Some recent results obtained with extensions of the Luthar - Passi method are given. Finally the question whether the prime graphs of  $V(\mathbb{Z}G)$  and  $G$  coincide is considered and results for soluble groups and Frobenius groups are presented.

## On Frobenius semidistributive algebras

V.V.Kirichenko and M.A.Khibina

We use terminology, definitions and results given in [1]. A quasi-Frobenius algebra  $A$  is called **weakly symmetric** if its Nakayama permutation  $\nu(A)$  is identity.

**Theorem 1.** *Let  $A$  be a weakly symmetric algebra. Then  $A$  is Frobenius and every algebra  $C$  Morita equivalent to  $A$  is also Frobenius. Conversely, if every finite dimensional algebra  $C$  Morita equivalent to a Frobenius algebra  $A$  is Frobenius, then  $A$  is a weakly symmetric algebra.*

We construct a countable set of Frobenius serial algebras which are not symmetric and give the example of a semidistributive weakly symmetric algebra which is not symmetric.

**Theorem 2.** *For any permutation  $\sigma \in S_n$  there exists a countable set of Frobenius semidistributive algebras  $A_n$  such that  $\nu(A_n) = \sigma$ .*

All such algebras may be finite.

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## On the projective representation type of finite groups over a local integral domain

Dariusz Klein

Let  $p \geq 2$  be a prime,  $S$  a local integral domain of characteristic  $p$ , which is not a field,  $S^*$  the multiplicative group of  $S$ ,  $F$  a subfield of  $S$ ,  $W$  a subgroup of  $S^*$ ,  $G$  a finite group whose order  $|G|$  is divisible by  $p$ , and  $G_p$  a Sylow  $p$ -subgroup of  $G$ . Denote by  $Z^2(G, W)$  the group of all  $W$ -valued normalized 2-cocycles of the group  $G$  that acts trivially on  $S^*$ . Let  $G'$  be the commutant of  $G$ ,  $C_p$  a Sylow  $p$ -subgroup of  $G'$ ,  $C_p \subset G_p$ , and  $G'_p$  the commutant of  $G_p$ .

The concept of projective  $(S, W)$ -representation type for the group  $G$  was introduced in paper [1] (finite, infinite, purely infinite, bounded, unbounded, purely unbounded, strongly unbounded, purely strongly unbounded projective  $(S, W)$ -representation type). A number of propositions was proved about  $p$ -groups with a given projective  $(S, W)$ -representation type. In this talk, we characterize arbitrary finite groups depending on their projective  $(S, W)$ -representation type. We also state necessary and sufficient conditions for  $G$  and  $G_p$  to be of the same projective  $(S, W)$ -representation type.

Let  $\Omega$  be a subgroup of the group  $F^*$ . Denote by  $i_F(\Omega)$  the number  $\sup\{0, m\}$ , where  $m$  is a natural number such that for some  $\gamma_1, \dots, \gamma_m \in \Omega$  the algebra

$$F[X]/(X^p - \gamma_1) \otimes_F \dots \otimes_F F[X]/(X^p - \gamma_m)$$

is a field.

**Theorem 1.** (i) *If  $|G_p| > 2$ , then  $G$  is of strongly unbounded projective  $(S, W)$ -representation type.*

(ii) *If  $|C_p| > 2$ , then  $G$  is of purely strongly unbounded projective  $(S, S^*)$ -representation type.*

(iii) *Let  $W \subset F^*$  and  $G_p/C_p$  be a direct product of  $r$  cyclic subgroups, where  $r \geq i_F(W) + 1$  for  $p > 2$  and  $r \geq i_F(W) + 2$  for  $p = 2$ . Then  $G$  is of purely strongly unbounded projective  $(S, W)$ -representation type.*

Let  $F[[X]]$  be the  $F$ -algebra of formal power series in the indeterminate  $X$  with coefficients in the field  $F$  of characteristic  $p$ .

**Theorem 2.** *Let  $S = F[[X]]$ . If  $C_p = G'_p$  or  $|G'_p| > 2$ , then the groups  $G$  and  $G_p$  are of the same projective  $(S, W)$ -representation type for any subgroup  $W$  of the group  $S^*$ .*

**Theorem 3.** *Let  $W$  be a subgroup of  $F^*$ ,  $S = F[[X]]$  and  $p \neq 2$ . If  $|C_p| \neq 1$  and  $|G'_p| = 1$ , then the groups  $G$  and  $G_p$  are of the same projective  $(S, W)$ -representation type if and only if  $G_p$  is a direct product of  $d$  cyclic subgroups and  $d \geq i_F(W) + 1$ .*

**Theorem 4.** *Let  $S = F[[X]]$  and  $p = 2$ . If  $|C_2| > 2$  and  $|G'_2| = 1$ , then the groups  $G$  and  $G_2$  are of the same projective  $(S, F^*)$ -representation type if and only if one of the following conditions is satisfied:*

- (i)  $G_2$  is a direct product of  $l$  cyclic subgroups and  $l \geq i_F(F^*) + 2$ ;
- (ii)  $G_2$  is a direct product of  $i_F(F^*) + 1$  cyclic subgroups whose orders are not equal to 2.

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## Computer investigations of the modular isomorphism problem

Alexander Konovalov

The talk will be devoted to the software package LAGUNA [2]. This package extends the computer algebra system GAP for computations in group rings. Besides computing some general properties and attributes of group rings and their elements, the version LAGUNA 3.3.1 is able to perform two main kinds of computations:

- it can calculate the structure of the normalized unit group of a group algebra of a finite  $p$ -group over the field of  $p$  elements;
- it can verify whether a group algebra of a finite group satisfies certain Lie properties.

In the first part of his talk the author would like to give a tutorial in LAGUNA package, giving a set of problems that can be investigated with its help, for example:

- how to find a subgroup of  $V(KG)$  generated by  $a$ ,  $b$  and  $a + b + ab$
- how to determine a minimal generating set of  $V(KG)$
- how to compute all bicycle units for a finite group  $G$

The author will give a report about checking that  $t^L(G) = t_L(G)$  for all 2-groups of order  $\leq 256$  and verifying (jointly with A. Tsapok) that normalised unit groups of modular group algebras over the field of  $p$  elements are pairwise non-isomorphic for 2-groups of orders 16 and 32.

In the second part of the talk the author would like to announce his contributions to the coming soon LAGUNA 4.0. It will contain a large new block of functionality related with the Modular Isomorphism Problem (MIP). In particular, it will be able:

- to compute a lot of invariants of  $p$ -groups, determined by their modular group algebras, such as the Quillen and Roggenkamp parameters, the number of conjugacy classes of  $p$ -th powers of elements, etc.;
- to apply the kernel size technique to a pair of group algebras to try to show that they are non-isomorphic;
- to maintain the library of MIP invariants that is necessary for checking MIP for groups of small orders.

In conclusion, the author will give a report about the current state of checking MIP for groups of orders 128, 256 and 729 with the development version of LAGUNA 4.0.

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## Bigroups and a Limit Variety of Groups

Alexei N. Krasilnikov

It follows easily from Zorn's lemma that if a variety of groups  $\mathbf{V}$  is not finitely based then it contains a subvariety  $\mathbf{V}^*$  such that all proper subvarieties of  $\mathbf{V}^*$  are finitely based, but  $\mathbf{V}^*$  itself is not. Any variety with these properties is called a *limit* or a *just non-finitely based* variety. In this sense limit varieties of groups form a "border" between those which are finitely based and those which are not. It is known that infinitely many such varieties exist (Newman [1]) although no explicit examples are known.

Recently in [2] the first example of a limit variety  $\mathbb{V}$  of bigroups was constructed. A *bigroup* is a pair  $(H, \pi)$  consisting of a group  $H$  and an idempotent endomorphism (projection)  $\pi$  of  $H$ . One can consider  $\pi$  as a unary operation on  $H$  so a bigroup is a universal algebra.

Let  $\mathbf{V}$  be the variety of groups defined by

$$\mathbf{V} = \text{var} \{H \mid \mathcal{H} = (H, \pi) \in \mathbb{V} \text{ for some projection } \pi : H \rightarrow H\}.$$

In other words, the variety of groups  $\mathbf{V}$  is generated by all the bigroups  $\mathcal{H} \in \mathbb{V}$  if we consider them as groups and "forget" about the additional operation  $\pi$  on  $\mathcal{H}$ . It was conjectured in [3] that  $\mathbf{V}$  is a limit variety of groups, that is, (i)  $\mathbf{V}$  is a non-finitely based variety and (ii) it satisfies the minimal condition on subvarieties. Our main result confirms the item (i) of the conjecture.

**Theorem.** *The variety of groups  $\mathbf{V}$  described above is non-finitely based.*

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## On strongly balanced groups

Jan Krempa

Let  $L$  be a lattice. Then  $L$  is *balanced* if for all  $x, y, z \in L$  we have

$$x \wedge y = 0 \quad \& \quad (x \vee y) \wedge z = 0 \quad \implies \quad (y \vee z) \wedge x = 0$$

and  $L$  is *strongly balanced* if all nonempty intervals of  $L$  are balanced lattices. It is well known that modular lattices are strongly balanced.

If  $G$  is a group, then the set  $L(G)$  of all subgroups of  $G$ , ordered by inclusion, is a lattice ([4]). Thus, using  $L(G)$  we can consider *modular groups*, *balanced groups* and *strongly balanced groups*.

Let us agree, that a group  $G$  is a  $P^\#$ -group if  $G$  is a semidirect product of an elementary abelian normal  $p$ -subgroup  $A$  and a cyclic group  $\langle t \rangle$  of prime power order such that  $t$  induces a power automorphism on  $A$ . If  $t$  induces an automorphism of prime order on  $A$  then  $G$  is a  $P^*$ -group. Under this notation we have ([4,1,3]):

**Theorem 1.** *A locally finite group is modular if and only if it is a direct product of modular  $p$ -groups and some  $P^*$ -groups with relatively prime orders.*

**Theorem 2.** *A locally finite group is strongly balanced if and only if it is a direct product of locally finite modular  $p$ -groups and some  $P^\#$ -groups with relatively prime orders.*

Locally finite modular  $p$ -groups are completely described ([4]). By results of Ol'shanskii, Deryabina and others ([2]) we know, that there are finitely generated, infinite and strongly balanced (even modular)  $p$ -groups. We are going to prove the following

**Theorem 3.** *Let  $G$  be a periodic, strongly balanced group. If  $G$  is locally graded, then  $G$  is locally finite.*

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## Some properties of a counterexample to G.Bergman's Problem

Olga Macedońska

The problem, posed in 1981 by G. Bergman asks whether a group  $G$  must satisfy a semigroup identity if its generating subsemigroup  $S$  does satisfy an identity. In spite of many hopes and tries the problem was open for more than 20 years. At the Algebraic Conference in Moscow 2004, S. Ivanov and A. Storozhev announced the existence of a group  $G$  with the generating relatively free subsemigroup  $S$  satisfying nontrivial identity, while  $G$  itself does not satisfy any identity. We call such a group the counterexample to the G. Bergman's Problem, and describe some properties it must satisfy, e.g. it must be a non-Hopf group.

## Generators for finite and profinite groups and probability

Federico Menegazzo

To every finitely generated group  $G$  we can associate a formal Dirichlet series  $P_G(s) = \sum_n \frac{a(G,n)}{n^s}$  where  $a(G,n) = \sum_{|G:H|=n} \mu_G(H)$ ,  $\mu_G$  being the Möbius function of the subgroup lattice of  $G$ . If  $G$  is finite and  $k$  is a sufficiently large natural number, then  $P_G(k)$  is the probability that  $k$  random elements of  $G$  generate  $G$ . We shall comment on relations between properties of  $P_G$  and the structure of  $G$ .

We then focus our attention to finitely generated prosoluble groups. These groups are positively finitely generated – a group  $G$  is positively finitely generated if there is an integer  $k$  such that the probability of generating  $G$  with  $k$  random elements is positive; we shall denote by  $d_P(G)$  the minimum such  $k$ . We shall discuss the possibilities for  $d_P(G)$  when the minimum number  $d(G)$  of generators of  $G$  is given.

## Solving equations in groups

Daniela Nikolova

It is a well-known fact that a finite group is nilpotent iff it satisfies an Engel law of some length. The subject of our recent research has been to establish a similar characterization for finite soluble groups. It is sufficient to check the problem on two-generated subgroups. For this purpose a sequence of two-variable commutator formulae are investigated (Conjecture of B.I.Plotkin). The solubility is checked by examining a counter-example of least possible order, i.e. we attempt to show that in minimal simple groups there are no such identities. Thus, we solve equations in matrix groups, especially for the generic case  $G = \text{PSL}(2, p)$  involving computer calculations. The solution of such equations is connected to some well-known problems in finite matrix groups, as for example the Ore conjecture.

## Representations of braid groups by automorphisms of rooted trees

Andriy Oliynyk

Let  $\mathcal{T}_n$  be a *rooted homogeneous tree* of degree  $n$  ( $n \geq 2$ ) and  $Aut\mathcal{T}_n$  its automorphism group. For a permutation  $\sigma$  from the symmetric group  $S_n$  of degree  $n$  and automorphisms  $g_1, \dots, g_n$  from  $Aut\mathcal{T}_n$  denote by  $(g_1, \dots, g_n)\sigma$  the element of  $Aut\mathcal{T}_n$ , which acts as  $\sigma$  on the edges adjacent to the root and as  $g_1, \dots, g_n$  on the subtrees initiated on the first level. Note that each automorphism  $g \in Aut\mathcal{T}_n$  can be uniquely expressed in this form. The automorphisms  $g_1, g_2, \dots, g_n$  are called *states* of the first level of  $g$ . The *states of the second level* of  $g$  are states of the first level of the automorphisms  $g_1, g_2, \dots, g_n$ . Inductively we define the *states of the  $k$ -th level* of  $g$  for every positive integer  $k$ . The state of the 0-th level of  $g$  is  $g$  itself. An automorphism  $g \in Aut\mathcal{T}_n$  is called a *finite state automorphism* if  $g$  has only finite number of different states. All finite state automorphisms form in  $Aut\mathcal{T}_n$  a subgroup ([GNS]).

The Artin's *braid group*  $B_n, n \geq 3$ , ([A]) is given by the presentation

$$\langle \sigma_1, \dots, \sigma_{n-1} \mid \sigma_i \sigma_j = \sigma_j \sigma_i, |i - j| > 1; \sigma_i \sigma_{i+1} \sigma_i = \sigma_{i+1} \sigma_i \sigma_{i+1}, i = 1, \dots, n - 1 \rangle.$$

The following results obtained jointly with Y.Lavrenyuk and V.Mazorchuk.

**Theorem 1.** *The braid group  $B_n$  acts faithfully on the rooted tree  $\mathcal{T}_n$ .*

**Theorem 2.** *The braid group  $B_3$  acts faithfully on the rooted tree  $\mathcal{T}_3$  by finite state automorphisms.*

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## Infinitely iterated wreath products as isometry groups of fractal constructions of metric spaces

Bogdana Oliynyk

Let  $(\mathcal{X}_1, d_1)$  and  $(\mathcal{X}_2, d_2)$  be finite metric spaces. Using ideas of [1] one can construct a *scale*, i.e. a strictly increasing continuous function  $s : \mathbb{R}^+ \rightarrow \mathbb{R}^+$  with  $s(0) = 0$  such that for arbitrary  $a, b \in \mathcal{X}_2$  the inequalities

$$2 \operatorname{diam} \mathcal{X}_1 \leq 4 s(d_2(a, b)) \leq 3 \operatorname{diam} \mathcal{X}_1$$

hold. Fix such a scale  $s$ . On the cartesian product  $\mathcal{X}_1 \times \mathcal{X}_2$  define a two-variable function  $\rho_s$  by the rule:

$$\rho_s((a_1, b_1), (a_2, b_2)) = \begin{cases} \tau(d_2(b_1, b_2)), & \text{if } a_1 = a_2 \\ d_1(a_1, a_2), & \text{if } a_1 \neq a_2 \end{cases}.$$

Then  $\rho$  is a distance on  $\mathcal{X}_1 \times \mathcal{X}_2$  and denote by  $P_s(\mathcal{X}_1, \mathcal{X}_2)$  the metric space  $(\mathcal{X}_1 \times \mathcal{X}_2, \rho_s)$ .

Let now  $(\mathcal{X}_1, d_1), (\mathcal{X}_2, d_2), \dots, (\mathcal{X}_n, d_n), \dots$  be a countable sequence of finite metric spaces. Having defined a metric space  $P_2(\mathcal{X}_1, \mathcal{X}_2) = P_{s_1}(\mathcal{X}_1, \mathcal{X}_2)$  for some scale  $s_1$  we can then define a space  $P_3(\mathcal{X}_1, \mathcal{X}_2, \mathcal{X}_3) = P_{s_2}(P_2(\mathcal{X}_1, \mathcal{X}_2), \mathcal{X}_3)$  for some scale  $s_2$ . In this way for each  $n \geq 1$  we obtain the space  $P_n(\mathcal{X}_1, \mathcal{X}_2, \dots, \mathcal{X}_n)$  (we put  $P_1(\mathcal{X}_1) = \mathcal{X}_1$ ). Note that  $P_n(\mathcal{X}_1, \mathcal{X}_2, \dots, \mathcal{X}_n)$  is a metric space on the set  $\mathcal{X}_1 \times \mathcal{X}_2 \times \dots \times \mathcal{X}_n$ . For each  $n \geq 2$  choosing an element  $x_n^0 \in \mathcal{X}_n$  and mapping  $(x_1, \dots, x_{n-1})$  to  $(x_1, \dots, x_{n-1}, x_n^0)$  we define an isometric embedding of  $P_{n-1}(\mathcal{X}_1, \mathcal{X}_2, \dots, \mathcal{X}_{n-1})$  into  $P_n(\mathcal{X}_1, \mathcal{X}_2, \dots, \mathcal{X}_n)$ . Hence we obtain the inductive limit and denote it by  $P(\mathcal{X}_1, \dots, \mathcal{X}_n, \dots)$ .

**Theorem 1.** *The isometry group of the space  $P(\mathcal{X}_1, \dots, \mathcal{X}_n, \dots)$  is isomorphic as a permutation group to the infinite wreath product of isometry groups of spaces  $\mathcal{X}_1, \dots, \mathcal{X}_n, \dots$ , i.e.*

$$(IsP(\mathcal{X}_1, \dots, \mathcal{X}_n, \dots), P(\mathcal{X}_1, \dots, \mathcal{X}_n, \dots)) \simeq \left( \prod_{i=1}^{\infty} Is\mathcal{X}_i, P(\mathcal{X}_1, \dots, \mathcal{X}_n, \dots) \right).$$

Let  $\mathcal{X}_i$  ( $i \geq 1$ ) be an  $m$ -point metric space and all non-zero distances in it are equal to 1.

**Theorem 2.** *The Hausdorff dimension of the space  $P(\mathcal{X}_1, \dots, \mathcal{X}_n, \dots)$  is equal to  $\log_2 m$ .*

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## Merzlyako 's theorem for groups with free regular length functions

Denis Serbin

A first-order sentence is called positive if it contains no negations or implications. It was proved by Yu.Merzlyakov that a positive sentence true in a free group  $F$  can be reduced to a positive universal sentence (all quantifiers are universal). Moreover, Merzlyakov proved existence of Skolem functions for positive theory of  $F$ .

We introduce an analog of Merzlykov's result for the class of groups with free regular length functions.

This is joint work with Bilal Khan and Alexei G. Miasnikov.

## Hyperbolic loops

Antonio Calixto de Souza Filho

Given a group  $G$  and considering the integral unit group  $U(ZG)$ , we may classify the groups  $G$ , for which the group  $U(ZG)$  satisfies a certain property  $P$ . For some suitable property  $P$ , we extended this sort of classification. (key words: unit, unit group, classification theorems).

## Ordered Semigroups

Andrzej Strojnowski

It is known that if  $G$  is an ordered or right ordered group then the Group Algebra  $KG$  does not contain zero divisors nor nontrivial units. We show that some of such results can be moved to Semigroup Algebras and some of them not.

## Unique Factorization Group and Semigroup Algebras

Qiang (Steven) Wang

A non-commutative prime unital ring  $R$  is called a unique factorization ring (UFR) if every non-zero prime ideal of  $R$  contains a non-zero principal prime ideal. Several authors have investigated when a group ring is a unique factorization ring. A full description has been obtained for group rings of polycyclic-by-finite group or group rings of abelian-by-finite groups. Let  $S$  be a submonoid of a torsionfree polycyclic-by-finite group or abelian-by-finite group and  $G$  be the group of quotients. We characterize when the semigroup algebra  $K[S]$  is UFR in terms of the group algebra  $K[G]$  and the underlying semigroup  $S$ . This is a joint work with E. Jespers.

## Almost diagonal matrices over $n$ -simple Bezout domains

B. Zabavsky

It is well known that a simple Bezout domain is an elementary division domain if and only if it is 2-simple [1]. In the case of  $n$ -simple Bezout domains ( $n > 2$ ), we obtained the following result.

**Theorem.** *If  $R$  is a  $n$ -simple Bezout domain, then for every  $m$  by  $m$  matrix  $A$ , where  $m > n$  exists unimodular matrices  $P, Q$  such that*

$$PAQ = \begin{pmatrix} 1 & & & & 0 \\ & \ddots & & & \\ & & 1 & & \\ & & & A' & \\ 0 & & & & 0 \end{pmatrix},$$

where  $A'$  —  $n$  by  $n$  matrix.

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## Finite approximation of groups and algebras

Milos. Ziman

We will study the problem of local approximation of a group by finite groups. The main tool for this approximation is a 'homomorphic' embedding of any finite part of the group into a finite group.

But not all groups admit this kind of approximation. So we will look for a class of finite groupoids approximating every group. The solution of this problem is closely connected with the question of extendability of partial Latin squares (rectangles).

A mentioned approximation can be generalized to an approximation of a linear algebra by some class of finite dimensional not necessarily associative algebras. We will study also a connection between an approximation of a group and an approximation of its group algebra.

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