MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

T a g u n g s b e r i c h t 20/1987

Gruppentheorie

3.5. bis 9.5.1987

Die Tagung fand unter der Planung der Herren O.H.Kegel (Freiburg) und K.W.Gruenberg (London) statt (letzterer konnte leider nicht anwesend sein). In insgesamt 40 Vorträgen wurden den 53 Teilnehmern aus 12 Staaten unter anderem Resultate über endlich präsentierte Gruppen, einfache Gruppen, endliche auflösbare Gruppen, Fittingklassen in unendlichen lokal auflösbaren Gruppen, Automorphismen von freien Gruppen und Produkten, Darstellungstheorie, verallgemeinerte lineare Gruppen, und universelle Strukturen vorgestellt. Die Themenliste war sehr vielfältig; für weitergehende Informationen muß daher auf die nachfolgenden Vortragsauszüge verwiesen werden. Das umfangreiche Tagungsprogramm regte die Teilnehmer zu zahlreichen interessanten und ausgedehnten Diskussionen an. Leider war es den eingeladenen sowjetischen Kollegen nicht möglich, an der Tagung teilzunehmen.

Vortragsauszüge

Z. Arad:

Table algebras and applications to finite group theory

Recently, several results were proved about products of irreducible characters and products of conjugacy classes in finite groups demonstrating, sometimes, an analogy between them. The main goal of our research (jointly with H.Blau) is to introduce a new concept which we call table algebras and then to study properties of these algebras. Table algebras are in some sense generalizations of finite groups. If G is a finite group then the table algebras generated either by the conjugacy classes or by the irreducible characters over the field of complex numbers are examples of table algebras. Every general theorem about table algebras can be applied to a theorem about characters and also to a theorem about conjugacy classes in finite groups. The main goal of our research is to develope a new theory about table algebras and to apply it to finite group theory.

J. C. Beidleman:

Fitting classes of $\underline{\underline{S}}_1$-groups

An $\underline{\underline{S}}_1$-group is one possessing a finite normal series in which the factors are abelian groups of finite rank whose torsion subgroups are Černikov groups. A Fitting class of $\underline{\underline{S}}_1$-groups is a subclass $\underline{\underline{X}}$ of $\underline{\underline{S}}_1$ such that:

(F1) If $G \in \underline{\underline{X}}$ and A asc G, then $A \in \underline{\underline{X}}$.

(F2) If $G \in \underline{\underline{S}}_1$ is generated by ascendant $\underline{\underline{X}}$-subgroups, then $G \in \underline{\underline{X}}$.

Let $\underline{\underline{X}}$ be a Fitting class of $\underline{\underline{S}}_1$-groups. (F2) ensures that the join of ascendant $\underline{\underline{X}}$-subgroups of G is a normal $\underline{\underline{X}}$-subgroup $G_{\underline{\underline{X}}}$ of G. $G_{\underline{\underline{X}}}$ is called the $\underline{\underline{X}}$-radical of G. The class $\underline{\underline{N}}$ of locally nilpotent $\underline{\underline{S}}_1$-groups is a Fitting class of $\underline{\underline{S}}_1$-groups. Also $G_{\underline{\underline{N}}}$ is just the Hirsch-Plotkin radical of G. Let p be a prime. For $G \in S_1$, the p-socle of G is $Soc_p(G) = \langle M \mid M$ a minimal normal p-subgroup of $G \rangle$. If G has no minimal normal p-subgroups, then $Soc_p(G) = 1$. $C(p) = (G \in \underline{\underline{S}}_1 \mid Soc_p(G) \leq Z(G))$ is a Fitting class of $\underline{\underline{S}}_1$-groups, and if $G \in \underline{\underline{S}}_1$ then $G_{C(p)} = C_G(Soc_p(G))$.

A subgroup X of $G \in \underline{\underline{S}}_1$ is called an $\underline{\underline{X}}$-injector of G provided that $X \cap A$ is a maximal $\underline{\underline{X}}$-subgroup of A for each ascendant subgroup A of G. The following theorems are considered.

<u>Theorem 1</u>. Let $\underline{\underline{X}}$ be a Fitting class of $\underline{\underline{S}}_1$-groups and let $G \in \underline{\underline{S}}_1$. If $G/G_{\underline{\underline{X}}}$ is finite, then G has $\underline{\underline{X}}$-injectors and any two $\underline{\underline{X}}$-injectors are conjugate. <u>Theorem 2</u>. Let $\underline{\underline{X}}$ be a Fitting class of $\underline{\underline{S}}_1$-groups such that $\underline{\underline{N}} \not\subseteq \underline{\underline{X}}$. Then there is a polycyclic group G which does not have $\underline{\underline{X}}$-injectors. <u>Theorem 3</u>. Let $\underline{\underline{X}}$ be a Fitting class of $\underline{\underline{S}}_1$-groups containing $\underline{\underline{N}}$ and let $G \in \underline{\underline{S}}_1$. Suppose that G has a normal subgroup M such that $M/G_{\underline{\underline{X}}}$ is finite and M contains all $\underline{\underline{X}}$-subgroups of G which contain $G_{\underline{\underline{X}}}$. Then G has $\underline{\underline{X}}$-injectors and any two such subgroups are conjugate, and $Inj_{\underline{\underline{X}}}(M) = Inj_{\underline{\underline{X}}}(G)$. <u>Theorem 4</u>. Let $\underline{\underline{X}}$ be a Fitting class of $\underline{\underline{S}}_1$-groups such that every $\underline{\underline{S}}_1$-group G has a unique conjugacy class of $\underline{\underline{X}}$-injectors. If $G \in \underline{\underline{S}}_1$ and $X \in Inj_{\underline{\underline{X}}}(G)$, then $X^G/G_{\underline{\underline{X}}}$ is finite and $Inj_{\underline{\underline{X}}}(X^G) = Inj_{\underline{\underline{X}}}(G)$.

Let $G \in \underline{\underline{S}}_1$. By Theorem 1 G has a unique conjugacy class of C(p)-injectors. Also G has a normal subgroup N such that $N/G_{\underline{\underline{N}}}$ is finite and N contains all the $\underline{\underline{N}}$-subgroups of G which contain $G_{\underline{\underline{N}}}$. Hence G has a unique conjugacy class of $\underline{\underline{N}}$-injectors. This was first established by M. Tomkinson (see Proc. Edinburgh Math. Soc. 1979).

D.Blessenohl:

Regular elements in Galois extensions

In a finite Galois extension L/K an element x will be called completely regular if x serves as a generator for the MU-module L for all $U \leq G := \mathrm{Gal}(L/K)$ and M the fixed field of U. One can show that completely regular elements always exist. The proof of this theorem (joint work with K.Johnsen in Kiel) for infinite K is a variation of a proof given by Emil Artin for the existence of a normal basis for L/K. If K is a finite field we can restrict ourselves to the case that G is a cyclic q-group for some prime q. The case $\mathrm{Char}\, K = q$ is easy. If $\mathrm{Char}\, K \neq q$, one has to look closer on the structure of L as a K_iG_i-module where $G = G_0 > G_1 > \dots > G_{n-1} > G_n = 1$ and $K = K_0 < K_1 < \dots < K_{n-1} < K_n = L$. By a comparison of the direct decompositions of $T = \mathrm{Ker}\, \mathrm{Tr}_{L/K_{n-1}}$ into the irreducible K_iG_i-submodules for $0 \leq i \leq n-1$ and induction for K_{n-1} the theorem is proved.

A.Brandis:

Modules and crossed homomorphisms of finite groups, especially p-solvable groups

Let G be a p-solvable group and P_1 the projective hull of the trivial representation of G over the prime field $\mathbb{F}_p$. Let $\mathcal{H}$ be a principal series of G and A the direct product of all splitting p-chief-factors of $\mathcal{H}$. A chief-factor L/K is a G-module by $(xK)^g = g^{-1}xgK$. So A is a G-module. We show the existence of a "canonical" crossed homomorphism ψ of G onto A; $\ker \psi = D$ is a p-prefrattinisubgroup of G. The group ring $\mathbb{F}_p[A]$ is made a G-module by $a \circ g = a^g \psi(g)$. This module is called $\mathbb{F}_p[A]_\psi$. Then we get:

Theorem. (a) There is a G-epimorphism $\hat{\psi}: P_1 \longrightarrow \mathbb{F}_p[A]_\psi$, $\ker \hat{\psi} \cong P_1(D)J_D \otimes_D \mathbb{F}_p[G]$, where J_D is the radical of $\mathbb{F}_p[D]$.
(b) $\hat{\psi}: P_1 J_G \twoheadrightarrow J_{A,\psi}$, the augmentation ideal of $\mathbb{F}_p[A]$ with the "$\circ$" structure. (c) There is a G-epimorphism $\pi: J_{A,\psi} \longrightarrow A$, given by $a-1 \xrightarrow{\pi} a$. (d) Let τ be the composed mapping: $P_1 J_G \longrightarrow A$, then $\ker \tau = P_1 J_G^2$.

So we get a new proof of Gaschütz's theorem: $P_1 J_G / P_1 J_G^2 \cong A$.
Moreover all composition factors of $\mathbb{F}_p[A]_\psi$ are composition factors of $\mathbb{F}_p[A]$, so we get new information on the structure of P_1. Especially we get a very simple proof of the theorem of Green and Hill.

R.Brandl:

Groups with thin lattices of subgroups

The width of a lattice is defined to be the maximum possible cardinality of its antichains. For a group G, let w(G) (resp. $w_n(G)$) denote the width of the lattice of all (normal) subgroups of G.
Theorem. Let n be a positive integer. Then there exist finitely many finite groups $H_1,\dots,H_t$ with the following property. If $w(G) = n$, then G is a split extension of a normal Hall subgroup $H \cong H_i$ (some i) by a locally cyclic torsion group Q. If Q is infinite, then there exists exactly one subgroup of type p^∞ in Q, and it is a direct summand of G. Corollary 1. For every given n there exist only finitely many non locally cyclic p-groups of width n.
Corollary 2. The derived length of a soluble group is bounded by a function of its width.
Finally, relations between finite p-groups G satisfying $w_n(G) = p+1$ and groups of maximal class are discussed.

B.Brewster:

Non-conjugate Fitting functors

A subgroup functor f on a class $\mathfrak{D}$ of finite groups assigns to each group $G \in \mathfrak{D}$ a set of subgroups f(G) of G such that if $\alpha: G \longrightarrow \overline{G}$ is an injective homomorphism, then $f(G^\alpha) = \{X^\alpha \mid X \in f(G)\}$. In two recent papers Beidleman, Hauck and I (MZ 182 (1983),359-384 and Proc. Cambr.Phil.Soc.(1987) 101, 37-55) studied a particular type subgroup functor. We were trying to analyze how $\mathfrak{F}$-injectors for Fitting class $\mathfrak{F}$ behaved in solvable groups without dependence on the class. We called a subgroup functor f a Fitting functor provided f satisfies (A) For $N \triangleleft G$ and $X \in f(G)$, $X \cap N \in f(N)$;
(B) For $N \triangleleft G$ and $Y \in f(N)$, there is $X \in f(G)$ such that $X \cap N = Y$.
The primary examples are injectors and radicals of Fitting classes but others were produced too. A Fitting functor f satisfies the Frattini argument provided for every group $G \in \mathfrak{D}$, $K \triangleleft G$ and $U \in f(G)$, $G = K \cdot \mathbb{N}_G(U \cap K)$. Our experience indicates that if extra properties are imposed on f, then f tends to satisfy the Frattini argument. We say f satisfies the cover-avoidance property provided each $U \in f(G)$ either covers or avoids each chief factor of G. Certainly a Fitting functor which satisfies the Frattini argument has the cover-avoidance property. Unfortunately, we know only two types of constructions which produce Fitting functors which do not satisfy the Frattini argument.

(1) If f and h are Fitting functors with domain $\mathfrak{D}$ then for $G \in \mathfrak{D}$, $f \cap h(G) = \{U \cap V \mid U \in f(G), V \in h(G)\}$ is a Fitting functor on $\mathfrak{D}$ which in general does not have the cover-avoidance property. In particular, if $f(G) = Syl_2(G)$, $f \cap f$ does not have the cover-avoidance property.
(2) If $\overline{f}$ is a subgroup functor on an s_n-closed class $\mathfrak{B}$ such that $\overline{f}$ satisfies condition (A) in definition of a Fitting functor, then $f(G) = \{V \mid \exists\, B \triangleleft\triangleleft G,\ B \in \mathfrak{B}$ with $V \in \overline{f}(B)\}$ is a Fitting functor (also $\triangleleft\triangleleft$ may be replaced by $\leq$). Note f satisfies (B) because it satisfies (*): For $N \triangleleft G$ and $U \in f(N)$, $U \in f(G)$.
(3) If f satisfies the cover-avoidance property on $\mathfrak{S}$ (finite solvable groups), p is a prime and $U \in f(G)$ such that $p \mid |U|$, then $O_p(G) \leq U$.

Corollary. If f is a Fitting functor on $\mathfrak{S}$ which has the cover-avoidance property and satisfies (*), then $f(G) = \{1\}$ for all $G \in \mathfrak{S}$.

R.M.Bryant:

Automorphisms of free groups

Let $F_{n,c}$ be the free nilpotent group of class c on n generators $x_1,\dots,x_n$ $(n \geq 2)$. Thus $F_{n,c} \cong F_n/\gamma_{c+1}(F_n)$ where F_n is free. Let T be the subgroup of $Aut(F_{n,c})$ consisting of those automorphisms induced from $Aut(F_n)$. Let δ be the automorphism of $F_{n,c}$ satisfying $x_1\delta = x_1[x_1,x_2,x_1]$ and $x_i\delta = x_i$ $(i \geq 2)$. Suppose that $n \geq \frac{c}{2}+1$. Then $Aut(F_{n,c}) = \langle T,\delta \rangle$. Hence, for $n \geq 4$ and $n \geq \frac{c}{2}+1$, $Aut(F_{n,c})$ is a 3-generator group. (Joint work with C.K.Gupta)

K.Buzási:

Structure of crossed group algebras of infinite groups over the real field

Let D be the infinite dihedral group $D = (a)\cdot(b)$, where (a) is the infinite cyclic group, (b) the cyclic group of order 2, and R the field of real numbers. We study the structure of a crossed group algebra A of the group D over R defined by the relations $A = (R,a,b)$; $\lambda a = a\lambda$, $\lambda b = b\lambda$, $b^{-1}ab = a^{-1}$, $b^2 = -1$ $(\lambda \in R)$. We show that the algebra A is not a ring of principal left ideals. We shall describe all the left ideals of A and examine the conditions of their isomorphism. We investigate the structure of A-modules and show that every finitely generated torsion-free A-module is either isomorphic to a left ideal of A or is a free A-module.

D.J.Collins:

The automorphism group of a free product of finite groups

Theorem. Let $G = \mathop{*}_{i=1}^{n} G_i$ be a free product of finite groups. Then the automorphism group Aut G has a torsion-free subgroup of finite index. □. This is established by embedding Aut G in Aut C(G) where C(G) is the kernel of the natural map from $\mathop{*}_{i=1}^{n} G_i \twoheadrightarrow \prod_{i=1}^{n} G_i$. Since C(G) is well-known to be free, of finite rank when all G_i are finite, the theorem follows from the corresponding result for free groups of finite rank.

M.Conder:

The groups $G^{k,l,m}$

For positive integers k,l,m, the group $G^{k,l,m}$ is defined by $G^{k,l,m} = \langle A,B,C \mid A^k = B^l = C^m = (AB)^2 = (BC)^2 = (CA)^2 = (ABC)^2 = 1 \rangle$. We consider the question: How small can k,l and m be made, while maintaining the property that all but finitely many alternating groups A_n and symmetric groups S_n occur as quotients of $G^{k,l,m}$? One approach is to make k as small as possible, then l, and then m, and here the best result we have so far is (k,l,m) = (3,7,168). Another approach is to make all of k,l and m small, and in this talk we show how (k,l,m) may be taken as (6,6,6); in other words, all but finitely many A_n and S_n can be generated by three elements A,B,C, all of order 6, satisfying also $(AB)^2 = (BC)^2 = (AC)^2 = (ABC)^2 = 1$.

M.Dixon:

Fitting classes in infinite groups

The infinite groups in question are periodic locally soluble groups with min-p for all primes p. The work on Fitting classes and injectors in such groups is just starting. If one restricts oneself to hyper-(locally nilpotent) groups then injectors exist for a number of the standard Fitting classes, but no general result has yet been obtained. An example exists in which the $\mathfrak{S}_\pi$-injectors are non-isomorphic. However locally nilpotent injectors are always isomorphic and have a certain conjugacy property.

A.Espuelas:

Regular orbits, fixed-point-free action and character degrees

Theorem. Let G be a solvable group and let H/K be a chief factor of G. Suppose that A is a p-subgroup of G acting faithfully on H/K and

$C_p \wr C_p$-free when p is either 2 or a Mersenne prime. Then H/K contains a regular A-orbit, i.e. there exists $v \in H/K$ with $C_A(v) = 1$.
This provides evidence for the following conjectures:
A. If A is a nilpotent f.p.f. automorphism group of the solvable group G, then $f(G) \leq n(A)$. (Here f(X) denotes Fitting length and n(X) denotes composition length).
B. Let A be a group of order p^n acting f.p.f. on each A-invariant p'-section of the p-solvable (resp. solvable) group G. Then $l_p(G) \leq$ $\leq n+1$ (resp. $f(G) \leq 2n+1$). (Here $l_p(X)$ denotes p-length.)
A consequence about character degrees: Let G be a primitive solvable group. Suppose that F(G) is a p-group, p odd. Take $P \in S_p(G)$. Then $b(P) = \max\{\psi(1) \mid \psi \in Irr(P)\} = |G:F(G)|_p$.

S.Franciosi:
Trifactorized soluble minimax groups

Suppose that the soluble minimax group G has a triple factorization $G = AB = AC = BC$ where A,B and C are subgroups. The following is proved: (a) If A and B are nilpotent and C is locally nilpotent, then G is locally nilpotent and hence hypercentral. (b) If A and B are nilpotent and C is locally supersoluble, then G is locally supersoluble and hence hypercyclic.
The proof uses the validity of these results for finite groups (Kegel 1965) and some homological results. (joint work with B.Amberg and F. de Giovanni)

F. de Giovanni:
Automorphisms and normal subgroups

The automorphisms of a group G which leave every normal subgroup of G invariant form a normal subgroup $Aut_n G$ of the automorphism group of G. When G is a nilpotent group, the structure of $Aut_n G$ can be described and in many cases $Aut_n G$ is itself nilpotent. Some information can be obtained also for the group $Aut_{sn} G$ of the automorphisms of a soluble group G which leave every subnormal subgroup of G invariant. (joint work with S.Franciosi)

B.Hartley:
Free subgroups in unit groups

The following theorem was discussed: Theorem. Let G be a finite group and $U = U(\mathbb{Z}G)$ the unit group of the integral group ring $\mathbb{Z}G$.

Then U has a subgroup U_o of finite index such that if $N \triangleleft U$ and N has no non-abelian free subgroup, then $N \cap U_o \leq Z(U)$, the centre of U. Further, $U = U_o$ unless some non-abelian quotient of G is isomorphic to a subgroup of the real quaternions $\mathbb{H}$.
The proof is a quite straightforward consequence of the well known fact that U can be viewed as an arithmetic group, together with Tit's theorem and a density theorem of Borel. In fact, the first part of the theorem holds for arbitrary arithmetic subgroups of reductive algebraic $\mathbb{Q}$-groups, and hence for unit groups of $\mathbb{Z}$-orders in finite dimensional semisimple $\mathbb{Q}$-algebras for example.

P.Hauck:

Supersoluble subgroups of symmetric groups

(joint work with M.Bianchi, A.Gillio Berta Mauri, Milano)
All maximal supersoluble subgroups of symmetric groups of finite degree are classified. One of the consequences of this result is the following: The symmetric group S_n contains exactly one conjugacy class of maximal supersoluble transitive subgroups if and only if $n \in M$ or $n \in 2M$ where $M = \{m \in \mathbb{N} \mid$ if p,q are primes dividing m, then p does not divide $q-1\}$.

H.Heineken:

The subnormal embedding of relatively complete groups

A group A is said to be complete with respect to a Fitting class F, if (i) $Z(A) = 1$, and

(ii) if U is a subgroup of Aut(A) containing Inn(A), then the F-radical of U is Inn(A).

The following statement holds: If A is complete with respect to some Fitting class F which is closed with respect to epimorphic images and is a subnormal subgroup of the finite group G, if furthermore A is not isomorphic to the 2,p-Hall subgroup of $Hol(C_{p^k})$ with $p \equiv 3 \bmod 4$, then $A^G/F(A^G)$ is the direct product of the conjugates of $AF(A^G)/F(A^G)$ and the nilpotent residual of A^G is the direct product of the conjugates of the nilpotent residual of A.
This result (obtained in joint work with P.Soules) generalizes in part the result for complete groups obtained earlier together with J.C.Lennox.

T.C.Hurley:

Free products and stability groups

(joint work with M.Ward)

Let $G = Y*X$ be the free product of an arbitrary non-trivial group Y and a free group X, freely generated by the set A. We investigate the structure of G via what we term basic subgroups of G, which have analogous properties to the basic commutator elements in a free group. In particular, there exists a series $X, Y, Y_1, Y_2, \ldots, Y_n, \ldots$ of subgroups of G such that each element w of G has a unique expression $w = xyy_1 \ldots y_n w_{n+1}$ with $x \in X$, $y \in Y$, $y_i \in Y_i$ for $i = 1, 2, \ldots, n$ and $w_{n+1} \in [Y,_{n+1}X]$ (and $[Y,_{n+1}X]$ is actually equal to $[Y_n, X]$). Explicit bases for the groups Y_i and $[Y,_n X]$ are given, so that their structures are completely known. The connection between stability groups and $G/[Y,_m X]^G$ is shown, and when Y is also free then $G/[Y,_m X]^G$ is the "free stability group". The structures are used to determine the exact class of the stability group of a series of subgroups. We also speculate on how these structures may be useful in the investigation of the solvability of a set of equations over a group. (The equations $w_1 = 1, \ldots, w_r = 1$ with $w_i \in H*X$ (X free) are solvable over H if $H \hookrightarrow H*X \longrightarrow (H*X)/\langle w_1, \ldots, w_r \rangle^{H*X}$ is injective.)

L.G.Kovács:

Primitive subgroups of wreath products in product action

Given a primitive subgroup G in a (finite) symmetric group $\mathrm{Sym}\,\Omega$ with soc G not regular, one may want to account for the subgroups W of $\mathrm{Sym}\,\Omega$ such that $W \geq G$, soc W = soc G, and W is a wreath product in product action. To this end, let H denote a point stabilizer in G, and K a maximal normal subgroup of soc G. Form the intersection P of the maximal normal subgroups K_i of soc G such that $H \cap K_i = H \cap K$. For each X with $(\mathrm{soc}\, G)\, \mathbb{N}_G(H \cap K) \leq X < G$, do:

(1) Form the orbit space $\Omega_X := \Omega/\mathrm{core}_X P$; denote by $\overline{X}$ and M_X the restrictions of X and soc G to Ω_X. Let a_X be the number of all A_X such that $\overline{X} \leq A_X \leq \mathbb{N}_{\mathrm{Sym}\,\Omega_X}(M_X)$ but A_X is not a wreath product in product action.

(2) Form the group $G{\div}X$ of permutations induced by G on the coset space G/X, and let b_X be the number of all B_X with $G{\div}X \leq B_X \leq \mathrm{Sym}\, G/X$.

There are precisely $\sum a_X b_X$ subgroups W of the required kind; namely, the A_X wr B_X in product action.

P.H.Kropholler:

Splittings of Poincaré duality groups

If G is an n-dimensional Poincaré duality group and S is a polycyclic subgroup of Hirsch length n-1 then it is common for G to split as a free product $G = G_0 *_S G_1$, or HNN-extension $G = G_2 *_{S,\phi}$; where S plays a rôle. I intend to describe some theorems which show when these splittings can occur. The results are based on a splitting theorem of Peter Scott.

K.Kurzweil:

Praefrattinigruppen und simpliziale Komplexe mit einer guten Strategie

Wir sagen, daß ein simplizialer Komplex $K = K_\Omega$ (d.h. $K \subseteq 2^\Omega$) ein Komplex mit einer guten Strategie (non-erasive) ist, wenn für eine beliebige Teilmenge $\Delta \subseteq \Omega$ es immer möglich ist, mit weniger als $|\Omega|$ Fragen der Form "Ist $a \in \Omega$ Element von Δ ?" zu entscheiden, ob Δ in K liegt. Sei H eine Untergruppe der auflösbaren, endlichen Gruppe G. Wir ordnen dem Intervall $[G/H] = \{H \leq A \leq G\}$ einen Komplex $K = K(G:H)$ auf folgende Weise zu: Ω sei die Menge aller Nebenklassen $Hg \neq H$ von H in G, die maximalen Elemente von K seien die maximalen Elemente von $[G/H]$. Dann besitzt $K(G:H)$ genau dann eine gute Strategie, wenn die Euler-Charakteristik $\chi(K) = 1$, oder wenn die H-Praefrattinigruppen von G ungleich H sind. Dabei sind H-Praefrattinigruppen von G eine natürliche Verallgemeinerung der von Gaschütz eingeführten Praefrattinigruppen $(H = 1)$. Sie kann man z.B. - in unserem Kontext - definieren als die minimalen Elemente der Menge $\{U \in [G/H] \mid \chi(K(G:U)) \neq 1\}$. Sie haben analoge Deck- und Meide-Eigenschaften und sind insbesondere unter G konjugiert.

J.Lafuente:

Chief factors and projective indecomposable modules

The abelian p-crowns C/D of a finite group G are canonically embedded in the second term PJ/PJ^2 of the lower Loewy series of the principal indecomposable projective module P over the group algebra $GF(p)G$, and there is a canonical bijective correspondence between the set of the conjugacy classes of supplements of C/D in G and the set of supplements of the image of C/D in PJ/PJ^2. This permits us to clarify the relation of this term PJ/PJ^2 of P with the normal structure of G.

F.Leinen:

Amalgamation of soluble groups

Let $\underline{X}$ be either the class of all finite soluble π-groups, or the class of all such groups of derived length $\leq n$. B.Maier has shown that there are either $2^{\aleph_0}$ (isomorphism types of) countable existentially closed locally-$\underline{X}$ groups, or one which is unique with regard to an additional requirement. All of this depends just on the question, whether or not amalgamation of $\underline{X}$-groups over any $A \in \underline{X}$ can be controlled by some $A \leq B \in \underline{X}$ in the sense that any two $\underline{X}$-supergroups of B can be amalgamated over A (within the class $\underline{X}$). For this reason we study amalgamation of $\underline{X}$-groups. We give a necessary and sufficient condition which shows that the heart of the problem actually is amalgamation of operator-groups ($\underline{X}$-groups acting on abelian groups). Using tensor products for the amalgamation of operator-groups, we obtain results about amalgamation of finite soluble π-groups over supersoluble groups, and about amalgamation of metabelian groups.

F.Levin:

The conjugacy problem for free centre-by-metabelian groups

(with C.K.Gupta and W.Herfort)
We show that it is recursively solvable.

A.Lichtman:

On linear groups over fields of fractions of enveloping algebras

Let L be a Lie algebra over a field K, U(L) its universal envelope. P.M.Cohn proved that U(L) can be embedded in a (skew) field. We denote this field by D, D^* is its multiplicative group.
Theorem. The group D^* is isomorphic to the direct product $K^* \times D_1$, where the group D_1 is residually torsion free nilpotent if char K = = 0 and is residually nilpotent p-group of bounded exponent if char $K = p > 0$. Corollary. Let L be a soluble-by-finite dimensional Lie algebra, Δ be the field of fractions of U(L). Then the conclusion of the Theorem is true for the group Δ^*.

M.W.Liebeck:

The classification of finite simple Moufang loops

A Moufang loop is a loop satisfying the identity $(xy)(zx) =$ $= (x(yz))x$. These were introduced by R.Moufang in connection with

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geometry. Properties. (1) Moufang's theorem: Every Moufang loop is di-associative - that is, any two elements generate a subgroup. (2) There is a Jordan-Hölder theorem: Every finite Moufang loop is built from a unique set of simple Moufang loops (where a simple Moufang loop is one with no proper normal subloops or, equivalently, no proper homomorphis images). Examples of simple Moufang loops. (a) Simple groups. (b) Let $\mathcal{E}$ be the 8-dimensional split Cayley algebra over GF(q) with norm function $n: \mathcal{E} \longrightarrow GF(q)$. Then $M(q) = \{x \in \mathcal{E} \mid n(x) = 1\} / \langle -1 \rangle$ is a non-associative simple Moufang loop (L.J.Paige 1956).

Theorem. If M is a finite simple Moufang loop, then either M is a simple group or $M \cong M(q)$ for some prime power q.

The proof uses work of S.Doro (1977), which reduces the study of simple Moufang loops to consideration of simple groups with triality - that is, simple groups G with automorphisms σ, ρ of order 2,3 respectively such that $\langle \sigma, \rho \rangle \cong S_3$ and for every $g \in G$, $[g,\sigma][g,\sigma]^{\rho}[g,\sigma]^{\rho^2} = 1$.

A.Lubotzky:

The diameter of the finite simple groups

Theorem A. There exist constants $k, c \in \mathbb{N}$ such that every finite simple non-abelian group G has k generators, with respect to, every element of G can be written as a word of length at most $c \cdot \ln(|G|)$. ($k \leq 11$ and probably less).

This theorem is not true for the cyclic groups. For the symmetric groups the proof is non-trivial but elementary (note that the standard generators give a diamater of n^2 while $n \cdot \log n = \log(n!)$ is needed). The groups of Lie type (except of Suzuki and Ree which are done by ad-hoc methods) are proved by a reduction to the special case: Theorem B. The diameter of $SL_2(p)$ with respect to the generators $\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$ and $\begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix}$ is $O(\log p)$.

Theorem B is a very special case of Theorem A, but it is the heart of it. We can prove it either as a corollary to the Ramanujan conjecture (as proved by Eichler) concerning the number of solutions of quadratic forms in four variables, or as a corollary to a deep theorem of Selberg, concerning the eigen-values of the Laplacian operator of various "arithmetic" hyperbolic surfaces. Both methods come from the theory of automorphic forms and are based on the Riemann hypothesis for finite fields of Weil. Thus illustrating another interesting connection between the theory of automorphic forms and finite simple groups.

O. Macedońska:

On induced automorphisms

It is known from Andreadakis and Bachmuth that for a free 3-nilpotent group (finitely generated) $G = F/\gamma_n(F)$, the map $\mathrm{Aut}\, F \longrightarrow \mathrm{Aut}\, G$ is not onto. We prove that in the countably generated case this map is onto.

B. Maier:

Universal nilpotent groups

If $\underline{\underline{K}}$ is a class of groups then $G \in \underline{\underline{K}}$ is called universal if $H \hookrightarrow G$ $\forall H \in \underline{\underline{K}}$ with $|H| \leq |G|$. Assume $\underline{\underline{K}} = L\underline{\underline{X}}$ for a countable set $\underline{\underline{X}}$ of isomorphism types of finitely generated groups. $G \in \underline{\underline{K}}$ is called closed if $\forall A, B \in \underline{\underline{X}}$ $(\exists H \in \underline{\underline{K}}$ $A \rightrightarrows {}^{B}_{G} \rightrightarrows H \Rightarrow A \to B \dashrightarrow G$, $A \to G$ $)$ where arrows denote embeddings. The class of closed groups in $\underline{\underline{K}}$ is cofinal in $\underline{\underline{K}}$ in each power. Theorem. If $\underline{\underline{K}}$ is first-order axiomatizeable and has a countable universal group, then there exists a unique countable closed universal homogeneous group G in $\underline{\underline{K}}$, where homogeneous means that any two isomorphic subgroups from $\underline{\underline{X}}$ which have the same supergroups from $\underline{\underline{X}}$ in G are conjugated by an automorphism of G. Proposition 1. There exists no countable universal group in the class $\underline{\underline{N}}_c$ of nilpotent groups of class $\leq c$ $(c \geq 2)$. Proposition 2. There exists no countable universal group in the class $\underline{\underline{N}}_{c,p}$ of groups in $\underline{\underline{N}}_c$ whose torsion subgroups are p-groups $(c \geq 2)$. Proposition 3. If G is closed in the class $\underline{\underline{N}}_c^n$ of groups in $\underline{\underline{N}}_c$ whose torsion subgroups have exponent n and if the prime divisors of n are $> c$, then $G = T \times G^n$ where G^n is closed in $\underline{\underline{N}}_c^+$ (torsion-free $\underline{\underline{N}}_c$-groups) and the torsion subgroup T of G is closed in $\underline{\underline{N}}_c \cap \underline{\underline{B}}^n$, where $\underline{\underline{B}}^n$ is the Burnside variety of groups of exponent n. Corollary. There is a unique countable closed group in $\underline{\underline{N}}_2^n$, if $2 \nmid n$. Proposition 4. The number of countable closed groups in $\underline{\underline{N}}_2^2$ is $2^{\aleph_0}$. Remark. There exists a unique countable closed group in the classes $L\underline{\underline{F}}$, $\underline{\underline{N}}_2 \cap L\underline{\underline{F}}$, $\underline{\underline{N}}_2 \cap \underline{\underline{B}}^n$, $\underline{\underline{N}}_c^+$, $L\underline{\underline{F}}_p$, $L\underline{\underline{N}}^+$ and L(finitely presented). The groups in the first and last case are simple, the groups in $L\underline{\underline{F}}_p$ and $L\underline{\underline{N}}^+$ are characteristically simple.

B. H. Neumann:

Commutator laws

This is a report on joint work with I.D. Macdonald, in partial response to a question asked by Luise-Charlotte Kappe about the existence of "new" commutator laws in 4 variables. Some results have been submitted for publication, but we are still trying to find more complete results.

R.E.Phillips:

Groups of finitary transformations

Let $\mathbb{K}$ be a field, V a vector space on $\mathbb{K}$ and $g \in GL(V,\mathbb{K})$; g is finitary if $[V,g] = \{v(g-1) \mid v \in V\}$ is finite dimensional. The group of finitary transformations is $FGL(V,\mathbb{K})$. Our main contribution is the following Theorem. Let G be a periodic subgroup of $FGL(V,\mathbb{K})$ and suppose that either $char(\mathbb{K}) = 0$ or G is a p'-group and $char(\mathbb{K}) = p$. Then

(i) G is a subdirect product of irreducible $\mathbb{K}$-finitary groups.

(ii) If G is an irreducible subgroup of $FGL(V,\mathbb{K})$ then G has a normal subgroup N such that N is a subdirect power of a finite-dimensional $\mathbb{K}$-linear group and G/N is a transitive group of finitary permutations.

(iii) If G is irreducible and V is infinite dimensional then G' is the unique minimal normal irreducible subgroup of G.

A key fact necessary for the proof of this Theorem is a result of J.I.Hall which asserts that the only periodic infinite simple groups in $FGL(V,\mathbb{K})$, $char\,\mathbb{K} = 0$, are alternating groups (and in this case V is the natural module for such an alternating group).

S.J.Pride:

Groups given by presentations in which each defining relator involves exactly two generators

Let $G = \langle \underline{x}\,;\,\underline{r} \rangle$ where each element of $\underline{r}$ is cyclically reduced and involves exactly two elements of $\underline{x}$. Let Γ be the graph with vertex set $\underline{x}$ and edge set $E = \{\{x,y\} : \text{some element of } \underline{r} \text{ involves both } x \text{ and } y\}$. For $\{x,y\} \in E$ let $G\{x,y\} = \langle x,y\,;\,\underline{r}\{x,y\} \rangle$, where $\underline{r}\{x,y\}$ consists of all elements of $\underline{r}$ involving x and y. We call $G\{x,y\}$ an "edge group". Under rather mild restrictions on Γ and the edge groups we obtain a series of results concerning the structure of G, namely: the embeddability of the edge groups into G; the diagrammatic asphericity of G; the structure of the relation module of G; the (co)homology of G in dimensions ≥ 3; torsion in G. Some of these results were obtained jointly with R.Stöhr. Our theorems have been generalized in two different directions, by M.Edjvet, and by E. Fennessey. In particular, Fennessey's work concerns the case when $G = \langle A_i\ (i \in I)\,;\,\underline{r} \rangle$ where the A's are non-trivial groups and each $R \in \underline{r}$ is a cyclically reduced element of $\ast_{i \in I} A_i$ involving terms from exactly two factors.

E.F.Robertson:

Symmetric presentations and some simple groups

In this talk I will discuss joint work with C.M.Campbell. Suppose we are given a group G with presentation $G = \langle a_1, a_2 \mid r_i(a_1,a_2) = 1$ for $1 \leqq i \leqq m \rangle$ with the condition that $r_i(a_2,a_1) = 1$ in G for $1 \leqq i \leqq m$. For each $n \geqq 2$ define $S_n(G)$ by $S_n(G) = \langle a_1, a_2, \ldots, a_n \mid r_i(a_{\theta(1)}, a_{\theta(2)}) = 1$ for $1 \leqq i \leqq m$ and all $\theta \in S_n \rangle$ where S_n is the symmetric group of degree n. Such a group $S_n(G)$ is said to be a group with a symmetric presentation. The alternating groups A_n and the groups PSL(2,p) have such symmetric presentations. I consider three examples:

(i) $G_1(p) = \langle a_1, a_2 \mid a_1^p = a_2^p = (a_1^i a_2^i)^2 = 1, \; 1 \leqq i \leqq \frac{p-1}{2}, \; p \text{ odd} \rangle$,

(ii) $G_2(p) = \langle a_1, a_2 \mid a_1^p = a_2^p = (a_1^i a_2^{1/i})^2 = 1, \; 1 \leqq i \leqq \frac{p-1}{2}, \; p \text{ odd} \rangle$,

(iii) $G_3(p) = \langle a_1, a_2 \mid a_1^p = a_2^p = 1, \; a_1 a_2^2 = a_2 a_1^2, \; p \text{ odd} \rangle$.

The groups $S_n(G_1(p))$ and $S_n(G_2(p))$ are in certain cases simple groups. For example $S_2(G_2(p))$ is PSL(2,p), p prime, $S_3(G_1(5))$ is SL(2,16), $S_4(G_1(5))$ is PSp(4,4), and $S_5(G_1(5))$ is PSU(4,4). Both finite and infinite groups occur in the class $S_n(G_3(p))$ and we classify these groups. Certain conjectures will also be given. As an example we conjecture that $S_3(G_2(p))$ is $PSL(2,p^2)$ if $\sqrt{2} \notin GF(p)$.

M.Ronan:

Buildings and Kac-Moody groups

In a recent joint paper with J.Tits a simple construction of buildings is given. As a consequence one obtains groups of Lie type, such as E_8 over any field, independently of the theory of algebraic groups and Lie algebras. One also obtains the buildings for all groups of Kac-Moody type, including "non-split" forms arrived at by Galois descent. The construction works at a combinatorial level and is very straightforward; no information about subgroups, such as the structure of B, is needed. There are however many open questions: Can one adapt the construction to obtain the affine building of a p-adic group; and do such buildings and groups exist for other, non-affine diagrams ?

G.Rosenberger:

The Tits alternative for one-relator quotients of free products of cyclics

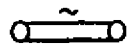
(joint work with B.Fine and F.Levin)

For a finitely generated group H, the Tits alternative says that H either contains a free subgroup of rank 2 or a solvable subgroup of finite index. We ask whether the Tits alternative holds for the one-relator product of cyclics $G = \langle a_1,\dots,a_n \mid a_1^{e_1} = \dots = a_n^{e_n} = R^m(a_1,\dots,a_n) = 1 \rangle$ with $n \geqq 2$, $m \geqq 2$, $e_i = 0$ or $e_i \geqq 2$ for $i=1,\dots,n$ and $R(a_1,\dots,a_n)$ a cyclically reduced word in the free product on $a_1,\dots,a_n$ which involves all $a_1,\dots,a_n$.

Theorem 1. Suppose one of the following holds:
(i) $n \geqq 3$; (ii) $n = 2$ and $e_i = 0$ for $i=1$ or $i=2$;
(iii) $n = 2$ and $m \geqq 3$. Then the Tits alternative holds for G. □

If n=2 and both generators have finite order then G is called a generalized triangle group and can be written in the form $G = \langle a,b \mid a^p = b^q = R^m(a,b) = 1 \rangle$ with $2 \leqq p \leqq q$ and $R(a,b) = a^{p_1}b^{q_1}\dots a^{p_k}b^{q_k}$ with $1 \leqq k$ and $1 \leqq p_j < p$, $1 \leqq q_j < q$ for $j=1,\dots,k$. By a theorem of G.Baumslag, J.Morgan and P.Shalen (preprint) G has a free subgroup of rank 2 if $\frac{1}{p}+\frac{1}{q}+\frac{1}{m} < 1$. If $m \geqq 3$ then the Tits alternative holds for G by Theorem 1. If m=2 then the corresponding question seems to be fairly difficult in general and we only have the following partial result. Theorem 2. If $n = m = 2$ and $1 \leqq k \leqq 2$ then the Tits alternative holds for G. Conjecture. The Tits alternative holds for all $k \geqq 1$.

P.Rowley:

Parabolic systems and 

By extending the ideas of parabolic systems and Dynkin diagrams, using the groups of Lie type as a model, it is possible to view many of the sporadic finite simple groups as having a "parabolic system". In this talk we will consider parabolic systems whose diagram is of the form  (examples of such groups occur in M_{24}, $.1$ and M).

O.Talelli:

On pairs of groups with periodic cohomology

(joint work with R.Bieri)

Let G be a group and $\underline{S} = \{S_i \leqq G \mid 1 \leqq i \leqq m\}$ and consider the short exact sequence of $\mathbb{Z}G$-modules $0 \to \Delta_{\underline{S}} \to \bigoplus_i \mathbb{Z}(G/S_i) \xrightarrow{\varepsilon} \mathbb{Z} \to 0$ where

$\varepsilon: xS_i \mapsto 1$. Definition. $(G,\underline{\underline{S}})$ is called periodic if the $\mathbb{Z}G$-module $\Delta_{\underline{\underline{S}}}$ has periodic cohomology (i.e. $\mathrm{Ext}^i_{\mathbb{Z}G}(\Delta_{\underline{\underline{S}}},-) \cong \mathrm{Ext}^{i+q}_{\mathbb{Z}G}(\Delta_{\underline{\underline{S}}},-)$ for $i \geq 1$).

I. G finite. Theorem A. If $(G,\underline{\underline{S}})$ is p-periodic then G is p-periodic iff S_i is p-periodic for all $1 \leq i \leq m$.

Theorem B. $(G,\underline{\underline{S}})$ is p-periodic iff one of the following holds: (i) G is p-periodic; (ii) $S_i = G$ and S_j is p-periodic for all $j \neq i$; (iii) $S_i \neq G$ for all i and there is a p-Sylow subgroup P of G such that (α) $\mathbb{N}_G(P) \leq S_i$; (β) $P \cap S_i^x$ is periodic for all $x \notin S_i$; (γ) $P \cap S_j^y$ is periodic for all $y \in G$ and $j \neq i$.

II. G a finitely generated accessible group. Theorem C. If $(G,\underline{\underline{S}})$ is periodic then G is the fundamental group of a graph $(\mathcal{G},X)$ of groups where all the edge groups are finite and $\{G_\nu ; G_\nu \text{ infinite}\} = \{S_i^{x_i} ; S_i \in \underline{\underline{S}} \text{ infinite}\}$.

M.J.Tomkinson:

Quasi-injective groups

G is quasi-injective if every homomorphism ϕ from a subgroup H of G into G extends to an endomorphism $\overline{\phi}$ of G. A characterization of finite quasi-injective groups was given by D.Berchoff and G.Wallis. We give a similar characterization for locally finite quasi-injective groups and also for soluble quasi-injective groups. The main interest lies in the extra condition which is needed in the locally finite case, i.e. that G is the extension of a π'-group K by a π-group such that every maximal π-subgroup complements K.

B.A.F.Wehrfritz:

Some matrix groups over finite dimensional division algebras

Extending work of A.Lichtman we partially describe the subgroups of GL(n,D) for D a finite-dimensional division algebra. (For example, if such a subgroup of GL(n,D) is soluble its derived length is bounded in terms of n and the number of factors of the degree of D over its centre.) If this degree is a prime power and if $n = 1$, the conclusions are especially precise.

F. Zara:

Hermitian forms over $\mathbb{Z}[\omega]$ and Fischer groups

Let M be a free rank n module over $\mathbb{Z}[\omega]$ (where $\omega = e^{2\pi i/3}$) and let $\phi: M \times M \longrightarrow K$ be an Hermitian form. For $p \in \mathbb{Z}$, $M_p := \{m \in M \mid \phi(m,m) = p\}$. We suppose that ϕ is positive non-degenerate and that

M_2 contains a base B of M. Theorem 1. The following conditions are equivalent: (i) $M_1 = \emptyset$; (ii) $\forall (a,b) \in B$, $a \neq b$, $\phi(a,b) \in \{0\} \cup K^*$.
If $a \in M_2$, we have the reflection $r_a: m \mapsto m - \phi(m,a)\,a$; it is an isometry of ϕ. We put $D = \{r_a \mid a \in M_2\}$ and $G = \langle D \rangle$.
Theorem 2. If the equivalent conditions of Theorem 1 are satisfied, then D is a set of 3-transpositions of G (and G is a Fischer group). Moreover the possibilities for G and ϕ are determined.

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