Workshop

**Group rings**

*and related topics*

*June 25-29, 2012*

*University of Stuttgart, Germany*

Organisers: Wolfgang Kimmerle, Steffen Koenig, and Ángel del Río

There will be a reception in room 7.531 on the 7th floor in Pfaffenwaldring 57, Campus Vaihingen on Monday, June 25 starting 13:00.

All talks take place in room 8.122 on the 8th floor in Pfaffenwaldring 57, Campus Vaihingen.
Monday, June 25

14:00

Idempotent matrices over group rings
INDER BIR SINGH PASSI, Panjab University, India

I will give a survey of some of the work on the Bass conjecture for the Hattori-Stallings ranks of finitely generated projective modules over group rings $R[G]$, or equivalently for the traces of idempotents in matrix rings $M_n R[G]$ over $R[G]$. The focus will mainly be on the approach to investigate this conjecture via the cyclic homology of group algebras.

15:00

Semi-invariant matrices
YUVAL GINOSAR, Haifa University, Israel

The semi-invariants of a module-algebra over a group $G$ are the elements in its 1-dimensional constituents. These elements span a subalgebra, called the semi-center, which is graded by the linear characters of $G$. By studying the projective representations of $G$, we describe the semi-center of matrix algebras, or more generally of artinian semi-simple $G$-module-algebras.

16:00

On some minimal supervarieties of exponential growth
ERNESTO SPINELLI, Università La Sapienza di Roma, Italy

In this talk we shall discuss the question of classifying minimal supervarieties of given superexponent over fields of characteristic zero. We show that any minimal supervariety of finite basic rank is generated by one of minimal superalgebras introduced by Giambruno and Zaicev in [Codimension growth and minimal superalgebras, Trans. Amer. Math. Soc. 355 (2003), 293–308]. This motivates us to investigate in more detail these superalgebras and the $T_2$-ideal of their graded polynomial identities. This is a joint work with O.M. Di Vincenzo.

16:30

On singular equivalences of Morita type
ALEXANDER ZIMMERMANN, Université de Picardie, France

This is joint work with Guodong Zhou. The singular category of an algebra is a triangulated analogue of the stable category of an algebra in case the algebra is not self-injective. Much work was done in recent years on this subject by many authors including Buchweitz, Orlov and Xiao-Wu Chen. Recently Xiao-Wu Chen and Long-Gang Sun defined singular equivalences of Morita type in analogy to stable equivalences of Morita type and showed some of their properties. We shall give an overview of what is known to be true and what is known to be not true. Moreover we study Hochschild homology invariance of this type of equivalences.
Automorphisms of extremal codes
GABRIELE NEBE, RWTH Aachen, Germany

This survey talk will report on recent results on possible automorphisms of self-dual binary codes with large minimum distance. The most wanted but very likely not existing code is of length 72 with minimum distance 16. Various techniques (elementary, computationally, using (modular) representation theory) allow to narrow down the structure of the automorphism group of such a code: It is either cyclic of order \(\leq 5\), elementary abelian of order 4 or 8, or \(S_3, D_8, A_4, S_4\).

Idempotents in rational group algebras
GABRIELA OLTEANU, Universitatea Babeș-Bolyai, Cluj-Napoca, Romania

We give an explicit and character-free construction of a complete set of orthogonal primitive idempotents for a rational and a finite group algebra of a finite nilpotent group. As an application, we obtain that the unit group of the integral group ring \(\mathbb{Z}G\) of a finite nilpotent group \(G\) has a subgroup of finite index that is generated by three nilpotent groups for which we have an explicit description of their generators. Another application is a new construction of free subgroups in the unit group.

In all the constructions dealt with, pairs of subgroups \((H,K)\), called strong Shoda pairs, and explicit constructed central elements \(e(G,H,K)\) play a crucial role. For arbitrary finite groups we prove that the primitive central idempotents of the rational group algebras are rational linear combinations of such \(e(G,H,K)\), with \((H,K)\) strong Shoda pairs in subgroups of \(G\).

Cyclic codes over Chain Rings
CÉSAR POLCINO MILIES, Universidade de São Paulo, Brazil


In this talk, we shall show how the use of an approach via group algebras gives the same results in a much simpler way and will correct some oversights in the literature. Also, using results of [3], we shall show how to compute dimensions and weights of minimal codes under some restrictions on the length of these codes.

References


On the structure of certain semiprime superalgebras with superinvolution

Roberto Rizzo, Università del Salento, Lecce, Italy

For an algebra with involution, a classical question of interest is to decide if crucial information on its structure can be deduced from properties of its skew or symmetric elements. More recently, this interplay has been the subject of a good deal of attention in the framework of superalgebras as well.

In this talk we shall discuss the structure of a non-trivial semiprime associative superalgebra with superinvolution $A$ upon certain conditions on the subspaces of its skew or symmetric elements. In particular, we determine the algebraic structure of $A$ when these subsets are Lie solvable or Lie nilpotent.

Zassenhaus conjecture for cyclic-by-abelian groups

Leo Margolis, Universität Stuttgart, Germany

Mauricio Caicedo, Universidad de Murcia, Spain

Let $G$ be a finite group and $\mathbb{Z}G$ denotes the integral group ring of $G$ with coefficients over the ring of integers $\mathbb{Z}$. In the 1960s Hans Zassenhaus established a series of conjectures about the finite subgroups of augmentation one units of $\mathbb{Z}G$. Namely he conjectured that every finite group of units of augmentation one of $\mathbb{Z}G$ is conjugate to a subgroup of $G$ in the units of $\mathbb{Q}G$. These conjecture is usually denoted (ZC3), while the version of (ZC3) for the particular case of subgroups of normalized units with the same cardinality as $G$ is usually denoted (ZC2). The most celebrated positive result for Zassenhaus Conjectures is due to Weiss who proved (ZC3) for nilpotent groups. However Roggenkamp and Scott found a counterexample to (ZC2).

The only conjecture of Zassenhaus that is still up is the version for cyclic subgroups namely:

Zassenhaus Conjecture for Torsion Units (ZC1) If $G$ is a finite group then every augmentation one torsion unit of $\mathbb{Z}G$ is conjugate in $\mathbb{Q}G$ to an element of $G$.

Let $u$ be an augmentation one torsion unit, it is well known that (ZC1) holds for $u$ if and only if the partial augmentation of the powers of $u$ are all non-negative. We prove (ZC1) for cyclic-by-abelian groups. For that we argue by induction to prove that the partial augmentations of a torsion unit which is an hypothetical counterexample of minimal order are non-negative. It is well known that this implies that such a counterexample does not exists.
Generalized oriented involutions in group rings

Alvaro P. Raposo, Universidad Politecnica de Madrid, Spain

Given an involution $*$ in the group $G$ and an orientation morphism $\sigma : G \to \{1, -1\}$, an involution $#$ in the group ring $RG$, where $R$ is a commutative ring, is defined by $(\sum a_g g)^# = \sum a_g \sigma(g) g^*$, provided a compatibility condition is verified. This involution is called oriented and, in this talk, I propose to generalize the orientation morphism by widening the image to any subgroup of $U(R)$, the group of units of $R$. In this context symmetric and skew-symmetric elements are studied.
Wednesday, June 27

09:00  
Set-theoretic solutions of the Yang-Baxter equation  
JAN OKNIŃSKI, Uniwersytet Warszawski, Poland

10:00  
Braces and the Yang-Baxter equation  
FERRAN CEDÓ, Universitat Autònoma de Barcelona, Spain

The aim of the talks is to present the main problems, methods and results of the theory of set-theoretic solutions of the quantum Yang-Baxter equation.

In the first talk, starting with the necessary background, we introduce certain algebraic objects that appear in a natural way in this theory. These include two classes of groups: the so called structure groups and involutive Yang-Baxter groups, as well as a class of associated algebras. Main properties of these groups and algebras are discussed. Two important notions of decomposable solutions and retractable solutions are presented and their role in an approach towards a classification of solutions is explained. A few of important problems on solutions of the quantum Yang-Baxter equation and some positive partial results are presented.

In the second talk, we explain several aspects of relations between non-degenerate involutive set-theoretic solutions of the Yang-Baxter equation and braces, a concept introduced by Rump. We will see how this relation allows to give new easier proofs of some previous results on the Yang-Baxter equation and even improve some of them. By using braces, we present a solution to a problem proposed by Cameron and Gateva-Ivanova about square free solutions.

11:30  
Constructing free subgroups in the multiplicative group of a division ring  
JAIRO Z. GONCALVES, Universidade de São Paulo, Brazil

Let $D$ be a division ring with center $k$ and multiplicative group $D^\times$. If $N$ is a normal subgroup of $D^\times$ containing a nonabelian torsion free nilpotent group $G$, then we exhibit a free noncyclic subgroup $F$ of $N$, whose free generators are obtained from $G$.

12:00  
Writing units as a product of Bass units  
INNEKE VAN GELDER, Vrije Universiteit Brussel, Belgium

We give a constructive proof of a theorem of Bass and Milnor saying that if $G$ is a finite abelian group then the Bass units of the integral group ring $\mathbb{Z}G$ generate a subgroup of finite index in its unit group $\mathcal{U}(\mathbb{Z}G)$. Our proof provides algorithms to represent some units that contribute to only one simple component of $\mathcal{U}G$ and generate a subgroup of finite index in $\mathcal{U}(\mathbb{Z}G)$ as product of Bass units. We also obtain a basis $B$ formed by Bass units of a free abelian subgroup of finite index in $\mathcal{U}(\mathbb{Z}G)$ and give, for an arbitrary Bass unit $b$, an algorithm to express $b^{\varphi(|G|)}$ as a product of a trivial unit and powers of at most two units in this basis $B$. This is joint work with Eric Jespers and Ángel del Río.
Bass cyclic units and free groups in integral group rings of simple groups

ÁNGEL DEL RÍO, Universidad de Murcia, Spain

Joint with Jairo Gonçalves and Robert Guralnik.

Let $G$ be a finite group, $a$ an element of $G$ of order $n$ and let $k$ and $m$ be integers such that $k^m \equiv 1 \mod n$. Then

$$u_{k,m}(a) = (1 + a + \cdots + a^{k-1})^m + \frac{1 - k^m}{d} (1 + a + \cdots + a^{d-1})$$

is a unit in $ZG$, the integral group ring of $G$ with integral coefficients. The units of this form were introduced by Higman Bass and are usually known as Bass units or Bass cyclic units. We also say that $a$ is the base of $u_{k,m}(a)$. Another family of units is that of bicyclic units which take the form

$$1 + (1 - a)g (1 + a + \cdots + a^{n-1})$$

with $a$ as above and $g \in G$. Bass and bicyclic units have an important role in $U(ZG)$, the group of units of $ZG$. For example Bass and Milnor proved that if $G$ is abelian then the Bass units generate a subgroup of finite index in $U(ZG)$. Latter Ritter and Sehgal proved that the group generated by the Bass and bicyclic units generates a subgroup of finite index in $U(ZG)$ for a large family of group. These was largely extended by Jespers and Leal.

If $a \in G$ then

$$D_G(a) = \{ g \in G : a^g \in \{ a, a^{-1} \} \}.$$ 

For a prime $p$ and $a \in G$, we say that $a$ is dihedral $p$-critical in $G$ if

- $a$ has order $p$ and $D_G(a) \neq G$;
- if $H$ is a proper subgroup of $G$, and $a \in H$, then $D_H(a) = H$; and
- if $G$ is a proper quotient of $G$ then $D_G(\bar{a}) = G$. (Here we use the standard bar notation.)

We will present some progress on the following conjecture.

**Conjecture.** Let $G$ be a finite group. Let $u$ be a Bass unit based on a non-central element of prime order. If $u$ has infinite order modulo the centre of $U(ZG)$ then $ZG$ contains a Bass cyclic unit or a bicyclic unit $v$ such that $\langle u^n, v^n \rangle$ is a non-abelian free group for some integer $n$.

This conjecture was proved for solvable groups by the first and last author. They also showed that to solve the conjecture in general it is enough to prove it for the simple groups containing a dihedral $p$-critical element.

We will classify the simple groups containing a dihedral $p$-critical element and solve the conjecture for some of these simple groups.

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Discontinuous action of a subgroup of $SL(2, \mathbb{R})$ on $\mathbb{H}^2 \times \mathbb{H}^2$

ANN KIEFER, Vrije Universiteit Brussel, Belgium

A non-trivial problem is that of describing units in an order of a non-commutative non-split division algebra. This problem is related to the construction of units in the integral group ring $ZG$ of a finite group $G$. Only for very few finite non abelian groups $G$ the unit group $U(ZG)$ has been described, and even for fewer groups $G$ a presentation of $U(ZG)$ has been obtained. Nevertheless, for many finite groups $G$ a specific finite set $B$ of generators of a subgroup of finite index in $U(ZG)$ has been given. The only groups $G$ excluded in this result are those for which the rational group algebra $\mathbb{Q}G$ has a simple component that is either a non-commutative division algebra different from a totally definite quaternion algebra or a $2 \times 2$ matrix ring $M_2(D)$,
where $D$ is either $\mathbb{Q}$, a quadratic imaginary extension of $\mathbb{Q}$ or a totally definite rational division algebra $\mathcal{H}(a,b,\mathbb{Q})$.

In an earlier work we handled the cases where the latter is either a quaternion algebra over a quadratic imaginary extension of $\mathbb{Q}$ or a $2 \times 2$ matrix ring over a quadratic imaginary extension of $\mathbb{Q}$. In both cases the group $\mathcal{U}(\mathbb{Z}G)$ has a discontinuous action on hyperbolic 2- or 3-space and hence the Poincaré method, involving fundamental domains, may be applied.

Now we are in a more complicated situation. We are considering the Hilbert modular group, which is the group $\text{SL}(2,\mathcal{O})$, where $\mathcal{O}$ is the ring of integers of $\mathbb{Q}(\sqrt{d})$, with $d$ a positive square free integer. This group is not discrete in $\text{SL}(2,\mathbb{R})$, but in a direct product $\text{SL}(2,\mathbb{R}) \times \text{SL}(2,\mathbb{R})$ and hence it acts discontinuously on the direct product of two copies of hyperbolic 2-space. Thus the main goal is to generalize the Poincaré method to direct products of hyperbolic spaces. This allows to find generators for the last group.

In a more general context, this is a first step towards the problem of finding generators for a subgroup of finite index in the unit group $\mathcal{U}(\Gamma)$ of an order $\Gamma$ in a classical quaternion algebra over $\mathbb{Q}[\xi_n]$, where $\xi_n$ is a primitive $n$-th root of unity.

16:00

**Dynamical braidings**

**WOLFGANG RUMP, Universität Stuttgart, Germany**

Dynamical quantum groups are based on a braid relation which depends on an additional parameter $\lambda \in \Lambda$. In categorical terms, this modification is obtained by replacing $\text{Set}$ by the tensor category $\text{Set}_\Lambda$ of dynamical sets. Many structures related to braidings can be transformed in a similar way, which leads to dynamical analogues of groups, for example. Some classical structures are hopefully better understood by considering their dynamical extensions. We illustrate this by showing that regular affine representations of finite groups, realized as bijective cocycles with values in an abelian group, can be regarded as fixed points of the abelian group under the action on a universal parameter set. The orbits under this action are the parameter sets of the dynamical analogues of such group representations.

17:00

**Central units of integral group rings of finite groups**

**ERIC JESPERS, Vrije Universiteit Brussel, Belgium**

In this talk we report on some recent joint work with G. Olteanu, A. del Rio and I. Van Gelder.

We give an explicit description for a basis of a subgroup of finite index in the group of central units of the integral group ring $\mathbb{Z}G$ of a finite abelian-by-supersolvable group such that every cyclic subgroup of order not a divisor of 4 or 6 is subnormal in $G$. The basis elements turn out to be a natural product of conjugates of Bass units. This extends and generalizes a result of Jespers, Parmenter and Sehgal showing that the Bass units generate a subgroup of finite index in the central unit group of $\mathbb{Z}G$ in case $G$ is a finite nilpotent group. Also, for an arbitrary finite strongly monomial group $G$ we give a new construction of units that generate a subgroup of finite index in the central unit group of $\mathbb{Z}G$. The construction is such that the well-known Bass-Milnor result on integral group rings of finite abelian groups follows at once.
Let $G = \{g_1, g_2, \ldots, g_n\}$ be a finite group (order $s$) and let $F(x_{g_1}, \ldots, x_{g_n})$ be the free algebra (over $F$) generated by variables indexed by elements of $G$. Here $F$ is any field of characteristic zero. Let $I$ be the $T$-ideal (i.e. closed under $G$-graded endomorphisms) of $F(x_{g_1}, \ldots, x_{g_n})$ generated by a set of $G$-graded polynomials. We show that if $U = F(x_{g_1}, \ldots, x_{g_n})/I$ is a PI algebra (i.e. satisfies an ordinary PI), then the Hilbert series of $U$ is a rational function. In particular this holds for the graded identities of the group algebra $FG$. Note that in that case the equivalence relation says that two monomials $X$ and $Y$ are equivalent iff (1) $Y$ is obtained from $X$ by permuting the variables (i.e. $X = x_{g_1}x_{g_2} \cdots x_{g_n}, Y = x_{g_{\sigma(1)}}x_{g_{\sigma(2)}} \cdots x_{g_{\sigma(n)}}, \sigma \in \text{Sym}(n)$) (2) the product in $G$ coincides, $g_1g_2 \cdots g_n = g_{\sigma(1)}g_{\sigma(2)} \cdots g_{\sigma(n)}$. The proof uses the solution of the Specht problem for $G$-graded algebras. In the lecture I plan to explain some of the ideas which enter in the proof. (Joint work with A. Kanel-Belov).

Refinements of universal covering for complex matrix algebras

Ofir Schnabel, Haifa University, Israel

A theorem of Bahturin and Zaicev says that any fine strong $G$-grading of $M_n(\mathbb{C})$ is induced by a twisted group algebra $\mathbb{C}^fG$, where $G$ is a group of central type of order $n^2$, e.g. $C_n \times C_n$, and $[f] \in H^2(G, \mathbb{C}^*)$ is nondegenerate. Any such twisted group algebra determines a simply connected grading of $M_n(\mathbb{C})$. In a recent paper, Cibils, Redondo and Solotar show that for any $n$ there is another simply connected grading of $M_n(\mathbb{C})$, namely by the free group $F_{n-1}$. Consequently there is no universal covering of $M_n(\mathbb{C})$. In this talk we discuss the question whether the existence of a universal covering of $M_n(\mathbb{C})$ can be disproved using only fine strong gradings. A joint work with Y. Ginosar.

The partial Schur Multiplier of a Group

Héctor Pinedo Tapia, Universidade de São Paulo, Brazil

The concept of partial Schur multiplier $pM(G)$ of a group $G$ was introduced in [1], it is a generalization of the classical Schur multiplier $M(G)$.

It was shown that $pM(G)$ can be written as a union of abelian groups called components, one of them is the total component $pM_{G \times \mathbb{C}}(G)$ which consists of the equivalence classes of totally defined partial factor sets. Working over algebraically closed fields, in [2] was given a characterization of $pM_{G \times \mathbb{C}}(G)$, it contains $M(G)$ as a subgroup but it is essentially bigger than the usual Schur multiplier [3].

In this talk, we present some results from a joint paper with M. Dokuchaev and B. Novikov [3]. We use the structure of Exel’s semigroup $E(G)$ to establish a one to one correspondence between the number of components of $pM(G)$ and the ideals of a quotient semigroup of $E(G)$. This will help us to improve the description of $pM_{G \times \mathbb{C}}(G)$ and also to characterize all the other components of $pM(G)$, in particular, we shall show that any component is an epimorphic image of the total one. Finally, we calculate the total component of the cyclics groups and describe $pM(G)$ for all the cyclics groups of order $\leq 5$. 

Thursday, June 28

On Hilbert series of relatively free $G$-graded algebras

Éli Aljadeff, Technion, Israel

09:00

09:00

10:00

11:00
Thursday, June 28

References


11:30

Globalization of twisted partial actions

JUAN JACOBO SIMÓN-PINERO, Universidad de Murcia, Spain

Let \( A \) be a unital ring which is a product of possibly infinitely many indecomposable rings. We establish a criteria for the existence of a globalization for a given twisted partial action of a group on \( A \). If the globalization exists, it is unique up to a certain equivalence relation and, moreover, the crossed product corresponding to the twisted partial action is Morita equivalent to that corresponding to its globalization. For arbitrary unital rings the globalization problem is reduced to an extendibility property of the multipliers involved in the twisted partial action.

12:00

Wreath products in the unit group

VICTOR BOVDI, Debreceni Egyetem, Hungary

Let \( V(KG) \) be the group of normalized units of the group algebra \( KG \) of a locally finite \( p \)-group \( G \) over the field \( K \) of the positive characteristic \( p \). It was proved in [4] that a wreath product \( C_p \wr C_p \) of two cyclic groups of order \( p \) is involved in \( V(KG) \). This result was generalized in [2]. Also, in [1, 3], all those locally finite \( p \)-groups were described for which \( V(KG) \) does not contain a subgroup isomorphic to \( C_p \wr C_p \).

In my talk I discuss the following conjecture of A. Shalev [10]:

- the group of normalized units \( V(KG) \) always possess a section isomorphic to the wreath product \( C_p \wr G' \), where \( G' \) is the derived subgroup of \( G \).

The papers [8, 9, 10, 11, 12] studied the nilpotency class of \( V(KG) \) and its connection to Shalev’s conjecture. In particular, the Shalev’s conjecture is true if \( G' \) is cyclic and \( p \) is an odd prime. For the case \( p = 2 \) see [5, 6, 7].

References


Variations on the Baer-Suzuki theorem

Gunther Malle, Universität Kaiserslautern, Germany

The well-known Baer-Suzuki theorem states that in a finite group any conjugacy class for which all pairs of elements generate a nilpotent group already lies inside a nilpotent subgroup itself. We discuss extensions of this result to pairs of conjugacy classes of finite groups and of algebraic groups. This is joint work with R. Guralnick and P.H. Tiep.

Isomorphic group rings of finite simple groups

Wolfgang Kimmerle, Universität Stuttgart, Germany

R. Brauer posed in his well known lectures on modern mathematics 1963 the question whether a finite group $G$ is determined by all its group algebras $KG$, $K$ a field. E. Dade showed that this is in general not true. However if $G$ is a finite simple group the answer is affirmative (established using CFSG by M. Nagl and myself). H. Tong-Viet (and partly as well M. Nagl) have shown that it suffices to consider the complex group algebra.

Combining results of T. Vassias, M. Nagl and myself it is shown that a finite simple group is also determined by all its modular group algebras $FG$, i.e. $F$ ranges through the fields whose characteristic divides $|G|$. For many groups it suffices to consider just one such field, e.g. a simple group of Lie type is determined by $FG$ when the characteristic of $F$ coincides with the describing characteristic of $G$. 
I will report on the current state of the project to determine prime graphs of normalised unit groups of integral group rings of sporadic simple groups, where we’ve already proved that they coincide with prime graphs of underlying groups for the following thirteen sporadic simple groups: Mathieu groups $M_{11}, M_{12}, M_{22}, M_{23}, M_{24}$; Janko groups $J_1, J_2, J_3$; Held, Higman-Sims, McLaughlin, Rudvalis and Suzuki groups. I am going to summarise known information about orders and partial augmentations of torsion units for these groups, explain enhancements of the Luthar-Passi method that were developed during the project, and describe some challenges arising from the remaining sporadic simple groups. This is a joint work with Victor Bovdi, Eric Jespers, Steve Linton, Salvatore Siciliano et al.

Using the Luthar-Passi method and results of M. Hertweck, we study the long-standing conjecture of H. Zassenhaus for normalized units in integral group rings $\mathbb{Z}A_n$ of alternating groups $A_n, n \leq 10$. As a consequence of our results, we confirm the W. Kimmerle’s conjecture about prime graphs for those groups.
Brauer’s generalized decomposition numbers and universal deformation rings 09:00
Frauke Bleher, University of Iowa, USA

In this talk, I will study the problem of lifting to local rings certain mod 2 representations $V$ of a finite group $G$ which belong to a 2-modular tame block $B$ of $G$ having at least two isomorphism classes of simple modules. Green’s lifting theorem determines when such a $V$ may be lifted to the ring of infinite Witt vectors. I will generalize this result by determining the full universal deformation ring $R(G, V)$ of such $V$ using Brauer’s generalized decomposition numbers. The isomorphism type of $R(G, V)$ will depend on whether the stable Auslander-Reiten quiver of $B$ contains 3-tubes.

Automorphisms of Group Algebras 10:30
Allen Herman, University of Regina, Canada

How does one calculate $Aut(QG)$? In order to do this, one needs to be able to determine when a pair of simple components of $QG$ are ring isomorphic. The crucial part of this is being able to tell when two central simple algebras representing classes in the Schur subgroup of the Brauer group are ring isomorphic. This leads to questions about how to characterize the Schur subgroup of the Brauer group of a cyclotomic number field. There are various approaches to this problem, one by calculating the maximal local Schur indices of cyclotomic crossed product algebras for a given center (joint work with del Rio and Olteanu), another by determining the range of an appropriate cohomology functor (by Adem and Milgram), and yet another by determining a minimal set of finite groups whose simple components generate any Schur subgroup (by Reise and Schmid). I will survey these different approaches and comment on approaches to the analogous problem if one works overrings other than $Q$.
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