MATHEMATISCHES FORSCHUNGSINSTITUT OBERWOLFACH

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Darstellungstheorie endlicher Gruppen

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The meeting was organized by J. Alperin (Chicago), R. Dipper (Stuttgart), B. Külshammer (Jena) and G. Robinson (Birmingham). In nine lectures of 45 minutes each and 30 short contributions of 20 minutes each, the participants reported on recent progress in different parts of the subject and outlined challenges for the future. This special format was chosen because of the great activity and connectivity of the various areas in representation theory. It meant that there were many talks, but the total number of hours of lectures was low, so that there was plenty of free time left for discussions. It was generally felt that 20 minutes are sufficient to communicate the most important ideas, and that this special format was adequate for this particular meeting.

One of the highlights of the conference was definitely M. Hertweck's talk. He reported on his construction of a counterexample to the isomorphism problem for integral group rings, a 60 year old question of G. Higman. The essential result is the existence of two nonisomorphic groups of order $2^{21} \cdot 97^{28}$ with isomorphic integral group rings. In Hertweck's talk it became apparent that the counterexample should give rise to new questions about inner and outer automorphisms of integral group rings. This point of view was reinforced by a further short lecture by W. Kimmerle who reported on recent progress connected with the so-called F^*-theorem.

Another highlight of the meeting was the report by J. Thévenaz on his joint work with S. Bouc on the structure of the Dade group of endo-permutation modules. These modules arise as sources of simple modules, in nilpotent blocks and in the study of equivalences between block algebras. The Dade group is a Grothendieck-type construction which gives an abelian group classifying endo-permutation modules. Bouc and Thévenaz have determined the rank of this group and thus answered a question open for about 20 years. Bouc reported on another approach heavily using tensor induction.

In his main talk L. Puig introduced a new concept into local representation theory, the hyperfocal subalgebra of a block. His definition is motivated by the transfer, an important tool in local group theory, and its use yields a vast generalization of Puig's celebrated theorem on the structure of nilpotent blocks. In a short contribution, R. Kessar reported on her joint work with M. Linckelmann which applied K. Erdmann's analysis of tame blocks and culminated in a generalization of the Brauer-Suzuki theorem to arbitrary blocks with quaternion defect groups.

In her talk "On representations of the symmetric groups and related groups", C. Bessenrodt reported on a number of interesting developments. One of these concerned the question of when a product of spin characters of a symmetric group S_n is homogeneous (that is, a multiple of a single irreducible character). A precise answer was obtained; we omit details here, but such a situation can only arise when n is a triangular number. The theme of irreducibility of products of characters and related questions also occurred in shorter talks, by G. James and I.M. Isaacs.

In Bessenrodt's talk, further arithmetical properties of spin characters and their blocks were obtained which have considerable interest, and suggest possible analogues for general finite groups; for example, the highest power of 2 dividing spin character values on elements of odd order was determined, as well as the elementary divisors of the "spin part" of the decomposition matrix of a general 2-block of a double cover of S_n.

In shorter related lectures, A. Mathas gave a combinatorial description of the irreducible Specht modules in characteristic two, reporting on joint work with James, and Kleshchev gave a classification of all pairs (G, M), where G is some subgroup of some symmetric group S_n and M is an irreducible representation of S_n which remains irreducible upon restriction to G.

The representation theory of finite reductive groups is a very active area. Accordingly, a substantial part of the lectures presented recent results in this field, and once more it became apparent that methods and results from many areas converge here.

Three major developments of the past few years were discussed in three main talks by Brundan, Geck and Broué. First J. Brundan gave a survey on recent developments tying together representation theory of quantum groups and representations of general linear groups in cross characteristic, based on ideas of Dipper-James, Cline-Parshall-Scott and Takeuchi. He reported on new results which he obtained in collaboration with Kleshchev and Dipper. Based on an extension of the main results on general linear groups to affine general linear groups, formulas for generic modular character degrees were obtained similar to those which are known in the characteristic 0 case.

Hecke algebras associated with Coxeter groups have become a major tool for the representations of groups of Lie type but also have many applications in other fields (for example, knot theory, operator algebras, and mathematical physics). Of particular interest are their representations at roots of unity and their decomposition matrices describing composition multiplicities in standard modules. These matrices are of central importance for finite reductive groups because they are, by a theorem of Dipper, part of the ℓ-modular decomposition matrices of reductive groups in non-describing characteristic ℓ. M. Geck reported in his main talk about his recent theorem, based on deep results of Lusztig. He showed that these decomposition matrices are unitriangular in all cases, generalizing an old result of Dipper-James in the type A case. He surveyed connections with the Kazhdan-Lusztig basis and the conjecture of Lascoux-Leclerc-Thibon, which has recently been extended to Ariki-Koike algebras and proved by Ariki. In a short lecture Ariki gave some details on how one obtains a classification of the irreducible modules of Ariki-Koike algebras from his result, confirming conjectures of Dipper-James-Murphy and Graham-Lehrer.

There were several short lectures on recent results in representations of Hecke algebras (Green, Cox, Ariki, Kim) and representations of finite reductive groups (Srinivasan, Nebe, Tiep, Hiss, Cabanes, Gruber). Tiep's lecture dealt with the describing characteristic case, Nebe's with integral representations.

In work of Broué, Malle and Michel the application of Hecke algebras associated with Coxeter groups is extended in two ways to include cyclotomic Hecke algebras which are associated with complex reflection groups. First these are conjectured to come up as endomorphism algebras of the Deligne-Lusztig complex (considered as an element of the derived category). Moreover, they allow one to formulate a long list of combinatorial data such as generic degrees, character formulas and block invariants, which in the classical case determine representations of finite reductive groups. One may consider these data to represent numerical invariants of representations of some unknown objects, called spetses. M. Broué gave a main lecture on these emphasizing connections with braid groups and his conjectures regarding derived equivalences in blocks of arbitrary finite groups with abelian defect groups.

Broué's conjecture has become a very active topic with tremendous progress. The conjecture is a structural one but would solve classical problems of Brauer about the degrees of complex representations in particular. R. Rouquier lectured on a program which should yield, and already does in important cases, a major reduction in the problem, relating it to stable equivalences of algebras and making work of J. Rickard applicable (which uses algebraic ideas from stable homotopy theory). J. Chuang and T. Okuyama reported on solutions of Broué's conjectures for classes of groups that tie in with the work of Rouquier and Rickard.

In one of the short contributions, W. Wheeler outlined a local description of the stable module category, based on Rickard's theory of idempotent modules. This theory uses infinite-dimensional modules in an essential way to obtain results on finite-dimensional ones. Another application of this theory was given in D. Benson's talk who reported on his joint work with H. Krause on generic modules. This is a concept first introduced by W. Crawley-Boevey in order to investigate the finite/tame/wild trichotomy in representation theory of algebras.

Another key idea from the representation theory of algebras, the almost split sequences of Auslander-Reiten, have long been applied to the representation theory of finite groups. In his main talk, S. Donkin reported on generalizations to infinite groups, profinite groups, Lie algebras and p-Lie algebras. Using Hopf algebras, he reduced the questions to affine algebraic groups, another topic with close ties to finite groups.

In addition to the lectures, private discussions constituted an important part of the meeting. New teams of cooperation emerged, and will surely lead to future progress in the area.

Abstracts:

Specht modules and Kleshchev multipartitions
Susumu Ariki

My recent research is mainly concerned with Hecke algebras of type $G(m,1,n)$. It was introduced as a deformation of group algebras of a series of complex reflection groups, and is a generalization of Hecke algebras of type A and B. The study of modular representations over these algebras turns out to be very fruitful. A starting point was a conjecture made by A.Lascoux, B.Leclerc and J.Y.Thibon [6, LLT]. They computed Kashiwara's global basis on the basic module of the quantum algebra of type $A^{(1)}_{r-1}$, and found that the coefficients evaluated at 1 coincide with the decomposition numbers of non-semisimple Hecke algebras of type A over $\mathbb{C}$. Its proof is given for the Hecke algebras of type $G(m,1,n)$ [1, A1].
If we consider the fields of positive characteristics, we can not say much about the decomposition numbers, but we can give classification of simple modules [4, AM]. Combined with Specht module theory developed by Dipper, James and Mathas, we can prove that $D^{\underline{\lambda}} := S^{\underline{\lambda}}/ \operatorname{rad} S^{\underline{\lambda}}$ is non-zero iff $\underline{\lambda}$ is a Kleshchev multipartition [2, A2]. Thus we have a satisfactory classification of simple modules, and the generating function for the number of simple modules. The result is also useful for verifying a conjecture of Vigneras [7, Vig].

References

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p-Subgroup complexes and Brauer pair complexes
Laurence Barker

The results below are already published, but we append some questions. Recall that a G-object is an object upon which our finite group G acts as automorphisms. Even if one is ultimately concerned only with G-modules and G-algebras, other G-objects may be pertinent. Consider a finite G-simplicial complex $\mathcal{S}$ (for instance, $\mathcal{S}$ may be a finite G-poset, and then the simplexes are the totally ordered subsets). From the underlying G-space $|\mathcal{S}|$, we form the space $|\mathcal{S}|/G$ consisting of the orbits of G on $\mathcal{S}$. One motive for considering $|\mathcal{S}|/G$ is that it has reduced Euler characteristic

$$\widetilde{\chi}(|\mathcal{S}|/G) = \sum_{S} (-1)^{\ell(S)}$$

where S runs over representatives of the G-orbits of the set of simplexes in $\mathcal{S}$. By contriving $\mathcal{S}$ appropriately, one can obtain alternating sums as in conjectures and theorems of Alperin, Dade,

Külshammer, Robinson, and others. Symonds, in *Comment. Math. Helv.* 73 (1998), proved (this is what his argument shows in general): **Theorem 1:** (Symonds) *Suppose that the vertices of $\mathcal{S}$ comprise a conjugacy-closed upwardly-closed set of p-subgroups of G. Suppose that the simplexes in $\mathcal{S}$ are the normal chains $P_0 \lhd P_1 \lhd \ldots \lhd P_\ell$; each $P_i \unlhd P_\ell$. Then $|\mathcal{S}|/G$ is contractible.*
A special case was a conjecture of Webb (1987).
Theorem 2: *As in Theorem 1, (with the same vertices) but allowing all chains of the form $P_0 < P_1 < \ldots < P_\ell$ as simplexes.*
Theorem 3: *Suppose that the vertices of $\mathcal{S}$ comprise a conjugacy-closed upwardly-closed set of Brauer pairs (Alperin–Broué subpairs) associated with a given p-block of G. Suppose that the simplexes in $\mathcal{S}$ are the normal chains $(P_0, e_0) \lhd (P_1, e_1) \lhd .. \lhd (P_\ell, e_\ell)$; each $(P_i, e_i) \unlhd (P_\ell, e_\ell)$. Then $|\mathcal{S}|/G$ is contractible.*
Theorem 1 is Theorem 3 in the special case of the principal block.
Question 4: *As in Theorem 3, but allowing all chains of the form $(P_0, e_0) < (P_1, e_1) < \ldots < (P_\ell, e_\ell)$ as simplexes?*
In all cases above, including Question 4, Alperin's Fusion Theorem shows that $|\mathcal{S}|/G$ is simply connected; see *J. Group Theory* 1 (1998) for details. In all cases above, except for Question 4, a spectral sequence argument shows that $|\mathcal{S}|/G$ is acyclic; see *J. Algebra* 212 (1999) for details. In an attempt to adapt these arguments and thereby to confirm an affirmative answer to Question 4, it would not be necessary to tangle with spectral sequences. The spectral sequence has already fulfilled its purpose in leading to the Lemma on page 463. That Lemma concerns three G-simplicial complexes X, Y, Z such that the join $X * Y$ contains Z, also Z contains X and Y. The idea is to compare a given G-simplicial complex $X = \mathcal{S}$ with a smaller complex Y. The comparision is effected by weaving X and Y together to form another G-simplicial complex Z. The very strong hypothesis of the Lemma ensures that X and Y have the same homology. Each of the three above Theorems may be proved in half a page, starting from the Lemma. The technique is to contrive a suitable Z satisfying the hypothesis of the Lemma. It seems possible that Question 4 may succumb similarly.
Glance at the only equation above. Since spectral sequences belong to magic, not science, it might not be entirely idle to pose:
Fantasy 5: *There exists an $\mathcal{S}$ such that:* **(1)** *Alperin's Weight Conjecture, in some form or another, is equivalent to the condition that $\widetilde{\chi}(|\mathcal{S}|/G) = 0$.*
(2) *Some conjecture of Dade or Robinson is equivalent to the condition that $|\mathcal{S}|/G$ is acyclic.*
(3) *A spectral sequence argument yields (2).*

Generic modules over finite group algebras

Dave Benson

In this talk, I report on joint work with Henning Krause. Over any ring Λ, a module M is said to be *endofinite* if it has finite length as a module over $\mathrm{End}_\Lambda(M)$. It is said to be *generic* if it is endofinite, indecomposable, and not of finite length over Λ. Crawley–Boevey introduced this concept in order to investigate the finite/tame/wild trichotomy.
Let V_G denote the maximal ideal spectrum of the cohomology ring $H^*(G, k)$ of a finite group G over a field k of characteristic p. Quillen has proved that the irreducible components $V_1, \ldots, V_t$ of V_G are in one-one correspondence with the conjugacy classes of maximal elementary abelian p-subgroups of G. Let $\mathcal{U}$ denote the set of closed homogeneous subvarieties of V_G which do not contain any irreducible components of V_G, and let F be the Rickard idempotent module corresponding to localization with respect to $\mathcal{U}$. Then our main theorem states that F is an endofinite module. The stable endomorphism ring $\underline{\mathrm{End}}_{kG}(F_i) \cong E_i$. The module F_i is a generic module for the irreducible component V_i, and $E_i/J(E_i)$ is the field of rational functions on V_i. It should be remarked that most Rickard idempotent modules are not endofinite.

On representations of the symmetric groups and related groups

C. Bessenrodt

Some interesting connections between representations of the symmetric group S_n and spin representations of its double covers $\tilde{S}_n$ were presented.
In the first part of the talk, the focus was on the question: when is a tensor product of two representations of S_n resp. $\tilde{S}_n$ irreducible resp. homogeneous? Here recent work was described which was largely joint work with A. Kleshchev.
At characteristic 0, our work led to a complete classification of the tensor-reducible irreducible representations of S_n resp. $\tilde{S}_n$. In fact, all homogeneous products of irreducible characters of S_n resp. of spin characters of $\tilde{S}_n$ have been determined.
At characteristic $p > 0$, Gow and Kleshchev have recently conjectured a classification of the irreducible tensor products of S_n-representations of dimension > 1. Taking a big step towards this conjecture, we have shown that such products can occur only if $p = 2$ and n is even, and one of the modules has a Jantzen-Seitz partition label. A second conjecture of Gow and Kleshchev on a family of homogeneous tensor products of irreducible representations of S_n at characteristic 2 was confirmed (together with Gow) by considering the reduction modulo 2 of the homogeneous spin character products mentioned above.
In the second part of the talk, connections between 2-divisibility properties of spin character values and representations of S_n at characteristic 2 were discussed that have been obtained in recent joint work with J. Olsson.
Generalizing a result by Wagner on spin character degrees to all 2-regular classes, the minimal 2-power in the spin character values on any given class of odd type has been found. Using this, the elementary divisors of the 'reduced' spin decomposition matrix of a 2-block $\tilde{B}$ of $\tilde{S}_n$ were determined; they are roughly the square roots of the elementary divisors of the Cartan matrix of the 2-block of S_n contained in $\tilde{B}$.

The generalized Brauer construction, Brauer sheaves, and monomial resolutions

R. Boltje
joint work with Burkhard Külshammer

Let F be an algebraically closed field of positive characteristic p and let G be a finite group. The classical Brauer construction associates to an FG-module V for every p-subgroup P of G an $FN_G(P)$-module $V(P)$. This construction can be extended from p-subgroups to pairs (H, φ) with $H \leq G$ and $\varphi \in \mathrm{Hom}(H, F^\times)$. We denote the corresponding $F[N_G(H, \varphi)]$-module by $\bar{V}(H, \varphi)$. The collection of these modules form a rigid object by the existence of various natural maps between them. There are obvious conjugation maps, but also restriction maps $\bar{V}(H, \varphi) \to \bar{V}(I, \psi)$ whenever $(I, \psi) \leq (H, \varphi)$ and $[H : I]$ is not divisible by p. Moreover, there are (what we call) translations

$$\mathrm{tl}_{(I,\psi)}^{(H,\varphi)} : \bar{V}(H, \varphi) \to \bar{V}(\bar{I}, \psi)(H, \varphi)$$

whenever $(I, \psi) \lhd (H, \psi)$ (i.e. $(I, \psi) \leq (H, \varphi)$ and $H \leq N_G(I, \psi)$). These maps satisfy a list of natural compatibilities. The translations have been introduced by R. Rouquier in the case of p-subgroups.
It is natural to axiomatize these data and structure maps to obtain a category $\mathcal{B}_{FG}$ whose objects we call *Brauer sheaves*. There are close connections between R. Rouquier's "sheaves" and a relative version of Brauer sheaves. One can show that the above construction induces a fully faithful embedding $\mathcal{I}\colon {}_{FG}\mathbf{mod} \to \mathcal{B}_{FG}$. Moreover, the category ${}_{FG}\mathbf{mon}$ of finite G-equivariant line bundles over F can be embedded fully and faithfully into the category of Brauer sheaves via a functor $\mathcal{J}\colon {}_{FG}\mathbf{mon} \to \mathcal{B}_{FG}$. Now we can define the notion of a monomial resolution of an FG-module V. This is a chain complex $M_* = (\cdots \to M_1 \to M_0)$ of objects in ${}_{FG}\mathbf{mon}$ together with an FG-linear map $\varepsilon\colon M_0 \to V$ such that $\mathcal{J}(M_*) \to \mathcal{I}(V) \to 0$ is an exact sequence in the category of Brauer sheaves.

Theorem (a) *For each FG-module V there exists a monomial resolution $M_* \to V$. The resulting functor $V \mapsto M_*$ induces a fully faithful embedding from ${}_{FG}\mathbf{mod}$ to the homotopy category of ${}_{FG}\mathbf{mon}$.*

(b) *For each trivial source FG-module V there exists a* finite *monomial resolution $M_* \to V$. The Lefschetz element of M_* in the Grothendieck group of ${}_{FG}\mathbf{mon}$ coincides with the canonical induction formula for V.*

Tensor induction of relative syzygies

Serge Bouc

Let k be a field of characteristic $p > 0$, let P be a finite p-group, and X be a non-empty finite P-set. The relative Heller translate (or relative syzygy) Ω_X of k relative to X is defined as the kernel of the augmentation morphism from kX to k. In other words, there is an exact sequence

$$0 \to \Omega_X \to kX \to k \to 0$$

It has been observed by J. Alperin that this module Ω_X is an endo-permutation kP-module, which is capped if P has no fixed points on X. One can consider its image in the Dade group, which is still denoted by Ω_X.

A natural question is then to try to express the effect of the functorial operations on the Dade group (restriction, inflation, deflation, tensor induction, isomorphisms) on these elements Ω_X. The only hard case is actually tensor induction, and in this case one can state a formula expressing the tensor induced relative syzygies as a linear combination of relative syzygies corresponding to transitive sets for the bigger group.

This formula has various consequences: first it gives relations in the Dade group between relative syzygies. It is also a tool to describe the structure of the Dade group. In particular, the relative syzygies generate a functorial subgroup of the Dade group, with finite index equal to a power of p. One can also describe exactly the relative syzygies which are torsion elements in the Dade group.

Finally, these formulas can be interpreted to explain (in some sense) the strange short exact sequence of functors stated in our work with J. Thévenaz, connecting the Dade group, the Burnside ring, and the rational representation ring.

Abelian Defect, Reflection Groups, Braid Groups

Michel Broué

Let G be a connected reductive algebraic group defined over an algebraic closure of the prime field with p elements, and let $F : G \to G$ be a Frobenius endomorphism defining a rational structure over $\mathbb{F}_q$. Let (B, T) be a rational Borus (also called Torel) of (G, F).

The *Spets* $\mathbb{G}$ associated with (G, F) is defined by $\mathbb{G} := (V, W\phi)$, where

- $V := \mathbb{C} \otimes_{\mathbb{Z}} Y(T)$,
- ϕ is the element of $N_{\mathrm{GL}(V)}(W)$ defined by the Frobenius endomorphim F.

Many data associated with (G, F) depend only on $\mathbb{G}$, and so, in particular, do not depend on q :

- The Spets $\mathbb{G}$ defines a polynomial $|\mathbb{G}| := x^N \prod_d \Phi_d(x)^{a(d)}$ such that $|\mathbb{G}|_{x=q} = |G^F|$.
- The G^F–conjugacy classes of rational tori in G, as well as the G^F–conjugacy classes of rational Levi subgroups of G, are parametrized by W–orbits on sets depending only on $\mathbb{G}$.
- The set of irreducible unipotent complex characters of G^F is naturally parametrized by a set $\mathrm{Un}(\mathbb{G})$ which depends only on $\mathbb{G}$.

Jordan decomposition of Blocks

Assume for simplicity that the center of G is connected.

Let ℓ be a prime different from p and let $(K, \mathcal{O}, k)$ be an ℓ–modular system. Then one has a decomposition of the group algebra $\mathcal{O}G^F$ into a sum of twosided ideals

$$\mathcal{O}G^F = \bigoplus_{(M,\theta)} (\mathcal{O}G^F)_{(M,\theta)}$$

where (M,θ) runs over a set of representatives of G^F–conjugacy classes of pairs such that M is a (rational) reductive subgroup of G of maximal rank and θ is a linear character of M^F, of order prime to ℓ and in general position. Let us denote by $\mathrm{Un}(\mathcal{O}G^F) := (\mathcal{O}G^F)_{(G,1)}$ the "unipotent part of the group algebra".

Conjecture. For all (M,θ), the algebra $(\mathcal{O}G^F)_{(M,\theta)}$ is Morita equivalent to the unipotent part $\mathrm{Un}(\mathcal{O}M^F)$.

The case of unipotent blocks

Decomposition of the unipotent part into blocks.

Assume now that ℓ does not divide $|W\langle\phi\rightarrow\rangle|$, which insures that all ℓ–subgroups of G^F are abelian. Assume that ℓ divides $|G^F|$. Then there exists a unique integer d such that

$$\ell \text{ divides } \Phi_d(q) \quad \text{and} \quad \Phi_d(x) \text{ divides } \mathbb{G}.$$

Then we have

$$\mathrm{Un}(\mathcal{O}G^F) = \bigoplus_{(L,\lambda)} \mathrm{Un}_{(L,\lambda)}(\mathcal{O}G^F)\,,$$

where (L,λ) runs over the G^F–conjugacy classes of pairs such that

- L is a (rational) d–split Levi subgroup of G,
- λ is a d–cuspidal unipotent irreducible character of L^F,

and where each $\mathrm{Un}_{(L,\lambda)}(\mathcal{O}G^F)$ is a block with defect group the Sylow ℓ–subgroup of ZL^F.

Note that the G^F–conjugacy classes of pairs (L,λ) are "spetsial" : they are parametrized by data depending only on $\mathbb{G}$.

Towards the structure of a block $\mathrm{Un}_{(L,\lambda)}(\mathcal{O}G^F)$.

1. Let (L,λ) be as above. Then the "relative Weyl group" $N_{G^F}(L,\lambda)/L^F$ is spetsial and has a natural representation as a (complex) reflection group.

2. Assume for simplicity that (G,F) is split (namely, $\phi=1$), that $\lambda=1$ and that L is a torus T : it corresponds to the case of the principal block, and of a *regular* number d.

The G^F–conjugacy class of T corresponds to a W–conjugacy class C of regular elements of W. The relative Weyl group $N_{G^F}(T)/T^F$ is then isomorphic to $C_W(w)$ for $w\in C$.

For each element $w\in C$, there is a Deligne–Lusztig variety $\tilde{X}_w$ acted on from the left by G^F and from the right by T^F. By a theorem of Rickard, there is a splendid bounded complex $R(\tilde{X}_w)$ of $\mathbb{Z}_\ell G^F$–modules–$\mathbb{Z}_\ell T^F$, which induces the Deligne–Lusztig generalized induction map R_T^G at the level of ordinary characters.

It is conjectured that there exists $w\in C$ such that

- the action of T^F on $R(\tilde{X}_w)$ may be extended to an action of $N_{G^F}(T)$,
- so that $R(\tilde{X}_w)$ induces a Rickard equivalence between the principal block of $N_{G^F}(T)$ and the principal block of G^F.

3. A program is given to solve the preceding conjecture.

- The center of pure braid group B_W associated with W is infinite cyclic and generated by the element $\pi=\mathbf{w}_0^2$ (where $\mathbf{w}_0$ is the element of the braid monoid B_W^+ corresponding to any reduced expression of the longest element w_0 of W). Then w may be chosen as the image of any element $\mathbf{w}\in B_W^+$ which is a d–th root of π.
- Let $X_w := \tilde{X}_w/T^F$. The action of $C_W(w)$ on $R(X_w)$ should be induced by an action of the generalized braid group associated with the reflection group $C_W(w)$ on the variety X_w : This action should factorizes on the cohomology of X_w through a finite rank $\mathcal{O}$–algebra, a "cyclotomic Hecke algebra" which is a deformation of the group algebra of $C_W(w)$.

Branching rules for the finite general linear group

Jonathan Brundan

In recent joint work with R. Dipper and A. Kleshchev, we have obtained generalizations to positive, non-defining characteristic of the branching rules of Thoma and Zelevinsky. Our results describe the restriction of an irreducible $GL_n(\mathbb{F}_q)$-module to the naturally embedded subgroup $GL_{n-1}(\mathbb{F}_q)$ in terms of the restriction to quantum GL_{n-1} of a corresponding irreducible high-weight module over quantum GL_n (i.e. the divided power version of the quantized enveloping algebra $U_q(\mathfrak{gl}_n)$ specialized over $\mathbb{F}_p$ at parameter q).

As an application, we obtain a "generic" formula for the degrees of the irreducible p-modular Brauer characters of $GL_n(\mathbb{F}_q)$ (where $p|q$) in terms of the weight space dimensions $m_{\lambda,\mu}$ of irreducible high-weight modules of quantum GL_n. For instance, for each partition λ of n, there is an irreducible *unipotent* p-modular Brauer character χ^p_λ. Our formula in this case shows that

$$\chi^p_{\lambda'}(1) = \sum_{\mu \leq \lambda} m_{\lambda,\mu} S_\mu(q)$$

where λ' denotes the transpose partition and $S_\mu(q)$ is some explicitly determined non-negative polynomial in q depending on the partition μ but independent of p.

This formula, combined with the Premet-Suprunenko theorem describing exactly when $m_{\lambda,\mu}$ is *non-zero*, leads to a useful lower bound for the irreducible Brauer character degrees of $GL_n(\mathbb{F}_q)$; for instance in the unipotent case for restricted λ, it turns out that the leading term of Green's hook formula for the degree of the corresponding ordinary irreducible unipotent character gives a lower bound for $\chi^p_\lambda(1)$ too.

Alvis-Curtis duality: The modular version

Marc Cabanes

I would like to report on a theorem of J.Rickard stating that Alvis-Curtis duality induces a self-equivalence of the derived category $D^b(RG)$ when G is a finite reductive group in characteristic p, and R is a commutative ring where p is invertible; thus establishing a conjecture of M.Broué. I describe a 'local coefficient system' version of Rickard's arguments and of the additional theorem that this duality commutes with Harish-Chandra induction in $D^b(RG \times RL)$ where L is a Levi subgroup of G.

Cohomology of HS, $2M_{12}$ and other computer calculations

Jon Carlson

In this report we calculate the mod two cohomology of the double cover of the Mathieu group M_{12} and HS-Sylowsubgroup. The latter being calculated in joint work with Adem, Karagueuzian and Milgram. The starting point is the calculation by Adem, Maginnis and Milgram of the mod two cohomology of M_{12}. We use a hypercohomology spectral sequence to determine a differential in the Lyndon–Hochschild–Serre spectral sequence of the central extension, and this gets us as far as the E_∞ page. Ungrading requires restriction to the Sylow 2-subgroup, and here some computer calculations come to our rescue.

The derived categories of some blocks of symmetric groups and a conjecture of Broué

Joseph Chuang

A guiding principle in the modular representation theory of finite groups is the belief that the representation theory of a finite group G in prime characteristic p should in some sense be determined by that of its p-local subgroups (normalizers of non-identity p-subgroups). This belief takes a numerical form in Alperin's weight conjecture: the number of isomorphism classes of simple modules for G is equal to the sum of the numbers of isomorphism classes of certain kinds of simple modules for p-local subgroups.

Broué has suggested that in certain situations there should even be a structural relationship between modules for G and modules for local subgroups, a relationship which involves derived categories. More precisely, he conjectures that if B is a p-block of G with abelian defect group D, and b is the block of the p-local subgroup $N_G(D)$ which is paired with B under the Brauer correspondence, then B and b are splendidly Rickard equivalent (in particular they have equivalent derived module categories).

I will outline a proof of this conjecture for all blocks of symmetric groups whose defect groups have order p^2. Using the work of Scopes, Rickard, and Marcus, the problem is reduced to demonstrating a Morita equivalence (originally conjectured by Rouquier) between one of these defect 2 blocks and the principal p-block of the wreath product $S_p \wr S_2$. The proof of this equivalence relies on a rule for computing decomposition numbers due to Richards, a description of the principal p-block of S_{2p} provided by Erdmann and Martin, and a theorem of Linckelmann on the images of irreducible modules under certain functors.

On calculating Ext for Weyl modules and Specht modules

Anton Cox

joint work with Karin Erdmann.

In the study of a highest weight category, it is natural to consider the class of Weyl modules $\Delta(\lambda)$ and their duals $\nabla(\lambda)$. Rather than considering the whole module category, we may then restrict our attention to the category $\mathcal{F}(\Delta)$, whose objects have a filtration $0 = M_0 \leq M_1 \leq \cdots \leq M_{i-1} \leq M_i = M$, with quotients isomorphic to $\Delta(\lambda)$ for various λ. Clearly, knowing $\mathrm{Ext}^r(\Delta(\lambda), \Delta(\mu))$ is essential in the understanding of this category.

Probably the simplest non-trivial example of such a setup occurs in the study of modules for $\mathrm{SL}(2,k)$ over a field k of characteristic $p > 0$. In this case Erdmann was able to completely determine Ext^1 between pairs of Weyl modules. Recently, we have extended this argument to calculate Ext^2 in an analogous way. Moreover, this also gives Ext^2 between any pair of Weyl modules $\Delta(\lambda)$, $\Delta(\mu)$ for $\mathrm{GL}(n,k)$ (where $n \geq 2$) such that both λ and μ have at most two rows or columns, or where they differ by some multiple of a simple root.

It is a basic general problem to characterise algebras of finite representation type. For the ordinary Schur algebras this was determined by Erdmann. Using the cohomology calculations for $\mathrm{SL}(2,k)$, we obtain the following necessary condition for Schur algebras to be of Δ-finite type; that is to only have finitely many indecomposable objects in $\mathcal{F}(\Delta)$. (For simplicity, we here only consider the case when p is odd.)

Theorem *Suppose that $p > 2$. If $d \geq 2p^2 + p - 2$, then for all $n \geq 2$ the algebra $S(n,d)$ is Δ-infinite.*

We may also consider analogous problems for Specht modules for the symmetric group. When $p > 2$ we can translate our Ext^1 calculations over to determine all extensions between Specht modules corresponding to two part partitions, but for Ext^2 this method only gives a submodule of the corresponding Ext^2 space in general. In this way we obtain a corresponding 'finite type' result for the category of modules for the symmetric group having a filtration by Specht modules corresponding to partitions with at most n parts.

Finally we note that the above results all extend, with appropriate modifications, to the corresponding quantum groups and Hecke algebras at roots of unity.

Odd M-groups

Everett C. Dade

An M-group is a finite group G each of whose complex irreducible characters is induced from a linear character of some subgroup of G. A well known theorem of Taketa (1930) tells us that any such G is solvable. In 1967 Dornhoff asked if every normal subgroup of an M-group was itself an M-group. In 1973 van der Waall and I independently found that the answer was no. But our examples had even order. So this left the

Question 1 If G is an M-group of odd order, must any normal subgroup N of G be an M-group?

This question turned out to be one of the most difficult in the character theory of finite solvable groups. During the 1980's both Isaacs and I tried very hard to resolve it. While we discovered several interesting theorems related to this problem, we were forced to give up on the main question. It was simply not approachable by any method we could think up. As far as I know, everyone else who thought about it at all reached the same conclusion.

My student Maria Loukaki has taken up this problem. After several years' effort she has been able to prove

Theorem 1 The answer to Question 1 is yes if G is an odd p,q-group.

Here an *odd p,q-group* is a finite group G whose order has the form $p^a q^b$ for some odd primes p, q and some non-negative integers a, b.

Loukaki's proof of her theorem is very long and complicated. It depends on her ability to construct new irreducible characters of G having certain prescribed properties. Ultimately her constructions can be reduced to

Theorem 2 Suppose that an odd p,q-group H has a normal p'-subgroup K and a Sylow p-subgroup P such that PK is a normal subgroup of H. Suppose also that K has an irreducible complex character θ whose stabilizer H_θ in H is a complement to P in H. Then K has some complex irreducible character θ', having the same stabilizer $H_{\theta'} = H_\theta$ as θ in H, such that θ' can be extended to a character of $H_{\theta'}$.

I have stated the above theorem in a curious way, using a normal p'-subgroup K and a p-complement $H_{p'}$ in H, instead of a normal q-subgroup and a Sylow q-subgroup, respectively, in order to point out a possible generalization. It turns out that this theorem is the only place in Loukaki's proof where she really uses the fact that her G is an odd p, q-group. This raises the interesting

Question 2 Does Theorem 2 hold if its hypothesis that H be an odd p, q-group is replaced by the assumptions that H is a finite group of odd order and that p is an odd prime?

If, by any miracle, the answer to this question is yes, then Loukaki's arguments show that the answer to Question 1 is also yes. On the other hand, a negative answer to Question 2 might give us some hints about how to answer Question 1 in a negative manner. At any event, this gives us a completely different way to approach the problem.

On the existence of Auslander-Reiten sequences of group representations

Stephen Donkin

We consider the problem of the existence of Auslander-Reiten (or almost split) sequences of finite dimensional modules in the following cases: (i) modules over an abstract group; (ii) discrete modules for a profinite group: (iii) finite dimensional modules for a Lie algebra; (iv) restricted modules for a p-Lie algebra. We approach these via the representation theory of group schemes. The main result is that a group scheme G has an almost split sequence if and only if either G is virtually linearly reductive but not linearly reductive or G is linearly reductive by infinite uniserial unipotent by linearly reductive.

Kazhdan–Lusztig cells and decomposition numbers of Hecke algebras

Meinolf Geck

Our aim is to explain the idea that decomposition numbers (of finite groups of Lie type in non-defining characteristic or of Hecke algebras) are related to properties of Kazhdan–Lusztig bases or, in a wider sense, to the concept of "canonical bases" of Lie algebras (via the Lascoux–Leclerc–Thibon conjecture).

In his work on cells in affine Weyl groups, Lusztig has constructed the so-called asymptotic Hecke algebra. We have shown that problems about decomposition numbers of Hecke algebras can be translated to similar problems about that asymptotic algebra. Using that translation we obtain, for example, a uniform proof for the fact that the decomposition matrix of a Hecke algebra has a lower unitriangular shape. (For example, in type A, this was proved much earlier by Dipper and James using completely different methods.)

The Lascoux–Leclerc–Thibon conjecture (now a theorem of Ariki's) states something much more precise: the decomposition numbers of a Hecke algebra of type A (specialized at a root of unity in characteristic 0) are completely determined by the base change from a PBW-type basis to the "canonical basis" (in the sense of Lusztig and Kashiwara) of a certain affine Kac–Moody algebra. We explain this result and its consequences to the modular representation theory of the finite general linear groups in non-defining characteristic.

Special properties of blocks for the prime 2

Rod Gow and John Murray

Suppose that G is a finite group and k is a field of characteristic 2. Let $B \leftrightarrow e \leftrightarrow \lambda$ be a 2-block of G with associated primitive central idempotent e and central character λ. A conjugacy class $\mathcal{K}$ of G is called a defect class for B if $\mathcal{K}^+$ appears with non-zero multiplicity in e and $\lambda(\mathcal{K}^+) \neq 0$ (where $\mathcal{K}^+$ is the sum in kG of all the elements in $\mathcal{K}$). A defect class always exists and consists of

2-regular elements, and the defect groups of a defect class coincide with the defect groups of B. We prove that B always has a real defect class, which gives a necessary condition for the existence of a 2-block that does not appear to have been observed before.

As a partial converse, we show that if G has a real 2-regular class with 2-defect group D and if $N_G(D)/D$ has no dihedral subgroup of order 8, then G has a real 2-block with defect group D (if G has a non-real 2-block with defect group D then by the previous paragraph it has a real 2-regular class with 2-defect group D and hence a real 2-block with defect group D). Here, a block B is *real* if whenever a given complex irreducible character is in B, so also is its complex conjugate.

We give a number of applications of these results which do not rely on any classification theorems. For example, if D is a maximal Sylow 2-intersection in G, then G has a 2-block with defect group D if and only if it has a real 2-regular class with 2-defect group D. Also, if G has an abelian Sylow 2-subgroup S, then S is normal in G if and only if all 2-blocks of G have maximal defect. Along similar lines, if G has a quaternion Sylow 2-subgroup, then G either has a unique involution or it has a real 2-block of defect 0. Finally, if N is a normal subgroup of G of odd order which contains a class of G with 2-defect group D, then N contains a real class of G with 2-defect group D. This result, proved using block theory, does not seem to be amenable to purely group-theoretic proof.

Canonical bases for Hecke algebra quotients

R.M. Green

joint work with J. Losonczy

We consider quotients of Hecke algebras associated to arbitrary Coxeter systems which generalize Jones' construction of the Temperley–Lieb algebra from the Hecke algebra of type A. We show that such a quotient, which we call a generalized Temperley–Lieb algebra, admits a particularly nice basis which we call the canonical basis. This basis, which is defined in terms of a known basis found by J.J. Graham, is formally analogous in a manner which we make explicit to the Kazhdan–Lusztig basis of the corresponding Hecke algebra. However, the precise relationship between the two bases is not completely obvious. We discuss briefly some natural questions concerning our bases, in particular, whether the structure constants are positive.

Modular representation theory of finite groups of Lie type

Jochen Gruber

The finite groups of Lie type are investigated within the setting of finite groups with split BN-pairs. Their representation theory over the complex numbers is known to great detail. The knowledge of the irreducible cuspidal representations and the irreducible representations of Hecke algebras give many of the informations one is interested in. In the modular representation theory in non-defining characteristics one has to investigate larger algebras. They are called (generalized parabolic) q-Schur algebras.

This talk is a survey of the results of a research project by R. Dipper at the University of Stuttgart and the speaker. It generalizes older results by various researchers on classical groups.

The main result is a partial description of the decomposition matrices of finite groups of Lie type in terms of decomposition matrices of suitable (generalized parabolic) q-Schur algebras.

Embedding of group bases in integral group rings

Martin Hertweck

The "isomorphism problem for integral group rings" asks whether for finite groups X and Y, an isomorphism $\mathbb{Z}X \cong \mathbb{Z}Y$ of their integral group rings implies that the groups are isomorphic, $X \cong Y$. (We might also consider X-adapted coefficient rings, like the semilocalisation $\mathbb{Z}_{\pi(X)}$ of $\mathbb{Z}$ at the primes dividing the order of X.)

In 1997, a counterexample was constructed: there are non-isomorphic groups X and Y, of order $2^{21} \cdot 97^{28}$, such that $\mathbb{Z}X \cong \mathbb{Z}Y$.

The construction involves a subgroup $G \leq X$ which has a non-inner automorphism which becomes inner in $\mathbb{Z}G$. Therefore the groups are necessarily of even order.

Analyzing the counterexample shows that the projections of X and Y to any block of the rational group algebra $\mathbb{Q}X$ are conjugate (in the units of the block). This leads to a version of a conjecture of Zassenhaus for blocks, for which no counterexamples are known.

We show how to prove (with different methods as in the global case) that the group rings are semilocally isomorphic, $\mathbb{Z}_{\pi(X)}X \cong \mathbb{Z}_{\pi(X)}Y$. This leads to more insight into the structure of the groups, and indicates how counterexamples of odd order (at least in the semilocal case) might be constructed.

Morita equivalence classes of blocks of classical groups

Gerhard Hiss

joint work with R.Kessar

Let l be a prime number. In a seminal paper of 1991 Joanna Scopes proved that there are only finitely many Morita equivalence classes of l-blocks of symmetric groups of a given defect. This has later been extended by Thomas Jost to the case of unipotent l-blocks of the groups $GL_n(q)$, where q is fixed. Using elementary results on the decomposition numbers of $GL_n(q)$ one can remove this latter condition. Here we consider the case of the other classical groups.

THEOREM 1. Let q be a prime power not divisible by l such that the multiplicative order of $-q$ modulo l is odd. Then the unipotent l-blocks of a given defect of the groups $GU_n(q)$, $n \in \mathbb{N}$, fall into finitely many Morita equivalence classes.

A similar result holds for the other classical groups. To formulate it, let $G_n(q)$ denote a classical group (distinct from $GL_n(q)$ and $GU_n(q)$) of dimension n over the field with q elements.

THEOREM 2. Let q be a prime power not divisible by l such that the multiplicative order of q modulo l is even. Then the unipotent l-blocks of a given defect of the groups $G_n(q)$, $n \in \mathbb{N}$, fall into finitely many Morita equivalence classes.

The condition on q and l in the theorems correspond to the so-called unitary prime case. The complementary conditions are known as the linear prime case. Although the representation theory of the classical groups in the linear prime case is much more advanced than in the unitary case, our methods do not work in the linear prime case.

To prove our theorems, we make essential use of the following results. Firstly, the combinatorial description of the l-blocks of the classical groups by Fong and Srinivasan. This allows us to follow Joanna Scopes' approach in the first part of our proof, although the combinatorics involved is considerably more complicated. Secondly, we use a result of Broué giving a purely character theoretic sufficient condition for Morita equivalence. This replaces the original argument of Scopes.

Irreducible products of characters: Two open problems

I.M. Isaacs

When is a product of two irreducible characters irreducible? If $\alpha, \beta \in \mathrm{Irr}\ (G)$, then a condition that guarantees that $\alpha\beta$ is irreducible is that the restriction of α to the kernel of β is irreducible (or vice versa). In order to avoid these 'uninteresting' cases, assume that both α and β are faithful characters of G.

If either α or β is a linear character, then $\alpha\beta$ is certainly irreducible, but since we are assuming that α and β are faithful, this situation can only occur if G is cyclic. We ask therefore, which noncyclic groups can have two faithful characters whose product is irreducible? This happens, for example, if $G = SL(2,5)$ or $G = A_9$. But can there be a noncyclic *solvable* group in which a product of two faithful characters is irreducible?

I believe that this is probably impossible, but I have not found a complete proof. I can show, however, that if a solvable noncyclic group G has two faithful characters whose product is irreducible, then G must have a fairly complex structure. In particular, there must be some prime p dividing both character degrees such that some minimal normal subgroup of G has order equal to a power of p^p. Also, a Sylow p-subgroup of G must have nilpotence class at least p.
The irreducible-product problem reduces to an interesting question in module theory. Suppose that some (not necessarily solvable) group G factors as $G = HK$, and consider a simple G-module V over some field F. If each of H and K has a nonzero fixed point in F, we ask if this implies that V is the trivial FG-module? If the answer is 'yes' for all solvable groups G, this would imply that a product of faithful characters of a noncyclic solvable group can never be irreducible.
Suppose, as before, that $G = HK$, where H and K have nontrivial fixed points on the simple FG-module V. If V is nontrivial, I can show that the characteristic of F must divide both $|H|$ and $|K|$. If G is solvable, then more is true: the characteristic divides both $|G : H|$ and $|G : K|$, and the module V must be imprimitive and of dimension divisible by the characteristic. I have been unable to show, however, that this situation cannot actually occur, although I do have additional information about a minimal counterexample.

Symmetric group representations

Gordon James
joint work with John Graham

We give "On a conjecture of Gow and Kleshchev" as a subtitle to our talk and we emphasize that the material is joint work with John Graham.

It has been observed that if U and V are FG–modules with dimensions bigger than 1, then $U \otimes V$ is usually reducible. For $G = \mathfrak{S}_n$, the symmetric group of degree n, Bessenrodt and Kleshchev have shown that the only exceptions occur when $\mathrm{char} F = 2$ and n is even. Assume hereafter that $\mathrm{char} F = 2$. The irreducible $F\mathfrak{S}_n$–modules D^λ are indexed by partitions of n into distinct parts.

Gow and Kleshchev have conjectured that if $n = 4l + 2$ then

$$D^{(2l+2,2l)} \otimes D^{(4l-2j+1,2j+1)} \cong D^{(2l+1-j,2l-j,j+1,j)}.$$

In our talk we illustrate how this conjecture is proved. The dimension of D^λ when λ has two parts is known (but $\dim D^\lambda$ is not known when λ has three or more parts). Gow and Kleshchev have proved that $D^{(2l+1-j,2l-j,j+1,j)}$ is a composition factor of the tensor product, so to settle the conjecture it is sufficient to find $\dim D^{(2l+1-j,2l-j,j+1,j)}$. It turns out that for precisely the four part partitions of this form there is a method for determining $\dim D^\lambda$; we show how this is done and state that we have proved that this dimension equals that of the tensor product, thereby verifying the conjecture.

A generalization of the Brauer-Suzuki theorem

R. Kessar
joint work with M. Linckelmann

Suppose that b is a 2-block of a finite group G with defect group D which is a generalized quaternion group. Let z be the unique element of order 2 of D and let $H = C_G(z)$. Let c be the Brauer correspondent of b in H. The Brauer-Suzuki theorem states that if b is the principal block of G, then the block algebras of b and c are isomorphic.
We are interested in exploring the relationship between these block algebras in the general case, i.e. when b is no longer assumed to be principal. Using results of Cabanes, Picaronny, Erdmann and Olsson, we are able to show that if $|D| = 8$, then in general the block algebras $kG\bar{b}$ and $kH\bar{c}$ are Morita equivalent.

Elements of minimal length in twisted conjugacy classes of finite Coxeter groups

Sungsoon Kim

Let (W, S) be a finite Coxeter system where S is the set of generators.

In [1, 2] it is established that elements of minimal length in the conjugacy classes of W play a quite special role. This allowed us, in particular, to define a 'character table' of the Iwahori–Hecke algebra associated to (W, S). These tables have now been determined for all types of (W, S), by work of Starkey, Solomon, Kilmoyer, Alvis, Lusztig, Ram, Halverson, Geck, Pfeiffer and Michel; see [1, 2] and the references there.

The aim of this article is to extend the results of [1] to elements of minimal lengths in the F-conjugacy classes of W, where F is any group automorphism $F\colon W \to W$ such that $F(S) = S$. It will turn out that, for example, groups of type A_n (the symmetric groups) were quite simple to handle in [1] (compared to other types of groups), but now this will actually be the most difficult case when we consider non-trivial automorphisms F. Indeed, elements of minimal length in the conjugacy classes of S_n have a quite simple description (they are Coxeter elements in parabolic subgroups) but if we consider a non-trivial automorphism, then the description becomes more complicated ([3]).

For the symmetric group S_n, the automorphism F is given by conjugation with the longest element of W, and we reduced to the study of elements of *maximal* length in the (usual) conjugacy classes of W. In the talk, there was given a method of finding some elements of maximal length in the conjugacy class corresponding to a given partition λ of n.

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Permutation lattices and automorphisms of integral group rings

Wolfgang Kimmerle
joint work with M. Hertweck

1987 Roggenkamp and Scott discovered the following [6], [5], [4] .

F^* **- Theorem.** Let G be a finite group. Assume that the generalized Fitting subgroup $F^*(G)$ is a p - group. Then $\mathbb{Z}G = \mathbb{Z}H$ implies that H is conjugate to G within $\mathbb{Q}G$.

With respect to automorphisms the F^* - theorem says that a normalized (i.e augmentation preserving) automorphism of $\mathbb{Z}G$ is the composition of one induced from a group automorphism followed by a central automorphism. Thus it establishes for such groups a conjecture of Zassenhaus and provides a strong positive answer to the isomorphism problem. Thus each soluble group may be written as a subdirect product of groups whose integral group rings satisfy the conjecture of Zassenhaus and therefore the F^* - theorem permits an obstruction theory to the isomorphism problem in Čech - style cohomology [3]. The negative solution of the isomorphism problem by M. Hertweck [1] makes such an obstruction theory even more interesting. This stresses the importance of the F^* - theorem.

However one of the main ingredients of the proof [4, Theorem 26] is wrong. It affects the proof of the F^* - theorem in the case when $p = 2$. Using A. Weiss' theorems on generalized permutation lattices [7] we could close together with the following observation the gap in the proof.

Proposition 1. Let G be a p - group. Let A be an integral domain of characteristic zero and let m be a maximal ideal which contains p. Put $k = A/m$ and denote the quotient field of A by K.
Suppose that M is an AG - permutation lattice and that N is a generalized AG - permutation lattice such that $kM \cong kN$ and $KM \cong KN$. Then $M \cong N$ and N is therefore an AG - permutation lattice.

Not necessary for the F^* - theorem but related to its context is the following.

Proposition 2. Let G be a finite group. Let $A = \hat{\mathbb{Z}}_p$. Put $k = A/pA$ and denote the quotient field of A by K.

(i) Suppose that α is a normalized A - algebra automorphism of AG which induces on kG the identity. Assume that p is odd or that α permutes the class sums of 2 - elements of G. Then α is conjugation with a unit in AG.

(ii) Let Q be a p - subgroup of G. Suppose that $\alpha : AQ \longrightarrow AG$ is an A - algebra homomorphism which induces mod p the inclusion of kQ into kG. Assume that p is odd or that α fixes for the irreducible characters of G the values of the elements of Q. Then α is conjugation with a unit in AG of the form $1 + pu$.

Finally it should be remarked that the proof of the F^* - theorem as stated above is now complete. However a stronger statement of Roggenkamp and Scott [4, Theorem 19] classifiying in particular the automorphisms of $\hat{\mathbb{Z}}_pG$ remains open for $p = 2$.

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Representations of Σ_n irreducible on subgroups

A. Kleshchev

We spoke on the recent results of Kleshchev-Sheth and Brundan-Kleshchev. Let F be an algebraically closed field of characteristic p, and Σ_n be the symmetric group on n letters. We classify all pairs (G, D), where D is an irreducible $F\Sigma_n$-module of dimension greater than 1 and G is a proper subgroup of Σ_n such that the restriction $D\downarrow_G$ is irreducible, provided $p > 3$.

Irreducible Specht modules

Andrew Mathas

Let $\mathfrak{S}_n$ be the symmetric group on $\{1, 2, \ldots, n\}$. For each partition λ there exists a $\mathbb{Z}\mathfrak{S}_n$–module S^λ, called a Specht module. For any field k let $S^\lambda_k := S^\lambda \otimes_{\mathbb{Z}} k$ be the Specht module over k; so, S^λ_k is a $k\mathfrak{S}_n$–module. In particular, when k is a field of characteristic zero then S^λ_k is absolutely irreducible and all irreducible $k\mathfrak{S}_n$–modules arise uniquely in this way. In general, the irreducible $k\mathfrak{S}_n$–modules arise as quotients of the S^λ_k.

In this talk we ask, and partially answer, the following question.

When is the Specht module S^λ_k irreducible?

When k is a field of characteristic 2 we can answer this question in full. For the general case we can only give a conjecture. Similar statements can be made for the Iwahori–Hecke algebra of $\mathfrak{S}_n$.

The Modular Atlas Project:
Techniques for finding decomposition matrices

Jürgen Müller

The aim of the Modular Atlas Project, begun by R. Parker 15 years ago, is to compute the Brauer character tables of all the almost quasi-simple groups whose ordinary character tables can be found in the Atlas Of Finite Groups. Work of different people has so far led to the following results:

Almost everything is known for 16 of the 26 **sporadic groups**, i. e., up to the second Conway group Co_2, which is of order $\sim 4 \cdot 10^{13}$, including the alternating and Lie type groups occurring in the Atlas and having order less than that.

For the **symmetric groups** S_n everything is known up to $n = 16$, even everything for $n = 17$ except the case $p = 3$, which currently is under progress.

Techniques involved encompass, e. g., computations with characters, LLL lattice base reduction within Grothendieck groups; for the symmetric groups: Scopes reduction and the Jantzen-Schaper formula; explicit construction of matrix representations, and condensation, i. e., explicit computation of images of modules under a certain Schur functor.

Zeros of characters

Gabriel Navarro

(A) If G is a finite group and p is a prime number, it is a standard fact that every character of G of degree not divisible by p never vanishes on any element of order a power of p. In some sense, it is natural to study to what extent we can replace p by not divisible by p. Can irreducible characters of G of p-power degree vanish on elements of p'-order?

The answer to this question is "yes", although it seems that not very often. In fact, more is going on in solvable groups.

THEOREM A. *Let G be a solvable group and let $\chi \in \mathrm{Irr}(G)$ be primitive. Suppose that $\chi(1)$ is a π-number. Let $x \in G$. Then $\chi(x) = 0$ if and only if $\chi(x_\pi) = 0$.*

(B) Burnside's theorem assures that for every nonlinear $\chi \in \mathrm{Irr}(G)$, there is $x \in G$ such that $\chi(x) = 0$. I would like to prove the following result.

CONJECTURE B. *Suppose that $\chi \in \mathrm{Irr}(G)$ is nonlinear. Then there exists $x \in G$ of order a power of prime such that $\chi(x) = 0$.*

I can prove conjecture B for prime power degree characters.

THEOREM C. *Let $\chi \in \mathrm{Irr}(G)$ with $\chi(1) > 1$. If $\chi(1)$ is a power of p, then $\chi(x) = 0$ for some p-element x of G.*

In general, I can prove the following reduction theorem (which uses twice the classification).

THEOREM D. *Conjecture B is true if it is true for all simple groups.*

(C) (Joint work with M. Isaacs and T. Wolf.)

Which columns of a character table can fail to contain zero? In other words, which are the nonvanishing elements of our group G, by which we mean the elements $x \in G$ such that $\chi(x) \neq 0$ for all characters $\chi \in \mathrm{Irr}(G)$. In general, nonvanishing elements need not to lie in any abelian normal subgroup of G (even for solvable groups).

It appears to be true, however, that such an element must always lie in a nilpotent normal subgroup. Unfortunately, we have been unable to establish this in general, but we do provide a proof for elements of odd order.

THEOREM E. *Let x be a nonvanishing element of the solvable group G. If x has odd order, then x lies in the Fitting subgroup of G .*

(D) Suppose that G is a simple group such that all of its p-Brauer characters never vanish on any p-regular element. Is $p = 2$?

The group ring of $SL_2(p^f)$ over p-adic integers

Gabriele Nebe

Using the description of $kSL_2(p^f)$ over a field k of characteristic p by Koshita, the group ring $RSL_2(p^f)$ over a ring of p-adic integers can be described nearly up to Morita equivalence. For simplicity only the results for $p = 2$ are stated here:
Let $3 \leq f \in \mathbb{N}$, R be the ring of integers in the unramified extension K of degree f of $\mathbb{Q}_2$ and $k := R/2R \cong \mathbb{F}_{2^f}$ the residue class field. Let $G := SL_2(2^f)$ denote the group of 2×2-matrices over k of determinant 1. Then (K, R, k) is a 2-modular splitting system for G.
The simple kG-modules S_I are indexed with the subsets I of $N := \{1, \dots, f\}$, such that $dim(S_I) = 2^{|I|}$.

Theorem. Let V be a simple KG-module of dimension n with corresponding representation Δ_V and $\{I_1, \dots, I_r\}$ be the set of indices of the 2-modular constituents of V and put $n_j := 2^{|I_j|}$ $1 \leq j \leq r$. Then there is a basis of V such that

$$\Delta_V(RG) = \{(X_{ij})_{1 \leq i,j \leq r} \in R^{n \times n} \mid X_{ij} \in 2^{|I_i \setminus I_j|} R^{n_i \times n_j}\}.$$

The endomorphism rings and homomorphism bimodules of the projective indecomposable RG-lattices can be described explicitly. In particular one finds

Corollary. The endomorphism ring of the projective cover of the trivial RG-module is isomorphic to the group ring of the Sylow 2-subgroup of G.

A construction of tilting complex

Tetsuro Okuyama

We shall discuss some method to construct tilting complexes for symmetric algebras and some applications of it.
Let A and B be symmetric algebras over an algebraically closed field k which are stably equivalent of Morita type given by a (B, A)-module ${}_BM_A$. We assume that A, B are connected, nonsimple, and ${}_BM_A$ has no projective summand. Let T_i ; $i \in I$ be the set of simple B-modules and $Q_i \to T_i$ be a projective cover of T_i. Let $P_i \xrightarrow{\pi_i} T_i \otimes_B M_A$ be a projective cover of the A-module $T_i \otimes_B M_A$. By a result of Rouquier, a projective cover of the (B, A)-module M has the form $\bigoplus Q_i^* \otimes_k P_i \xrightarrow{\pi} M \to 0$. Take a subset I_0 of I and set $P = \bigoplus_{i \in I_0} Q_i^* \otimes P_i$ and $\delta = \pi|_P$. Now define the complex $M^\bullet = M^\bullet(I_0)$ by $M^\bullet : \cdots \to 0 \to P \xrightarrow{\delta} M \to 0 \to 0 \to \cdots$. We consider the condition (C): For all $i \in I_0$ and $l \notin I_0$ (1) ker $\mathrm{Hom}_A(T_l \otimes_B M, \pi_i) = 0$ and (2) coker $\mathrm{Hom}_A(\pi_i, T_l \otimes_B M) = 0$.
THEOREM As a complex of projective A-modules, $M_A^\bullet$ is a tilting complex for A iff condition (C) holds.
If $M_A^\bullet$ is a tilting complex for A, the left action on ${}_BM_A^\bullet$ gives an algebra monomorphism from B to C and we see that ${}_BC_C$ gives a stable equivalence of Morita type between B and C.
COROLLARY Suppose that (1) for $i, l \in I_0$, dim $\mathrm{Hom}_A(\Omega(T_i \otimes_B M_A), \Omega(T_l \otimes_B M_A)) = \delta_{il}$ and (2) for $j, m \notin I_0$, dim $\mathrm{Hom}_A(T_j \otimes_B M_A, T_m \otimes_B M_A) = \delta_{jm}$. Then $B = C$ and ${}_BM_A^\bullet$ is a two sided tilting complex for (B, A).

The hyperfocal algebra of a block
Lluis Puig

It is well-known that the intersection of a Sylow $p-$subgroup S of G with $\mathbf{O}^p(G)$ coincides with $< [\mathbf{O}^p\big(N_G(Q)\big), Q] \mid Q \subset S >$. We prove an analogous statement in any block b of G : let P_γ be a defect pointed group of b and set

$$Q = < [\mathbf{O}^p\big(N_G(R_\varepsilon)\big), R] \mid R_\varepsilon \ local\,,\, R_\varepsilon \subset P_\gamma >$$

Theorem. *There is a P-stable $\mathcal{O}$-subalgebra D of $(\mathcal{O}G)_\gamma$, unique up to $\big((\mathcal{O}G)_\gamma^P\big)^*$conjugation, containing the image of Q and fulfilling $(\mathcal{O}G)_\gamma = \oplus_{u\in U} D\,u$, where U is a set of representatives for P/Q in P .*

Now, the structure of the source algebra of a nilpotent block is an easy consequence of this result.

Gluing modules and Rickard equivalences
Raphaël Rouquier

We explain how various categories of modules, permutation modules, G-sets are determined locally (as 'G-equivariant sheaves' over the poset of non-trivial p-subgroups).
Then, we apply these construction to construct stable equivalences, given (good systems of) Rickard equivalences for local subgroups.
As an application, we can show that a block with defect group $(\mathbb{Z}/p)^2$ is stably equivalent to its Brauer correspondent.

Symmetric functions associated with finite general linear groups
Bhama Srinivasan

The Kostka polynomials $K_{\lambda\mu}(q)$, when suitably normalized, give the values of the unipotent characters of $GL(n,q)$ at unipotent classes. Given a semistandard tableau T of shape λ and weight μ, one can associate a power $t^{c(T)}$ to T such that $K_{\lambda\mu}(t) = \sum t^{c(T)}$, the sum being over all such T. Macdonald [Hall polynomials and symmetric functions, 2nd edition, Oxford] has introduced two variable polynomials $K_{\lambda\mu}(q,t)$ and asked whether to any standard tableau T of shape λ a power $a(T)$ of q and a power $b(T)$ of t (depending on μ) can be attached such that $\sum q^{a(T)}t^{c(T)} = K_{\lambda\mu}(q,t)$.

In this talk we describe a possible approach to this problem. Lynne Butler has observed a pattern of how, for fixed λ, $K_{\lambda\mu}(q,t)$ appears to change when we replace μ by ν, a neighbor of μ in the dominance ordering of partitions. Thus if we can explain this pattern we can use it to define $K_{\lambda\mu}(q,t)$ starting from $K_{\lambda 1^n}(q,t)$ which is known. Work is in progress regarding this.

The two-variable Macdonald polynomials, suitably specialized, occur in the work of Bannai, Kawanaka and Song on the Hecke algebra of a representation induced from $Sp(2n,q)$ to $GL(2n,q)$.

The group of endo-permutation modules
Jacques Thévenaz
joint work with Serge Bouc

Let k be a field of characteristic p and let P be a finite p-group. Let $D(P)$ be the set of isomorphism classes of endo-permutation modules which are indecomposable with vertex P. Tensor product induces a structure of abelian group on $D(P)$ (called the *Dade group* of P). When P is abelian, the structure of $D(P)$ was determined by Dade in 1978. In the general case, Puig proved in 1981 that $D(P)$ is finitely generated, but its structure remained unknown.

Theorem 1. *The torsion-free rank of $D(P)$ is equal to the number of conjugacy classes of non-cyclic subgroups of P.*

The proof of this result is rather involved and is based on an analysis of $D(-)$ as a functor with respect to the following five morphisms: restriction to a subgroup, tensor induction from a subgroup, inflation from a quotient group, deflation to a quotient group, and group isomorphisms. Let $\mathbf{Q}D(P)$ denote the $\mathbf{Q}$-vector space obtained by tensoring $D(P)$ with $\mathbf{Q}$.

Theorem 2. *The functor $\mathbf{Q}D(-)$ is a simple functor, isomorphic to the simple functor $S_{E,\mathbf{Q}}$, where E is elementary abelian of rank 2 (and $\mathbf{Q}$ is the value of the functor at the minimal group E).*

It is a remarkable coincidence that $S_{E,\mathbf{Q}}$ is also a subfunctor of the Burnside functor $B(-)$ tensored with $\mathbf{Q}$, with quotient isomorphic to $\mathbf{Q}R_{\mathbf{Q}}(-)$, where $R_{\mathbf{Q}}(P)$ is the Grothendieck group of $\mathbf{Q}P$-modules (i.e. the ring of rational characters of P). Thus we obtain the following rather strange exact sequence.

Theorem 3. *There is an exact sequence of functors* $0 \to \mathbf{Q}D \to \mathbf{Q}B \to \mathbf{Q}R_{\mathbf{Q}} \to 0.$

When p is odd, we have analogous results for a suitable quotient of the torsion subgroup of $D(P)$. In fact, this quotient is conjecturally equal to the torsion subgroup of $D(P)$.

Reduction modulo p of unramified representations of finite groups of Lie type

Pham Huu Tiep
(joint work with A. E. Zalesskii)

We would like to study the following problem:
Problem. *Let G be a finite group, p a prime. Determine the complex representations of a finite group G which remain irreducible under the reduction modulo some prime p dividing the order of G.*

Two particular cases when one has a complete answer are the cases where $G = Sym_n$, $p = 2$, and where $G = GL_n(q)$, p coprime to q, both due to G. James and A. Mathas. Our main theorem solves the problem for finite groups of Lie type and p the defining characteristic (and the representations in question are unramified above p, i.e. they can be realized over an unramified extension of $\mathbf{Q}_p$).

Theorem. *Let G be a connected reductive finite group of Lie type in characteristic $p > 3$, with no component of type A_1, G_2, F_4. Suppose Φ is an unramified complex representation of G such that $Ker(\Phi)$ is solvable. Then $\Phi(\mathrm{mod} p)$ is irreducible if and only if $\Phi = St \otimes \alpha$, where St is the Steinberg representation and α is any representation of degree 1.*

In the case of simple groups of Lie type over prime fields we obtain a stronger result, classifying all unramified complex representations with a semisimple reduction modulo p. Our next result shows that for many finite groups of Lie type, all complex representations are unramified. We also give a criterion for (non-) lifting representations from $\mathbf{Z}/p$ to $\mathbf{Z}/p^k$ for $k > 1$.

Simple modules in the Auslander-Reiten quivers of finite groups

Katsuhiro Uno

Let G be a finite group, and let B be a block algebra of G over an algebraically closed field k of characteristic p, where p is a prime. It is proved by Erdmann that, if B is wild, then any AR component has tree class A_∞. In this case, we say that a module X lies at the end if there is only one arrow which goes into (or goes from) X. Concerning the positions of simple modules, we have the following.

Theorem Assume that B is wild. Then every simple module lies at the end of its AR component, if B, G and p satisfy one of the following.
(i) ([2]) G is a finite group of Lie type defined over a field of characteristic p.
(ii) ([1]) G is a symmetric group, an alternating group, or their covering groups. For covering groups, we assume also that the weight of B is at least 3.

(iii) ([3]) G has an abelian Sylow 2-subgroup, and B is the principal 2-block.

Remark 1. The principal 5-block of $F_4(2)$ has a simple module with dimension 875823 which does not lie at the end of its AR component.

Remark 2. In most cases given in Theorem, every non-periodic AR component has at most one simple module.

Remark 3. In case of (iii) of Theorem, every periodic simple module has period $2^m - 1$, where m is the rank of a Sylow 2-subgroup of G.

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A local description of the stable category

Wayne W. Wheeler

One of the common themes of modular representation theory is the idea that the representations of a finite group are closely related to those of its local subgroups. Suppose that G is a finite group and k is an algebraically closed field of characteristic p. The stable category kG-Mod is the category in which the objects consist of all left kG-modules, and morphisms are equivalence classes of kG-homomorphisms; two homomorphisms from M to M' are defined to be equivalent if their difference factors through a projective kG-module. This report gives a brief description of a category $\L(G,k)$ that is equivalent to kG-Mod and is defined in terms of local subgroups.

The definition of $\L(G,k)$ depends upon two main ingredients: Rickard's work on idempotent modules and Benson, Carlson, and Rickard's theory of varieties for infinitely generated modules. Let $ProjH^*(G,k)$ denote the collection of all homogeneous prime ideals in $H^*(G,k)$ that do not contain $\bigoplus_{n=1}^{\infty} H^n(G,k)$. Associated to any kG-module M is a subset $\bar{V}_G(M) \subseteq ProjH^*(G,k)$. If M is finitely generated, then $\bar{V}_G(M)$ is closed in $ProjH^*(G,k)$, so it defines a projective variety. For an arbitrary module M the set $\bar{V}_G(M)$ is again called the *variety of* M, even though it may fail to be closed when M is infinitely generated. Now suppose that V is a closed subset of $\bar{V}_G(k)$. Then Rickard has constructed modules e_V and f_V such that $e_V \otimes e_V \cong e_V$ and $f_V \otimes f_V \cong f_V$ in kG-Mod. If P is a p-subgroup of G, set

$$V_{G,P} = res^*_{G,P}\big(\bar{V}_P(k)\big)$$

and $e_{G,P} = e_{V_{G,P}}$.

Let $\P(G)$ denote the collection of all p-subgroups of G, and let M be any kG-module. Suppose that $P \in \P(G)$, and set $N = N_G(P)$. Then there is an object $e_{N,P} \otimes M\downarrow_N$ in kN-Mod, and $\bar{V}_N(e_{N,P} \otimes M\downarrow_N) \subseteq V_{N,P}$. The modules in the collection $\{e_{N,P} \otimes M\downarrow_N \mid P \in \P(G)\}$ clearly satisfy certain compatibility conditions under conjugation and restriction. The objects of the category $\L(G,k)$ are essentially defined to be the collections $L = \{L(P) \mid P \in \P(G)\}$, where $L(P)$ is an object of $kN_G(P)$-Mod with $\bar{V}_{N_G(P)}\big(L(P)\big) \subseteq V_{N_G(P),P}$ for all $P \in \P(G)$ and the modules satisfy appropriate compatibility conditions under conjugation and restriction. Using the properties of varieties and idempotent modules, one can show that kG-Mod is equivalent to $\L(G,k)$.

On the complexity of modules

Jiping Zhang

Let k be a field of characteristic $p > 0$ and G a finite group. For a finitely generated kG-module M, the complexity $c_G(M)$ of M is defined to be the least integer $s \geq 0$ such that $\lim_{n\to\infty} \frac{dim(P_n)}{n^s} =$

0, where ...... $\to P_n \to P_{n-1} \to ... \to P_0 \to M \to 0$ is a minimal projective resolution of M. As is well-known, $c_G(M)$ is equal to the dimension of the variety $V_G(M)$ associated with M.

We prove the following theorem which generalizes the related results by Erdmann, Bessenrodt and Ma.

Theorem . Let G be a finite p-soluble group and B a p-block of G with defect group D. Let M be a simple kG-module in B with an abelian vertex V. If $c_G(M) \leq p-1$ then V is conjugate in G to D unless $c_G(M) = p-1 = 2^n$ with $D^G/L \cong p^{p-1} : (2^{1+2n} : p)$ where D^G is the normal closure of D in G and L is a normal subgroup of D^G.

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