

# Brauer groups, Hopf algebras and monoidal categories

A conference in honour of Stef Caenepeel on the occasion of his 60th birthday

24-27 May, 2016

*University of Turin*

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List of participants

Program

Book of abstracts

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Dear Participant,

We welcome you at the University of Turin to participate at the conference “Brauer groups, Hopf algebras and monoidal categories - Stef Fest”. The aim of the meeting is to celebrate the 60th birthday of Stef Caenepeel as well as to bring the Hopf algebra community together. We are sure that you will all enjoy the talks, the discussions, the social events and the city of Turin.

Ana, Alessandro, Sorin, Isar, Gigel, Paolo, Joost.

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- (28) Adam-Christiaan Van Roosmalen - *Universiteit Hasselt, Belgium*
- (29) Yinhua Zhang - *Universiteit Hasselt, Belgium*

## Poster session

- (1) Khaled A. Al-Sharo - *Al al-Bayt University, Jordan*
- (2) Umamaheswaran Arunachalam - *Indian Institute of Science Education and Research, India*
- (3) Ryan Kasyfil Aziz - *Queen Mary, University of London, UK*
- (4) Salim Badidja - *Kasdi Merbah Ouargla, Algeria*
- (5) Filoteia Besleaga - *University of Bucharest, Romania*
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- (10) Luz Adriana Mejia - *National University of San Luis, Argentina*
- (11) Laura Elena Năstăsescu - *Institute of Mathematics of the Romanian Academy and University of Bucharest, Romania*
- (12) Deividi Pansera - *University of Porto, Portugal*
- (13) Ana Rovi - *Newcastle University, UK*

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- (75) Nikolaas Verhulst - *University of Antwerp, Belgium*
- (76) Yinhuo Zhang - *Universiteit Hasselt, Belgium*

# Schedule

	Tuesday 24th	Wednesday 25th	Thursday 26th	Friday 27th
9:00-9:50	Registration and coffee			
9:50-10:00	Welcome			
10:00-10:30	Van Oystaeyen	9:30-10:00 Bulacu	9:30-10:00 Cuadra	9:30-10:00 Alev
10:40-11:10	Sommerhäuser	10:10-10:40 Böhm	10:10-10:40 Menini	10:10-10:40 Stolin
11:10-11:40	coffee	10:40-11:10 coffee and poster session	10:40-11:10 coffee	10:40-11:10 coffee
11:40-12:10	Brzeziński	11:40-12:10	11:10-11:40 Zhang	11:10-11:40 Jespers
12:20-12:50	Lenagan	11:40-12:10 Gómez-Torrecillas	11:50-12:20 Femić	11:50-12:20 Caenepeel
12:50-15:00	Lunch	12:10-14:30 Lunch	12:10-14:30 Lunch	
15:00-15:30	Ştefan	14:30-15:00 Janelidze	14:30-15:00 Năstăsescu	
15:40-16:10	Guédénon	15:10-15:40 Fieremans	15:10-15:40 Mărcuș	
16:10-16:40	coffee	15:50-16:20 Torrecillas	15:50-16:20 Panaite	
16:40-17:10	Ion	16:20-16:50 coffee	16:20-16:50 coffee	
17:20-17:50	Gordienko	16:50-17:20 Batista	16:50-17:20 Van Roosmalen	
20:30	Welcome evening	17:30-18:00 El Kaoutit	17:30-18:00 Kowalzig	
		20:30	20:30	Conference dinner

## Program

Tuesday May 24

09.00-09.50 *Registration and coffee*

09.50-10.00 *Welcome*

10.00-10.30 Fred Van Oystaeyen (Universiteit Antwerpen, Belgium)  
*Localizations and Sheaves of Glider Representations*

10.40-11.10 Yorck Sommerhäuser (Memorial University of Newfoundland, Canada)  
*Cores in Yetter-Drinfel'd Hopf Algebras*

11.10-11.40 *Coffee*

11.40-12.10 Tomasz Brzeziński (Swansea University, UK)  
*Differentially smooth algebras*

12.20-12.50 Tom Lenagan (University of Edinburgh, UK)  
*Torus invariant primes in the quantum grassmannian*

12.50-15.00 *Lunch*

15.00-15.30 Dragoş Ştefan (University of Bucharest, Romania)  
*Further applications of Koszul pairs*

15.40-16.10 Thomas Guédénon (Université de Ziguinchor, Senegal)  
*Projectivity and flatness over the endomorphism ring of a finitely generated quasi-Poisson comodule*

16.10-16.40 *Coffee*

16.40-17.10 Bogdan Ion (University of Pittsburgh, USA)  
*Quantization, affinization, and modularity*

17.20-17.50 Alexey Gordienko (Vrije Universiteit Brussel, Belgium)  
*H-simple algebras and Ore extensions*

20.30 *Welcome evening*

## Wednesday May 25

- 09.30-10.00 Daniel Bulacu (University of Bucharest, Romania)  
*From algebras to Hopf algebras in two sided two cosided categories of Hopf modules over quasi-Hopf algebras*
- 10.10-10.40 Gabriella Böhm (Wigner Research Centre for Physics, Hungary)  
*A simplicial approach to multiplier bimonoids*
- 10.40-11.40 *Coffee and poster session*
- 11.40-12.10 José Gómez Torrecillas ( Universidad de Granada, Spain)  
*Weak multiplier bimonoids*
- 12.10-14.30 *Lunch*
- 14.30-15.00 George Janelidze (University of Cape Town, South Africa)  
*Galois cohomology in general categories and profinite extensions of commutative rings*
- 15.10-15.40 Timmy Fieremans (Vrije Universiteit Brussel, Belgium)  
*Descent and Galois theory for Hopf categories*
- 15.50-16.20 Blas Torrecillas Jover (University of Almeria, Spain)  
*Galois theory and cleft extensions for monoidal cowreaths*
- 16.20-16.50 *Coffee*
- 16.50-17.20 Eliezer Batista (Universidade Federal de Santa Catarina, Brazil)  
*Dual constructions for partial actions of Hopf algebras and partial co-representations*
- 17.30-18.00 Laiachi El Kaoutit (University of Granada, Spain)  
*Finite dimensional representations of abstract groupoids, representative functions and commutative Hopf algebroids*

## Thursday May 26

- 09.30-10.00 Juan Cuadra (University of Almeria, Spain)  
*Gradings on central division algebras*
- 10.10-10.40 Claudia Menini (Universita di Ferrara, Italy)  
*BiHom-structures*
- 10.40-11.10 *Coffee*
- 11.10-11.40 Yinhuo Zhang (Universiteit Hasselt, Belgium)  
*The Green rings of finite dimensional pointed Hopf algebras of rank one*
- 11.50-12.20 Bojana Femić (Universidad de la Republica, Uruguay)  
*Villamayor-Zelinsky sequence for symmetric finite tensor categories and Eilenberg-Watts theorem for 2-categories*
- 12.20-14.30 *Lunch*
- 14.30-15.00 Constantin Năstăsescu (Institute of Mathematics of the Romanian Academy, Romania)  
*Symmetric algebras of corepresentations and smash products*
- 15.10-15.40 Andrei Mărcuș (Babeș-Bolyai University, Romania)  
*Frobenius induction for algebras*
- 15.50-16.20 Florin Panaite (Institute of Mathematics of the Romanian Academy, Romania)  
*Twisted algebras and Rota-Baxter type operators*
- 16.20-16.50 *Coffee*
- 16.50-17.20 Adam-Christiaan Van Roosmalen (Universiteit Hasselt, Belgium)  
*Hall algebras for directed categories*
- 17.30-18.00 Niels Kowalzig (Universita di Roma La Sapienza, Italy)  
*When Ext is a Batalin-Vilkovisky algebra*
- 20.30 *Conference dinner*

## Friday May 27

- 09.30-10.00 Jacques Alev (Université de Reims, France)  
*The enveloping field of certain super Lie algebras*
- 10.10-10.40 Alexander Stolin (Gothenburg University, Sweden)  
*Classification of quantum groups, Lie bialgebras. Relations with Brauer group.*
- 10.40-11.10 *Coffee*
- 11.10-11.40 Eric Jespers (Vrije Universiteit Brussel, Belgium)  
*Finitely generated algebras defined by homogeneous quadratic monomial relations and their underlying monoids*
- 11.50-12.20 Frederik Caenepeel (Universiteit Antwerpen, Belgium)  
*Glider representations*

## List of abstracts

**Jacques Alev** (Université de Reims, France)

*The enveloping field of certain super Lie algebras*

ABSTRACT. The structure of the enveloping field of fractions of a finite dimensional algebraic Lie algebra over a field of characteristic zero is described by the famous Gelfand-Kirillov Hypothesis. In recent work joint with François Dumas, we studied the case of certain super Lie algebras having enveloping skew fields. In this talk we will present the situation of significant sub-super Lie algebras of the family  $\mathfrak{osp}(1, 2n)$  and point out some natural questions that arise in this theme.

**Eliezer Batista** (Universidade Federal de Santa Catarina, Brazil)

*Dual constructions for partial actions of Hopf algebras and partial co-representations*

ABSTRACT. Partial (co)actions of Hopf algebras were first introduced by S. Caenepeel and K. Janssen in order to put several advances of partial group actions into a co-ring theoretical framework [1]. In fact, this theory seems to be richer than expected at first. This is because the fact that partial actions of a given Hopf algebras are algebra objects in the monoidal category of modules of a Hopf algebroid constructed upon the original Hopf algebra [2]. The notion of partial actions and partial co-actions of Hopf algebras also opened a door to explore other aspects related to the duality between modules and comodules which were not at all evident in the group case.

In this talk, we intend to present briefly some dual constructions which appear naturally in the context of partial actions and partial representations of Hopf algebras [3]. We also present some results of a work in progress on partial co-representations and partial comodules of Hopf algebras [4].

### REFERENCES

- [1] S. Caenepeel, K. Janssen, "Partial (co)actions of Hopf algebras and partial Hopf-Galois theory", *Comm. Algebra* 36 (2008), 2923-2946.
- [2] M. M. S. Alves, E. Batista, J. Vercruyssen, "Partial representations of Hopf algebras", *J. Algebra* 426 (2015) 137-187.
- [3] E. Batista, J. Vercruyssen, "Dual constructions for partial actions of Hopf algebras", *J. Pure Appl. Algebra* 220, vol 2 (2016) 518-559.
- [4] M. M. S. Alves, E. Batista, F. Castro, G. Quadros, J. Vercruyssen, "Partial co-representations of Hopf algebras", in preparation.

**Gabriella Böhm** (Wigner Research Centre for Physics, Hungary)

*A simplicial approach to multiplier bimonoids*

ABSTRACT. A bimonoid in a braided monoidal category  $\mathcal{C}$  is just a comonoid in the category  $\text{mon}(\mathcal{C})$  of monoids; equivalently, a monoid in the opposite category  $\text{mon}(\mathcal{C})^{\text{op}}$ . By [3], monoids in any monoidal category  $\mathcal{M}$  correspond bijectively to simplicial maps from the so-called Catalan simplicial set  $C$  to the monoidal nerve  $N(\mathcal{M})$  of  $\mathcal{M}$ . Consequently, bimonoids in  $\mathcal{C}$  correspond bijectively to simplicial maps  $C \rightarrow N(\text{mon}(\mathcal{C})^{\text{op}})$ .

General multiplier bimonoids of [1] in  $\mathcal{C}$  are not known to be comonoids in any monoidal category. Hence the findings of [3] are not directly applicable to describe them as simplicial maps. In the talk we shall show that there is, still, a suitable simplicial set  $M$  such that the simplicial maps  $\mathcal{C} \rightarrow M$  are in bijection with the multiplier bimonoids in  $\mathcal{C}$ .

The talk is based on the joint work [2] with Steve Lack in Sydney.

#### REFERENCES

- [1] G. Böhm and S. Lack, *Multiplier bialgebras in braided monoidal categories*, J. Algebra 423 (2015), 853-889. arXiv:1405.4668
- [2] G. Böhm and S. Lack, *A simplicial approach to multiplier bimonoids*, Bull. Belgian Math. Soc. in press. arXiv:1512.01259
- [3] M. Buckley, R. Garner, S. Lack and R. Street, *The Catalan simplicial set*, Math. Proc. Camb. Phil. Soc. 158 (2015), 211-222. arXiv:1309.6120

**Tomasz Brzeziński** (Swansea University, UK)

*Differentially smooth algebras*

ABSTRACT. The aim this talk is to explain the notion of differential smoothness of algebras and describe some examples and properties of differentially smooth algebras. There are many ways in which a noncommutative algebra can be understood as a coordinate algebra of a smooth noncommutative variety. Most commonly, one studies homologically smooth algebras, i.e. algebras that admit a finite resolution by finitely generated and projective bimodules. More demanding is the requirement of the existence of a Poincaré-type duality between Hochschild homology and cohomology, which is embodied in the Calabi-Yau condition. Here we propose the notion of differential smoothness which is based on the existence of a differential structure which explicitly displays a Poincaré-type duality. To formulate this duality, in addition to the de Rham complex of differential forms one needs the complex of integral forms, which we define. We give the definition of differentially smooth algebras and explain their properties. The ideas of differential smoothness are illustrated on (classes of) examples: the noncommutative pillow, quantum cones, Hopf algebras of low Gelfand-Kirillov dimension and (skew) polynomial algebras.

**Daniel Bulacu** (University of Bucharest, Romania)

*From algebras to Hopf algebras in two sided two cosided categories of Hopf modules over quasi-Hopf algebras*

ABSTRACT. We present a braided monoidal structure on  $\mathcal{C}$ , the category of Two sided Two cosided Hopf modules over a quasi-Hopf algebra  $H$ , that is equivalent to the braided monoidal structure of  ${}^H_H\mathcal{YD}$ , the category of left Yetter-Drinfeld modules over  $H$ . This allows to give structure theorems for an algebra, coalgebra, etc. within  $\mathcal{C}$  and connections between quasi-Hopf algebras with a projection and Hopf algebras in  ${}^H_H\mathcal{YD}$ , respectively. The results above can be viewed as generalizations to the quasi-Hopf setting of some results obtained in:

#### REFERENCES

- [1] Y. Bespalov, B. Drabant, "Hopf (bi-)modules and crossed modules in braided monoidal categories", JPAA 123 (1998), 105-129.
- [2] M. Rosso, "Quantum groups and quantum shuffles", Invent. Math. 133 (1998), 399-416.
- [3] S. Woronowicz, "Differential calculus on compact matrix pseudogroups (quantum groups)", Commun. Math. Phys. 122 (1989), 125-170.

**Frederik Caenepeel** (Universiteit Antwerpen, Belgium)

*Glider representations*

ABSTRACT. In mathematics, many objects are given by iterated constructions, such as iterated Ore extensions of rings or quantum groups. In studying the representation theory of these objects, one does not fully take into account this additional chain structure. Therefore we introduce the notion of glider representations for positively filtered rings  $R$  with filtration  $FR$  and subring  $F_0R = S$ . We provide many examples where such filtered rings appear, varying from algebraic geometry to rings of differential operators. In particular, we discuss chains of normal subgroups and by performing a Clifford theory for glider representations for these filtrations, we lay out some of the general theory for glider representations.

**Juan Cuadra** (University of Almeria, Spain)

*Gradings on central division algebras*

ABSTRACT. There have recently been a number of attempts by Etingof, Kirkman, Kuzmanovich, Walton, Zhang, and collaborators to extend to a noncommutative setting various results from Invariant Theory. The role of a group acting on a commutative algebra is played here by a finite-dimensional Hopf algebra. In several cases, the research led to the study of actions on a finite-dimensional central division algebra and the following question arose:

**Question.** Let  $k$  be an algebraically closed field of characteristic zero. Let  $D$  be a division algebra of degree  $d$  over its center  $Z(D)$ . Assume that  $k \subset Z(D)$ . Which finite-dimensional Hopf algebras can act inner faithfully on  $D$ ?

An action of a finite-dimensional Hopf algebra  $H$  (over  $k$ ) is called inner faithful if it does not factor through a smaller Hopf algebra  $H/I$  for some nonzero Hopf ideal  $I$  of  $H$ . It suffices to focus on such actions because any action factors through an inner faithful one.

Not much is known about this question. The novelty with respect to previous investigations of the same kind is that the center is allowed to be an infinite extension of  $k$  and that the action is not necessarily linear over the center.

In this talk we will tackle this problem when  $H$  is the function algebra  $k^G$  for a finite group  $G$ . A faithful action of  $k^G$  on  $D$  is just a faithful grading by  $G$ . We will show that  $G$  faithfully grades  $D$  if and only if  $G$  contains a normal abelian subgroup of index dividing  $d$ . This result is part of a joint work with Pavel Etingof (Massachusetts Institute of Technology) to appear in *Int. Math. Res. Not.* and available at [arXiv.org](https://arxiv.org).

**Laiachi El Kaoutit** (University of Granada, Spain)

*Finite dimensional representations of abstract groupoids, representative functions and commutative Hopf algebroids*

ABSTRACT. The aim of the first part in this talk is to show to the audience how the functor of representative functions can be constructed from the category of (abstract) groupoids to the category of commutative Hopf algebroids. Analogously to the classical case of groups, a construction of a fibre functor on finite dimensional representations is then carried out. It turns out that in this general context the fibre functors land in the category of finitely generated and projective modules over the base algebra (i.e. the algebra of all functions on the set of objects). Several illustrative examples will be displayed along this part. The second part of the talk is devoted to the particular case of transitive groupoids. In this case, we will show the main steps required in building up the contravariant adjunction between

the representative functions functor and the characters groupoid functor on geometrically transitive Hopf algebroids.

**Bojana Femić** (Universidad de la Republica, Uruguay)

*Villamayor-Zelinsky sequence for symmetric finite tensor categories and Eilenberg-Watts theorem for 2-categories*

ABSTRACT. In 2005 with Stef we introduced the Brauer group of Azumaya corings, it is isomorphic to a cohomology group of Villamayor-Zelinsky and thus fits into their infinite exact sequence. With the Brauer group of a commutative ring defined in this new fashion, the Villamayor-Zelinsky sequence becomes a generalization of the classical Crossed Product Theorem. In this way we gave an interpretation of the middle cohomology term on the second level in the Villamayor-Zelinsky sequence. In the subsequent work we constructed a commutative bialgebroid version of the sequence, interpreting the middle terms in the first three levels of the new sequence. In 2014-2015 I extended these constructions replacing a commutative ring by a symmetric finite tensor category  $\mathcal{C}$ , this talk is about the results I obtained. In this setting bimodules over a commutative ring give place to  $\mathcal{C}$ -bimodule categories and in place of Azumaya corings I introduce  $\mathcal{C}$ -coring categories. The latter are invertible  $\mathcal{C}$ -bimodule categories - those from the Picard group of  $\mathcal{C}$ , introduced in 2009 by Davydov and Nikshych - equipped with an additional structure. A version of the Villamayor-Zelinsky sequence is obtained and the middle terms in the second and the third level of this sequence are interpreted. To get the results in the third level, Eilenberg-Watts theorem for 2-categories is proved.

**Timmy Fieremans** (Vrije Universiteit Brussel, Belgium)

*Descent and Galois theory for Hopf categories*

ABSTRACT. We give an overview of the needed definitions and properties of a  $k$ -linear Hopf category as defined in [1]. Similar results about Hopf-galois theory for Hopf algebras will be presented for  $k$ -linear categories. We introduce the definition of a Galois category extension for  $k$ -linear categories. This is all based on joint work with Stefaan Caenepeel.

#### REFERENCES

- [1] E. Batista, S. Caenepeel, J. Vercruyssen, "Hopf categories", *Algebras Repres. Theory*, to appear.

**José Gómez Torrecillas** ( Universidad de Granada, Spain)

*Weak multiplier bimonoids*

ABSTRACT. Based on the novel notion of 'weakly counital fusion morphism', regular weak multiplier bimonoids in braided monoidal categories are introduced. They generalize weak multiplier bialgebras over fields and multiplier bimonoids in braided monoidal categories. Under some assumptions the so-called base object of a regular weak multiplier bimonoid is shown to carry a coseparable comonoid structure; hence to possess a monoidal category of bicomodules. In this case, appropriately defined modules over a regular weak multiplier bimonoid are proven to constitute a monoidal category with a strict monoidal forgetful type functor to the category of bicomodules over the base object. The theory works for braided monoidal categories like categories of modules or graded modules, the category of complete bornological spaces, and the category of complex Hilbert spaces and continuous linear transformations. This is a joint work with Gabriella Böhm and Stephen Lack.

**Alexey Gordienko** (Vrije Universiteit Brussel, Belgium)

*H-simple algebras and Ore extensions*

ABSTRACT. Many pointed (and not only pointed) Hopf algebras  $H$  can be obtained from smaller algebras  $H_1$  using Ore extensions by adding to  $H_1$  a skew-primitive element. It turns out that study of  $H$ -actions can be largely reduced to the study of  $H_1$ -actions.

Our interest in this topic is concerned, in particular, with polynomial  $H$ -identities. Study of polynomial identities in algebras is an important aspect of study of algebras themselves. And when one considers polynomial identities, their numeric characteristics naturally come into play.

One of the most important characteristics is the codimension sequence. The  $n$ th codimension  $c_n(A)$  of an algebra  $A$  is the dimension of the factor space of the space of multilinear polynomials in the noncommutative variables  $x_1, x_2, \dots, x_n$  by the subspace of those of them that are polynomial identities in  $A$ . In the 1980s S.A. Amitsur conjectured that if  $A$  is a PI-algebra, i.e. it has a nontrivial polynomial identity, then there exists an integer limit  $\text{PIexp}(A) := \lim_{n \rightarrow \infty} \sqrt[n]{c_n(A)}$ . Amitsur's conjecture was proved in 1999 by A. Giambruno and M.V. Zaicev who also provided an explicit formula for  $\text{PIexp}(A)$  that involves the structure of  $A$ .

If an algebra is endowed with an additional structure like a (semi)group grading, group, Lie algebra, or a Hopf algebra action, it is natural to introduce this structure in the signature of polynomial identities. One of the most interesting questions here is whether the analog of Amitsur's conjecture holds for polynomial  $H$ -identities of  $H$ -module algebras. The answer is true if an algebra is finite dimensional and its Jacobson radical is an  $H$ -submodule. The last always holds if, say,  $H$  is finite dimensional semisimple. Thus the most interesting case here is when  $H$  is non-semisimple and the Jacobson radical is not an  $H$ -submodule.

We will show how the analog of Amitsur's conjecture for polynomial  $H$ -identities in the case of  $H$  being obtained by an Ore extension from  $H_1$  can be reduced to the same problem for  $H_1$ . This will enable us to prove the conjecture for a wide class of Hopf algebras  $H$ .

Also we will discuss the problem of classification of  $H$ -simple algebras.

**Thomas Guédénon** (Université de Ziguinchor, Senegal)

*Projectivity and flatness over the endomorphism ring of a finitely generated quasi-Poisson comodule*

ABSTRACT. Let  $k$  be a field of characteristic 0,  $A$  a noncommutative Poisson  $k$ -algebra,  $U(A)$  the ordinary enveloping algebra of  $A$ ,  $\mathcal{C}$  a quasi-Poisson  $A$ -coring that is projective as a left  $A$ -module,  ${}^*\mathcal{C}$  the left dual ring of  $\mathcal{C}$  and  $\Lambda$  a right quasi-Poisson  $\mathcal{C}$ -comodule that is finitely generated as a right  $U(A)\#{}^*\mathcal{C}$ -module. The vector space  $\text{End}^{\mathcal{P},\mathcal{C}}(\Lambda)$  of right quasi-Poisson  $\mathcal{C}$ -colinear maps from  $\Lambda$  to  $\Lambda$  is a ring. We give necessary and sufficient conditions for projectivity and flatness of a module over  $\text{End}^{\mathcal{P},\mathcal{C}}(\Lambda)$ . If  $\mathcal{C}$  contains a fixed quasi-Poisson grouplike element, we can replace  $\Lambda$  with  $A$ .

**Bogdan Ion** (University of Pittsburgh, USA)

*Quantization, affinization, and modularity*

ABSTRACT. To any quantized enveloping algebra of Kac-Moody Lie algebra one can associate a certain algebra extension called affinization. This was originally introduced by

Drinfeld who showed that the affinization of the quantized enveloping algebra of a simple Lie algebra is the quantized enveloping algebra of an affine Lie algebra. However, this is the only instance for which the affinization is still a quantized enveloping algebra of a Kac-Moody Lie algebra and it is unclear whether the construction can be further iterated or even whether it produces Hopf algebras. There are speculations based on analogies with mathematical physics and the theory of special functions that seem to suggest that iterated affinizations should not exist. I will discuss a canonical context (mostly in the Schur-Weyl dual setting of Hecke algebras) in which the affinization construction can be iterated and explain how it leads to a new source of modularity.

**George Janelidze** (University of Cape Town, South Africa)

*Galois cohomology in general categories and profinite extensions of commutative rings*

ABSTRACT. Given a Galois structure on a category  $\mathcal{C}$  and a normal extension  $E/B$  in  $\mathcal{C}$ , we define the corresponding Galois cohomology as the cohomology of the Galois groupoid of  $E/B$ . We then discuss various examples of the standard interpretation of the one-dimensional cohomology in terms of torsors. This includes the case when the torsors become Galois objects over quasi-separable commutative Hopf algebras, and, in particular Galois extensions of commutative rings with profinite Galois groups.

**Eric Jespers** (Vrije Universiteit Brussel, Belgium)

*Finitely generated algebras defined by homogeneous quadratic monomial relations and their underlying monoids*

ABSTRACT. A survey is given of our recent results, joint with M. Van Campenhout, on algebras  $R$  over a field  $K$  with generators  $x_1, x_2, \dots, x_n$  subject to  $\binom{n}{2}$  quadratic relations of the form  $x_i x_j = x_k x_l$  with  $(i, j) \neq (k, l)$  and, moreover, every monomial  $x_i x_j$  appears at most once in one of the defining relations. If these relations are non-degenerate then, for example, it is shown that the underlying monoid  $S$  (called a quadratic monoid) contains an abelian submonoid  $A = \langle s^N \mid s \in S \rangle$ , that is finitely generated. Furthermore, it is shown that there exists a finite subset  $F$  of  $S$  such that  $S = \bigcup_{f \in F} fA = \bigcup_{f \in F} Af$ . So,  $R = K[S]$  is a finite module over the Noetherian commutative algebra  $K[A]$ ; in particular  $R$  is a Noetherian algebra that satisfies a polynomial identity. Well-known examples of such monoids are the monoids of  $I$ -type that correspond to non-degenerate set-theoretical solutions of the Yang-Baxter equation. In case  $S$  satisfies the so called cyclic condition then  $K[S]$  turns out to be a normalizing extension of  $K[A]$ . These investigations are a continuation and generalization of earlier work of the authors as well as of work of Cedó, Gateva-Ivanova, Jespers and Okniński in the case the defining relations are square free.

**Niels Kowalzig** (Universita di Roma La Sapienza, Italy)

*When Ext is a Batalin-Vilkovisky algebra*

ABSTRACT. We show under what conditions the complex computing general Ext-groups carries the structure of a cyclic operad such that Ext becomes a Batalin-Vilkovisky algebra. This is achieved by applying known cyclic homology theories to the dual of a (left) Hopf algebroid made possible by an explicit formula we give for the inverse of the Hopf-Galois map on the dual, illustrating recent categorical results. As an application, we prove that the Hochschild cohomology of an associative algebra  $A$  is Batalin-Vilkovisky if  $A$  itself is a

contramodule over its enveloping algebra  $A^e$ .

**Tom Lenagan** (University of Edinburgh, UK)  
*Torus invariant primes in the quantum grassmannian*

ABSTRACT. A survey of known and conjectured results on the invariant prime spectrum of the quantum grassmannian. Joint work (or work in progress) at various times with Casteels, Kelly, Launois and Rigal.

**Andrei Mărcuș** (Babeș-Bolyai University, Romania)  
*Frobenius induction for algebras*

ABSTRACT. In finite group representation theory a notion of Frobenius induction for algebras was introduced by Lluís Puig in the 1970s. Puig also introduced in [3] a non-injective version. Linckelmann showed in [2] that Puig's induction may be generalized as follows. If  $A$  and  $B$  are  $k$ -algebras,  $M$  is an  $(A, B)$ -bimodule and  $C$  is a  $B$ -interior algebra, then, by definition

$$\mathrm{Ind}_M(C) := \mathrm{End}_{C^{\mathrm{op}}}(M \otimes_B C),$$

which is naturally an  $A$ -interior algebra.

On the other hand, if  $C$  is a  $k$ -algebra acted upon by the subgroup  $H$ , Turull defined in [4] the induced  $G$ -algebra  $\mathrm{Ind}_H^G C := kG \otimes_{kH} C$ . Turull's construction occurs in the context of Clifford theory for group representations.

We are concerned with two problems. The first is to give conditions on the  $(A, B)$ -bimodule  $M$  such that the induced algebra  $\mathrm{Ind}_M(C)$  can be expressed in two ways: as an endomorphism algebra, and as a tensor product. The second problem is to find the relationship between the two types of induction.

We give a positive answer to the first question when  $A$  is  $\beta$ -Frobenius extension of  $B$ . Next, we generalize the surjective version of Puig's induction to the case of a homomorphism  $B \rightarrow A$  of augmented algebras with some additional conditions. We define Turull's induction in the situation when  $B$  is a Hopf subalgebra of the Hopf algebra  $A$  and  $C$  is a  $B$ -module algebra. We also define an surjective version of Turull's induction through a homomorphism  $B \rightarrow \bar{B}$  of Hopf algebras.

Our main results establish the connection between the two inductions. We consider a Hopf subalgebra  $B$  of  $A$ , and a  $B$ -module algebra  $C$ . Then the smash product  $C \# B$  is a  $B$ -interior algebra, so we may construct Puig's induction from  $B$  to  $A$  of  $C \# B$ , and also the smash product between the Turull's induced algebra  $\mathrm{Ind}_B^A C$  and  $A$ . We prove that, briefly speaking, induction commutes with the construction of the smash product, and this may also be regarded as a duality theorem.

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**Claudia Menini** (Universita di Ferrara, Italy)  
*BiHom-structures*

ABSTRACT. Inside a categorical framework, we introduce BiHom-structures. The content of the talk stems from the paper "BiHom-Associative Algebras, BiHom-Lie Algebras and BiHom-Bialgebras" by G. Graziani, A. Makhlouf, C. Menini and F. Panaite available at <http://www.emis.de/journals/SIGMA/2015/086/>.

**Constantin Năstăsescu** (Institute of Mathematics of the Romanian Academy, Romania)  
*Symmetric algebras of corepresentations and smash products*

ABSTRACT. We investigate Frobenius algebras and symmetric algebras in the monoidal category of right comodules over a Hopf algebra  $H$ ; for the symmetric property  $H$  is assumed to be cosovereign. If  $H$  is finite dimensional and  $A$  is an  $H$ -comodule algebra, we uncover the connection between  $A$  and the smash product  $A\#H^*$  with respect to the Frobenius and symmetric properties.

**Florin Panaite** (Institute of Mathematics of the Romanian Academy, Romania)  
*Twisted algebras and Rota-Baxter type operators*

ABSTRACT. A pseudotwistor (with a particular case called twistor) for an algebra  $(A, \mu)$  in a monoidal category is a morphism  $T : A \otimes A \rightarrow A \otimes A$  satisfying a list of axioms ensuring that  $(A, \mu \circ T)$  is also an algebra in the category. This concept provides a unifying framework for various deformed (or twisted) algebras from the literature, such as twisted tensor products of algebras, twisted bialgebras and algebras endowed with Fedosov products. We will discuss a recent generalization of this, called weak pseudotwistor, that covers a number of examples of twisted algebras that cannot be covered by pseudotwistors, mainly examples provided by Rota-Baxter operators and some of their relatives (such as Leroux's TD-operators and Reynolds operators). By using weak pseudotwistors, we introduce an equivalence relation (called "twist equivalence") for algebras in a given monoidal category. The talk is based on joint work with Fred Van Oystaeyen and Javier Lopez Pena.

**Yorck Sommerhäuser** (Memorial University of Newfoundland, Canada)  
*Cores in Yetter-Drinfel'd Hopf Algebras*

ABSTRACT. By the structure theorem for cocommutative cosemisimple Yetter-Drinfel'd Hopf algebras over groups of prime order  $p$ , every such algebra, if it is not trivial, contains a  $p$ -dimensional Yetter-Drinfel'd Hopf subalgebra, called the core, with the property that the quotient by the core is trivial and therefore an ordinary group algebra, at least under suitable assumptions on the base field. In this case, it is not difficult to see that the action and the coaction of the group of prime order must be trivial. Therefore, every nontrivial such Yetter-Drinfel'd Hopf algebra is an extension of two trivial ones.

This result raises the question whether action and coaction on the core are also trivial over more general finite abelian groups. This is however, not the case: We describe an example of a core with a nontrivial action and a nontrivial coaction of an elementary abelian group of order 4. However, the core is still trivial as a Yetter-Drinfel'd Hopf algebra; i.e., it is an ordinary Hopf algebra. We conjecture that this is always the case, and describe some partial

results in this direction. The talk is based on joint work with Yevgenia Kashina.

**Alexander Stolin** (Gothenburg University, Sweden)

*Classification of quantum groups, Lie bialgebras. Relations with Brauer group.*

ABSTRACT. Given an arbitrary field  $F$  of characteristic 0, we study Lie bialgebra structures on  $\mathfrak{sl}(n, F)$ , based on the description of the corresponding classical double. For any Lie bialgebra structure  $\delta$ , the classical double  $D(\mathfrak{sl}(n, F), \delta)$  is isomorphic to  $\mathfrak{sl}(n, F) \otimes_F A$ , where  $A$  is either  $F[\varepsilon]$ , with  $\varepsilon^2 = 0$ , or  $F \oplus F$  or a quadratic field extension of  $F$ . In the first case, the classification leads to quasi-Frobenius Lie subalgebras of  $\mathfrak{sl}(n, F)$ . In the second and third cases, a BelavinDrinfeld cohomology can be introduced which enables one to classify Lie bialgebras on  $\mathfrak{sl}(n, F)$ , up to gauge equivalence. The BelavinDrinfeld untwisted and twisted cohomology sets associated to an  $r$ -matrix are computed. For the CremmerGervais  $r$ -matrix in  $\mathfrak{sl}(3)$ , we also construct a natural map of sets between the total BelavinDrinfeld twisted cohomology set and the Brauer group of the field  $F$ .

**Dragoş Ştefan** (University of Bucharest, Romania)

*Further applications of Koszul pairs*

ABSTRACT. Let  $R$  be a semisimple ring. A pair  $(A, C)$  is called almost-Koszul if  $A$  is a connected graded  $R$ -ring and  $C$  is a connected graded  $R$ -coring, these structures being compatible in an appropriate way. It is known that to an almost-Koszul pair corresponds six (co)chain Koszul-like complexes, so that one of them is exact if and only if all other are so. In this situation one says that  $(A, C)$  is a Koszul pair.

During the talk we will discuss about the strong relationship between Koszul rings and Koszul pairs. First, we will present in a unifying way several equivalent descriptions of Koszul rings, some of which being well known in the literature. Most of them are stated in terms of coring theoretical properties of  $\mathrm{Tor}_*^A(R, R)$ .

This approach to Koszul rings will allow us to introduce Koszul corings and prove by duality several equivalent characterizations of them. In the case of locally finite  $R$ -rings, we will see that a graded  $R$ -ring is Koszul if and only if its left (or right) graded dual coring is Koszul. As an application of these characterizations we will investigate the Koszulity of the incidence rings of finite graded posets, indicating an algorithm to produce new classes of Koszul posets. Finally, for finite graded posets, we will show that its incidence ring is Koszul if and only if its incidence coring is so. (Joint work with Adrian-Costin Manea).

**Blas Torrecillas Jover** (University of Almeria, Spain)

*Galois theory and cleft extensions for monoidal cowreaths*

ABSTRACT. The Galois theory for monoidal cowreaths is developed. Cleft cowreaths are introduced in this context and its relation with the normal basis property investigated. The connection of this class of cowreath with some wreath algebra structures is obtained. Finally, several applications to quasi-Hopf algebras will be discussed. This is a joint word with D. Bulacu.

**Adam-Christiaan Van Roosmalen** (Universiteit Hasselt, Belgium)

*Hall algebras for directed categories*

ABSTRACT. The Hall algebra of a quiver is closely related to the quantized enveloping algebra of the associated Kac-Moody Lie algebra. In this talk, I want to discuss the Hall algebras of some (larger) directed categories, which are then closely related to quantized enveloping algebras of some locally finite Lie algebras. As a consequence, we obtain different Hopf algebra structures on the quantized enveloping algebra of  $\mathfrak{sl}(\infty)$ . This talk is based on joint work with Qunhua Liu and Guillaume Pouchin.

**Fred Van Oystaeyen** (Universiteit Antwerpen, Belgium)

*Localizations and Sheaves of Glider Representations*

ABSTRACT. Glider representations appear for towers of groups, leading to towers of group rings, towers of Lie algebras, leading to towers of enveloping algebras, towers of iterated Ore extensions, leading to most usual quantum groups, towers of rings of differential operators by differential extensions, aso... . More generally glider representations are associated to positive filtrations linking a ring appearing as the part of filtration degree zero to the total filtered ring. A glider representation is a substructure of a module over the total ring with some partial multiplication structure given by a descending chain of some additive subgroups of the total module. This leads to a non-trivial generalization of module theory allowing to study properties depending on the filtration, ie on the tower of subrings in all the special cases mentioned. The localization theory of gliders is very different from the case of modules, yet it is possible to obtain a localized filtration on nice localizations of the filtered ring and finally one is able to introduce some sheaf theory for glider representations. As work in progress we can mention the application to chains of varieties corresponding to chains of coordinate rings. This work is joined with F.Caenepeel.

**Yinhua Zhang** (Universiteit Hasselt, Belgium)

*The Green rings of finite dimensional pointed Hopf algebras of rank one*

ABSTRACT. In this talk, we present the Green rings of finite dimensional pointed rank one Hopf algebras  $H$  of both nilpotent and non-nilpotent type. We first determine all non-isomorphic indecomposable  $H$ -modules and describe the Clebsch-Gordan formulas for them. We then study the structures of both the Green ring  $r(H)$  and the Grothendieck ring  $G_0(H)$  and establish the precise relation between the two rings. We use the Cartan map of  $H$  to study the Jacobson radical and the idempotents of  $r(H)$ . It turns out that the Jacobson radical of  $r(H)$  is exactly the kernel of the Cartan map, a principal ideal of  $r(H)$ , and  $r(H)$  has no non-trivial idempotents. Besides, we show that the stable Green ring of  $H$  is a transitive fusion ring. This enables us to calculate Frobenius-Perron dimensions of objects in the stable category of  $H$ . Finally, as an example, we present both the Green ring and the Grothendieck ring of the Radford Hopf algebra in terms of generators and relations.

## Poster session

**Khaled A. Al-Sharo** (Al al-Bayt University, Jordan)

*On Nearly  $S$ -permutable subgroups*

**Umamaheswaran Arunachalam** (Indian Institute of Science Education and Research, India)

*$\mathcal{X}^\perp$ -projective,  $\mathcal{X}$ -injective and  $\mathcal{X}$ -flat modules and their characterizations*

**Ryan Kasyfil Aziz** (Queen Mary, University of London, UK)

*New Examples of Braided-Lie Algebras*

**Salim Badidja** (Kasdi Merbah Ouargla, Algeria)

*Generalization and characteristics of tribonacci numbers*

**Filoteia Besleaga** (University of Bucharest, Romania)

*On group gradings of structural matrix algebras*

**Hoan-Phung Bui** (Université Libre de Bruxelles, Belgium)

*Compatibility of Hopf Galois extensions for separable fields*

**Clarisson Rizzie Canlubo** (University of Copenhagen, Denmark)

*Noncommutative covering spaces*

**Jiawei Hu** (Université Libre de Bruxelles, Belgium)

*A new definition of partial (co)actions*

**Adrian Manea** (University of Bucharest, Romania)

*On Koszul Finite Graded Posets*

**Luz Adriana Mejia** (National University of San Luis, Argentina)

*Crossed extensions of the corepresentation category of finite supergroup algebras*

**Laura Elena Năstăsescu** (Institute of Mathematics of the Romanian Academy / University of Bucharest, Romania)

*Some results regarding  $\sigma$ -graded Frobenius algebras*

**Deividi Pansera** (University of Porto, Portugal)

*A note on a paper by Cuadra, Etingof and Walton*

**Ana Rovi** (Newcastle University, UK)

*Courant algebroids and their enveloping algebras. Hopf algebroids*