

The 17<sup>th</sup>  
International  
Conference on  
Representations of  
Algebras

*Syracuse University  
Syracuse, New York*

15–19 AUGUST 2016

Conference Abstracts



## On the abundance of silting modules

Monday

Lidia Angeleri Huegel

University of Verona

Silting modules are the modules that arise as zero cohomologies of (not necessarily compact) 2-term silting complexes over an arbitrary ring. They provide a generalization of (not necessarily finitely generated) tilting modules. Moreover, over a finite dimensional algebra, the finitely generated silting modules are precisely the support  $\tau$ -tilting modules introduced by Adachi, Iyama and Reiten. We will see that silting modules are abundant. Indeed, they parametrize the definable torsion classes over a noetherian ring, and the hereditary torsion pairs of finite type over a commutative ring. Also the universal localizations of a ring can often be parametrized by silting modules. In my talk, I will give a brief introduction to the concepts of silting and cosilting module, and I will explain some of the classification results mentioned above. The talk will rely on joint work with Michal Hrbek, Frederik Marks and Jorge Vitória.

## Thick subcategories over graded simple hypersurface singularities

Tuesday

Tokuji Araya

Okayama University of Science

Ryo Takahashi classified the thick subcategories of the stable category of maximal Cohen-Macaulay modules over a hypersurface local ring. By his classification, we can see that if the base ring has a simple singularity, then the thick subcategories are trivial. On the other hand, if the base ring is graded, then there exist non-trivial thick subcategories. In this talk, we will classify the thick subcategories of the stable category of graded maximal Cohen-Macaulay modules over a graded hypersurface which has a simple singularity.

## The Grothendieck groups of mesh algebras

Thursday

Sota Asai

Nagoya University

We deal with the finite-dimensional mesh algebras given by stable translation quivers. These algebras are self-injective, and thus the stable categories have a structure of triangulated categories. Our main result determines the Grothendieck groups of these stable categories. As an application, we give a complete classification of the mesh algebras up to stable equivalences.

## Covering theory for bimodules and stable equivalences of Morita type

Hideto Asashiba  
Shizuoka University

We fix a commutative ring  $\mathbb{k}$  and a group  $G$ . To include infinite coverings of  $\mathbb{k}$ -algebras into consideration we usually regard  $\mathbb{k}$ -algebras as locally bounded  $\mathbb{k}$ -categories with finite objects, so we will work with small  $\mathbb{k}$ -categories. For small  $\mathbb{k}$ -categories  $R$  and  $S$  with  $G$ -actions we introduce  $G$ -invariant  $S$ - $R$ -bimodules and their category denoted by  $S\text{-Mod}^G\text{-}R$ , and denote by  $R/G$  the orbit category of  $R$  by  $G$ , which is a small  $G$ -graded  $\mathbb{k}$ -category. For small  $G$ -graded  $\mathbb{k}$ -categories  $A$  and  $B$  we introduce  $G$ -graded  $B$ - $A$ -bimodules and their category denoted by  $B\text{-Mod}_G\text{-}A$ , and denote by  $A\#G$  the smash product of  $A$  and  $G$ , which is a small  $\mathbb{k}$ -category with  $G$ -action. Then the Cohen-Montgomery duality theorem [2, 1] says that we have equivalences  $(R/G)\#G \simeq R$  and  $(A\#G)/G \simeq A$ , by which we identify these pairs. In the talk we introduce functors  $(-)/G : S\text{-Mod}^G\text{-}R \rightarrow (S/G)\text{-Mod}_G(R/G)$  and  $(-)\#G : B\text{-Mod}_G\text{-}A \rightarrow (B\#G)\text{-Mod}^G\text{-}(A\#G)$ , and show that they are equivalences and quasi-inverses to each other (by applying  $A := R/G$ ,  $R := A\#G$ , etc.), have good properties with tensor products and exchange “canonically  $G$ -invariant projectivity” and “canonically  $G$ -graded projectivity” of one-sided modules and bimodules. We apply this to equivalences of Morita type to obtain the following.

**Theorem.**

- (1) There exists a “ $G$ -invariant stable equivalence of Morita type” between  $R$  and  $S$  if and only if there exists a “ $G$ -graded stable equivalence of Morita type” between  $R/G$  and  $S/G$ .
- (2) There exists a “ $G$ -graded stable equivalence of Morita type” between  $A$  and  $B$  if and only if there exists a “ $G$ -invariant stable equivalence of Morita type” between  $A\#G$  and  $B\#G$ .

Here we note that a  $G$ -invariant (resp.  $G$ -graded) stable equivalence of Morita type is defined to be a usual stable equivalence of Morita type with additional properties, and does not mean an equivalence between stable categories of  $G$ -invariant (resp.  $G$ -graded) modules. The corresponding results for standard derived equivalences and singular equivalences of Morita type hold as well.

### References

- [1] Asashiba, H.: *A generalization of Gabriel’s Galois covering functors II: 2-categorical Cohen-Montgomery duality*, to appear in Applied Categorical Structures, DOI: 10.1007/s10485-015-9416-9. (preprint arXiv:0905.3884)
- [2] Cohen, M. and Montgomery, S.: *Group-graded rings, smash products, and group actions*, Trans. Amer. Math. Soc. **282** (1984), 237–258.

## The Peterson Variety and the Wonderful Compactification

Ana Balibanu  
University of Chicago

The wonderful compactification of a complex semisimple algebraic group  $G$  links the geometry of  $G$  to the geometry of its partial flag varieties. In this talk, we will explain the construction of the wonderful compactification and some of its important properties, and we will show that if  $x \in \text{Lie}(\mathfrak{g})$  is a regular element, then the closure of the centralizer of  $x$  in the wonderful compactification is isomorphic to the closure of a general orbit of this centralizer in the full flag variety. In particular, there is an isomorphism between the closure of the centralizer of a regular nilpotent element and the Peterson variety.

## Unstructurality of Cluster Algebras of type A-tilde

Wednesday

Véronique Bazier-Matte  
Université de Sherbrooke

It is conjectured by Ibrahim Assem, Ralf Schiffler and Vasilisa Shramchenko in “Cluster Automorphisms and Compatibility of Cluster Variables” that every cluster algebra is unstructural, that is to say, that the set of cluster variables determines uniquely the cluster algebra structure. In other words, there exists a unique decomposition of the set of cluster variables into clusters. This conjecture has been proven to hold true for algebras of type Dynkin or rank 2 by Assem, Schiffler and Shramchenko. The aim of this talk is to prove it for algebras of type A-tilde. We use triangulations of annuli and algebraic independence of clusters to prove unstructurality for algebras arising from annuli, which are of type A-tilde. We also prove the automorphism conjecture from Assem, Schiffler and Shramchenko for algebras of type A-tilde as a direct consequence.

## Applying the functorial filtration method to derived categories

Monday

Raphael Bennett-Tennenhaus  
University of Leeds

Bekkert and Merklen used a matrix problem (which was studied by Bondarenko) in order to classify indecomposables in the bounded derived category of a finite-dimensional gentle algebra. These indecomposables are indexed using string and band data, and their construction is reminiscent of representations arising in certain module classifications solved by Gelfand and Ponomarev, Gabriel, Ringel and Crawley-Boevey. These authors used a different approach sometimes called the functorial filtration method. In this classification method one constructs two functorially-defined vector space filtrations of a module, and verifies compatibility conditions between these filtrations and a candidate list of indecomposables. In this talk I will consider infinite-dimensional generalisations of the gentle algebras studied by Bekkert and Merklen, and I will discuss how the functorial filtration method may be adapted to classify the objects of the right bounded derived category of these algebras.

## Categorical matrix factorizations

Tuesday

Petter Andreas Bergh  
NTNU

We define categorical matrix factorizations in a suspended additive category, with respect to a central element. Such a factorization is a sequence of maps which is two-periodic up to suspension, and whose composition equals the corresponding coordinate map of the central element. When the category in question is that of free modules over a commutative ring, these factorizations are just the classical matrix factorizations. We show that the homotopy category of categorical matrix factorizations is triangulated, and discuss some possible future directions. This is joint work with Dave Jorgensen.

Tuesday

## Homological transfer on Hecke algebras

Philippe Blanc

C.N.R.S.

We define the transfer operation in the theory of homology in the category of differentiable modules on real Lie groups. We set explicit formulas for the Poincaré duality, the main result is that the associated Poincaré isomorphism send the homological restriction on the cohomological transfer. These results can be applied to compute the Hochschild homology of Hecke algebras for real reductive groups. This article appeared in the Journal of Lie Theory in 2015.

---

Monday

## Derived classification of the gentle two-cycle algebras

Gregorz Bobiński

Nicolaus Copernicus University

According to a result of Schröer and Zimmermann the gentle algebras are closed with respect to the derived equivalence. The tree gentle algebras are precisely the algebras derived equivalent to the Dynkin algebras of type A and their derived classification is well known. Similarly, the derived classification of one-cycle gentle algebras is known. In both cases the derived equivalence classes are determined by the invariant introduced by Avella-Alaminos and Geiss. Using this invariant Avella-Alaminos and, independently, Malicki and the speaker obtained partial derived classification of the gentle two-cycle algebras. In the talk we complete this classification. Important role in the proof is played by a recent result by Amiot.

---

Thursday

## String cones and cluster varieties

Lara Bossinger

University of Cologne

Gross, Hacking, Keel and Kontsevich in 2014 wrote an article on canonical bases for cluster algebras. It is a fundamentally different geometric approach using scattering diagrams and wall-crossing. It has been in important question since, how to relate it to known results in representation theory. In 2015 Magee showed that the theory can be applied to the base affine space  $SL_n/U$  and that one obtains a Gelfand-Tsetlin cone this way. We managed to prove that in fact one can obtain all string cone parametrizations of Lusztig's canonical basis/Kashiwara's global basis. These have been studied by Littelmann in 98 and Berenstein Zelevinsky in 99.

---

## Hochschild Cohomology, Koszul Duality, and the $A_\infty$ -Centre

Benjamin Briggs

University of Toronto

Monday

In this joint work with Vincent Gelinas, we will discuss the notion of commutativity and the centre of an  $A_\infty$ -algebra. After examining possible definitions, we show that if  $A$  is a dg (or  $A_\infty$ ) algebra over a field, then the image of the natural projection map  $HH^*(A, A) \rightarrow H(A)$  is the  $A_\infty$ -centre of  $H(A)$  (with its higher operations). The Hochschild cohomology of  $A$  acts on derived category  $D(A)$ , giving rise to the characteristic morphism from  $HH^*(A, A)$  to the Koszul dual  $A^! = \text{Ext}_A(k, k)$ . Buchweitz announced in Canberra in 2003 that the Hochschild cohomology of  $A$  and  $A^!$  coincide when  $A$  is a Koszul algebra. Generalising this to arbitrary augmented dg (or  $A_\infty$ ) algebras (with some mild finiteness assumptions) there is a canonical isomorphism  $HH^*(A, A) \cong HH^*(A^!, A^!)$ , and we show that the projection and characteristic map are exchanged under this isomorphism. Consequently, the image of the characteristic map is the  $A_\infty$ -centre of  $A^!$ , generalising from the Koszul case established by Buchweitz, Green, Snashall and Solberg. To be continued by Vincent Gelinas.

## Fourier-Mukai transform on Weierstrass cubics and commuting differential operators

Igor Burban

University of Cologne

Friday

Any commutative subalgebra  $A$  in the algebra of ordinary differential operators admits a natural geometric invariant consisting of an irreducible (possibly singular) projective curve  $C$  (called spectral curve) and a semi-stable torsion free sheaf  $\mathcal{F}$  on it (called spectral sheaf). In the case the rank of  $A$  is one (meaning that  $A$  contains a pair of differential operators of mutually prime orders), the algebra  $A$  can be recovered from its spectral datum  $(C, \mathcal{F})$  (Krichever correspondence).

All commutative subalgebras of ordinary differential operators of genus one and rank two were classified in the 80ies by Krichever, Novikov and Gruenbaum. It is a natural problem to describe the spectral sheaves of such algebras. This problem was solved by Previato and Wilson in the case the spectral curve is smooth, their answer was given in terms of Atiyah's classification of vector bundles on an elliptic curve. However, the case of a singular spectral curve remained opened.

In my talk (based on a joint work with Alexander Zheglov: arXiv:1602.08694) I shall explain how the Fourier-Mukai transform allows to describe the spectral sheaf of a genus one commutative subalgebra of ordinary differential operators. As a byproduct, I shall also show how the low rank objects of the category of semi-stable sheaves on a cuspidal Weierstrass cubic curve (known to be representation wild) can be classified.

Tuesday

## Homological Koszul Duality for Koszul Quadratic Algebras

Jesse Burke

Australian National University

Let  $A$  be a graded quadratic Koszul algebra and  $A^!$  its Koszul dual. We will consider dg- $A$ -modules  $M$  and their Koszul duals  $M^!$  (heuristically a dg-module over a graded algebra is a complex of graded modules along with higher homotopy data). Such dg-modules occur in nature, especially in the study of complete intersection rings, and in equivariant cohomology (in these cases  $A$  is an exterior algebra and  $A^!$  a symmetric algebra). I will show how the higher homotopies on  $M$  and  $M^!$  are related by Koszul duality. In particular, this recovers a recent result of Eisenbud-Peeva-Schreyer that shows that for a finitely generated module  $N$  a local complete intersection ring  $R = Q/I$ , with residue field  $k$ , and  $Q$  a regular local ring,  $\text{Ext}_R^*(N, k)$  determines  $\text{Tor}_*^Q(N, k)$  under the usual Bernstein-Gelfand-Gelfand correspondence. I will also talk about conjectural generalizations to representation theoretic contexts, particularly coordinate rings of highest weight orbits for semi-simple Lie algebras.

---

Wednesday

## Cluster automorphism groups of cluster algebras

Wen Chang

Shaanxi Normal University

A cluster automorphism is an algebra automorphism which is compatible with the mutations of a cluster algebra. I will talk about some results on the cluster automorphism groups, especially on those relate to cluster algebras with geometric coefficients, cluster algebras of finite type and automorphism groups of cluster exchange graphs.

---

Thursday

## Reduction for negative Calabi-Yau triangulated categories

Raquel Coelho Simões

Universidade de Lisboa

Iyama and Yoshino introduced a tool, now known as Iyama-Yoshino reduction, which is very useful in studying the generators and decompositions of positive Calabi-Yau triangulated categories. However, this technique does not preserve the required properties for negative Calabi-Yau triangulated categories. In this talk, we establish a Calabi-Yau reduction theorem for this class of categories. This will be a report on joint work with David Pauksztello.

---

## Products of flat modules and global dimension relative to $\mathcal{F}$ -Mittag-Leffler modules

Manuel Cortés-Izurdiaga

Universidad de Almería

The motivation of this talk comes from the study of right Gorenstein regular rings. A (non necessarily commutative with unit) ring  $R$  is said to be right Gorenstein regular if the category of right  $R$ -modules is a Gorenstein category in the sense of [1] and [2]. These rings are precisely those for which the right global Gorenstein dimension is finite. Classical Iwanaga-Gorenstein rings, that is, two sided noetherian rings with finite left and right self-injective dimensions, are left and right regular Gorenstein. Actually, the right Gorenstein regular property can be viewed as the natural one-sided generalization of the Iwanaga-Gorenstein condition to non-noetherian rings.

In [1, Corollary VII.2.6], Beligiannis and Reiten have proved that a ring  $R$  is right Gorenstein regular if and only if the class of all right  $R$ -modules with finite projective dimension coincides with the class of all right  $R$ -modules with finite injective dimension. A direct consequence of this fact is that the class of all modules with finite projective dimension is closed under direct products. Moreover, rings with this property satisfy that direct products of right  $R$ -modules with finite flat dimension have finite flat dimension. So, in order to understand right regular Gorenstein rings it is necessary to study rings in which the class of right  $R$ -modules with finite flat dimension is closed under direct products.

The main objective of this talk is to study rings with this property. We shall prove that these rings are characterized by the following conditions:

- There exists a natural number  $n$  such that all products of flat right modules have flat dimension less than or equal to  $n$ .
- The class of right modules with flat dimension less than or equal to  $n$  is preenveloping.
- The ring has finite left global projective dimension relative to the class of all  $\mathcal{F}$ -Mittag-Leffler modules, where  $\mathcal{F}$  is the class of all flat right modules.
- Every finitely generated left ideal has finite projective dimension relative to the class of all  $\mathcal{F}$ -Mittag-Leffler modules.

In order to prove this last assertion, we shall obtain a general result concerning global relative dimension. Namely, if  $\mathcal{X}$  is any class of left  $R$ -modules closed under filtrations that contains all projective modules, then  $R$  has finite left global projective dimension relative to  $\mathcal{X}$  if and only if each left ideal of  $R$  has finite projective dimension relative to  $\mathcal{X}$ . This result contains, as particular cases, the well known results concerning the classical left global, weak and Gorenstein global dimensions.

The results presented in this talk are contained in [3], that will be published in Proceedings of the American Mathematical Society.

### References

- [1] Beligiannis, A. Reiten, I. Homological and homotopical aspects of torsion theories. Mem. Amer. Math. Soc. 188 (2007), no. 883.
- [2] Enochs, E. Estrada, S. Garcia-Rozas, J. R. Gorenstein categories and Tate cohomology on projective schemes. Math. Nachr. 281 (2008), no. 4, 525-540.
- [3] Cortes-Izurdiaga, M. Direct products of flat modules and global dimension relative to  $\mathcal{F}$ -Mittag-Leffler modules. To appear in Proc. Amer. Math. Soc.

Thursday

## On quiver Grassmannians and orbit closures for representation-finite algebras

William Crawley-Boevey

University of Leeds/Bielefeld University

This is joint work with Julia Sauter. We show that Auslander algebras have a unique tilting and cotilting module which is generated and cogenerated by a projective-injective; its endomorphism ring is called the projective quotient algebra. For any representation-finite algebra, we use the projective quotient algebra to construct desingularizations of quiver Grassmannians, orbit closures in representation varieties, and their desingularizations. This generalizes results of Cerulli Irelli, Feigin and Reineke.

Monday

## Cluster-tilting modules of self-injective Nakayama algebras

Erik Darpö

Nagoya University

In this talk, I will present an explicit numerical criterion characterising when a self-injective Nakayama algebra has an  $n$ -cluster-tilting module. The proof relies upon the description, due to Baur and Marsh, of the higher cluster categories of type  $A$  by diagonals in certain polygons.

Thursday

## Algebras of partial triangulations

Laurent Demonet

Nagoya University

This is a report on [Demonet, arXiv: 1602.01592]. We introduce a class of finite dimensional algebras coming from partial triangulations of marked surfaces. A partial triangulation is a subset of a triangulation. This class contains Jacobian algebras of triangulations of marked surfaces introduced by Labardini-Fragoso (see also Derksen-Weyman-Zelevinsky) and Brauer graph algebras (see Wald-Waschbüsch). We generalize properties which are known or partially known for Brauer graph algebras and Jacobian algebras of marked surfaces. In particular, these algebras are symmetric when the considered surface has no boundary, they are of tame presentation type, and we give a combinatorial generalization of flips or Kauer moves on partial triangulations which induces derived equivalences between the corresponding algebras. Notice that we also give an explicit formula for the dimension of the algebra.

Monday

## Hall algebras of cyclic quivers and $q$ -deformed Fock spaces

Bangming Deng

Yau Mathematical Sciences Center, Tsinghua University

By extending a construction of Varagnolo and Vasserot, we define a module structure on the  $q$ -deformed Fock space  $\mathcal{F}$  over the double Ringel–Hall algebra  $D(Q)$  of a cyclic quiver  $Q$  and then show that  $\mathcal{F}$  is isomorphic to the basic representation of  $D(Q)$ . This is joint work with Jie Xiao.

## Non-commutative nodal curves and related algebras

Wednesday

Yuriy Drozd

Institute of Mathematics, National Academy of Sciences of Ukraine

This is a joint work with Igor Burban.

A *non-commutative curve* is a pair  $(X, \mathcal{A})$ , where  $X$  is an algebraic curve and  $\mathcal{A}$  is a sheaf of  $\mathcal{O}_X$ -algebras which is torsion free and coherent as  $\mathcal{O}_X$ -module. We always suppose that  $\mathcal{A}$  is *central* over  $\mathcal{O}_X$  and *reduced*, i.e. without nilpotent ideals. We also suppose that  $X$  is a projective curve over an algebraically closed field. We denote by  $\mathcal{J}$  the ideal of  $\mathcal{A}$  such that  $\mathcal{J}_x = \mathcal{A}_x$  if  $\mathcal{A}_x$  is hereditary and  $\mathcal{J}_x = \text{rad} \mathcal{A}_x$  otherwise. Let also  $\mathcal{A}^\# = \text{End}_{\mathcal{A}} \mathcal{J}_x$  as of *right*  $\mathcal{A}$ -module; obviously,  $\mathcal{A}$  embeds into  $\mathcal{A}^\#$ . Recall that  $\mathcal{A}$  is hereditary if and only if  $\mathcal{A}^\# = \mathcal{A}$ .

We call a non-commutative curve  $(X, \mathcal{A})$  *nodal* if  $\mathcal{A}^\#$  is hereditary. In this case, let  $\tilde{\mathcal{A}} = \text{End}_{\mathcal{A}}(\mathcal{A} \oplus \mathcal{A}^\#)$ . Then the category of  $\mathcal{A}$ -modules is a *bilocalization* (i.e. both localization and colocalization) of the category of  $\tilde{\mathcal{A}}$ -modules and the same is true for their derived categories [1]. Moreover,  $\tilde{\mathcal{A}}$  is *quasi-hereditary* and of global dimension 2.

Suppose that the curve  $X$  is *rational*. Then  $\tilde{\mathcal{A}}$  has a perfect tilting complex  $\mathcal{T}$ , hence is derived equivalent to the finite dimensional algebra  $R = \text{Hom}_{\mathcal{D}\tilde{\mathcal{A}}}(\mathcal{T}, \mathcal{T})$  [1]. We show that the algebra  $R$  can be obtained from a Ringel canonical algebra by a sequence of operations of *gluing two vertices* and *blowing up of a vertex* (see [3] for their definitions).

Using the results of [2], we define representation types of such algebras. Note that if only the blowing up occurs, these algebras are a partial case of *supercanonical algebras* from [4]. Namely, they are supercanonical algebras such that all related posets are linear or semichains. This class contains, in particular, all tame supercanonical algebras. Another example (using gluing) can be obtained by adding to some vertices  $i$  of the quiver of a canonical algebra loops  $\beta_i$  with  $\beta_i^2 = 0$ .

### References

- [1] Burban I., Drozd Y., Gavran V. Non-commutative schemes and categorical resolutions. Preprint MPIM 14-6 (2014).
- [2] Drozd Y., Voloshyn D. Vector bundles over noncommutative nodal curves. Ukr. Math. J. 64, No.2 (2012) 185-199.
- [3] Drozd Y., Zembyk V. Representations of nodal algebras of type A. Algebra Discrete Math. 15, No.2 (2013) 179-200.
- [4] Lenzing H., de la Peña J. A. Supercanonical algebras. J. Algebra 282 (2004) 298-348.

## Stable auto-equivalences for local symmetric algebras

Monday

Alex Dugas

University of the Pacific

We describe two constructions of auto-equivalences of the stable module category for local symmetric algebras. These auto-equivalences are inspired by the spherical twists of Seidel and Thomas and the  $\mathbb{P}^n$ -twists of Huybrechts and Thomas, which give auto-equivalences of the derived category of coherent sheaves on a projective variety. At the same time, the auto-equivalences we construct generalize those induced by tensoring with endo-trivial modules over group algebras of certain  $p$ -groups in characteristic  $p$ . We also give examples showing how these can be used to build stable equivalences between symmetric algebras which are not derived equivalent.

Monday

## From Submodule Categories to Stable Auslander Algebras

Ögmundur Eiriksson  
Bielefeld University

C. Ringel and P. Zhang have studied a pair of functors from the submodule category of a truncated polynomial ring to a preprojective algebra of type  $A$ . This talk presents the analogous process starting with any self-injective  $k$ -algebra  $\Lambda$  of finite representation type. I describe two functors from the submodule category of  $\Lambda$  to the module category of the stable Auslander algebra of  $\Lambda$ . Both functors factor through the full subcategory of torsionless objects in the module category of the Auslander algebra.

Moreover I am able to describe the kernels, which have finitely many indecomposables.

If  $\Lambda$  is uni-serial this subcategory arises as the subcategory of  $\Delta$ -filtered objects for a quasi-hereditary structure on the Auslander algebra.

After projecting to the stable category of the module category of the stable Auslander algebra the two functors differ by the syzygy functor.

Tuesday

## Knoerr lattices for symmetric orders

Florian Eisele  
City University London

R. Knoerr introduced the concept of “virtually irreducible lattices” in the hope that it could be used to prove one implication of Brauer’s height zero conjecture. A “virtually irreducible” (or “Knoerr”) lattice is a lattice defined over  $RG$  ( $R$  a discrete valuation ring,  $G$  a finite group), such that the invertible elements of its endomorphism ring can be distinguished from the non-invertible ones merely by looking at the valuation of their traces. Later, J.F. Carlson and A. Jones introduced what they called the “exponential property” for  $RG$ -lattices, a condition on the stable endomorphism ring of a lattice which is equivalent to Knoerr’s virtual irreducibility. All of this makes sense for arbitrary symmetric  $R$ -algebras with separable  $K$ -span ( $K =$  the field of fractions of  $R$ ), but the property of being virtually irreducible and the exponential property need no longer be equivalent if we are not dealing with a group algebra. I’ll report on joint work with M. Geline, R. Kessar and M. Linckelmann which characterises those symmetric  $R$ -algebras for which those two properties are equivalent, and studies the properties of this class of algebras.

Thursday

## The ideal of $\mathcal{P}$ -phantom maps

Sergio Estrada  
Universidad de Murcia

We define the notion of  $\mathcal{P}$ -phantom map with respect to a class of conflations in a locally  $\lambda$ -presentable exact additive category  $(\mathcal{C}; \mathcal{P})$  and we give sufficient conditions to ensure that the ideal  $\Phi(\mathcal{P})$  of  $\mathcal{P}$ -phantom maps is a (special) covering ideal. As a byproduct of this result, we infer the existence of various covering ideals in categories of sheaves which have a meaningful geometrical motivation. Our approach is necessarily different from others that have recently appeared in the literature, as the categories involved in most of the examples we are interested in do not have enough projective morphisms.

## Noncommutative resolutions of discriminants

Wednesday

Eleonore Faber

University of Michigan

Let  $G$  be a finite subgroup of  $\mathrm{GL}(n, K)$  for a field  $K$  whose characteristic does not divide the order of  $G$ . The group  $G$  acts linearly on the polynomial ring  $S$  in  $n$  variables over  $K$ . When  $G$  is generated by reflections, then the discriminant  $D$  of the group action of  $G$  on  $S$  is a hypersurface with a singular locus of codimension 1. In this talk we give a natural construction of a noncommutative resolution of singularities of the coordinate ring of  $D$  as a quotient of the skew group ring  $A = S * G$  by the idempotent  $e$  corresponding to the trivial representation. We will explain how this can be seen in some sense as a McKay correspondence for reflection groups. This is joint work with Ragnar-Olaf Buchweitz and Colin Ingalls.

## Tensor Multiplicity via Upper Cluster Algebras

Friday

Jiarui Fei

NCTS Taipei

By *tensor multiplicity* we mean the multiplicities in the tensor product of any two finite-dimensional irreducible representations of a simply connected Lie group. Finding their *polyhedral models* is a long-standing problem. The problem asks to express the multiplicity as the number of lattice points in some convex polytope.

Accumulating from the works of Gelfand, Berenstein and Zelevinsky since 1970's, around 1999 Knutson and Tao invented their *hive model* for the type  $A$  cases, which led to the solution of the *saturation conjecture*. Outside type  $A$ , Berenstein and Zelevinsky's models are still the only known polyhedral models up to now. Those models lose a few nice features of the hive model.

In this talk, I will explain how to use *upper cluster algebras*, an interesting class of commutative algebras introduced by Berenstein-Fomin-Zelevinsky, to discover new polyhedral models for all Dynkin types. Those new models improve the ones of Berenstein-Zelevinsky's, or in some sense generalize the hive model.

It turns out that the quivers of relevant upper cluster algebras are related to the Auslander-Reiten theory of presentations, which can be viewed as a categorification of these quivers. The upper cluster algebras are graded by triple dominant weights, and the dimension of each graded component counts the corresponding tensor multiplicity.

The proof also invokes another categorification – Derksen-Weyman-Zelevinsky's quiver-with-potential model for the cluster algebra. The bases of these upper cluster algebras are parametrized by  $\mu$ -supported  $g$ -vectors. The polytopes will be described via stability conditions. The talk is based on the preprint arXiv:1603.02521.

Thursday

## Multisemigroups arising from quiver algebras

Love Forsberg

Uppsala Universitet

Let  $Q$  be a quiver whose underlying undirected graph is the affine Dynkin diagram  $\tilde{A}_n$  and let  $A = \mathbb{k}Q$  be the corresponding path algebra. We study the multisemigroup (with multiplicities) of indecomposable two-sided ideals in  $A$  (or, equivalently, indecomposable subbimodules of  ${}_A A_A$ ) under the operation of tensoring over  $A$ . Under a mild assumptions we show that all ideals of  $A$  are linearized semigroup ideals and can be described using weak cylindrical Dyck paths in a matrix form. None of these multisemigroups are semigroups and it also turns out that the only mutplicities appearing are 0 and 1. This continues the study initiated by Gensing and Mazorchuk where special kinds of tree algebras were considered and where the multisemigroup structure degenerate to a semigroup.

---

Tuesday

## A formula for the value of the Kac polynomial at one via torus localization

Hans Franzen

University of Bonn

The Kac polynomial counts the number of absolutely indecomposable representations of a given quiver over a finite field. Hausel–Letellier–Rodriguez-Villegas define a variety whose cohomology groups determine the Kac polynomial. By defining a torus action on this variety we show that the value of the Kac polynomial at one can be expressed in terms of Kac polynomials of the universal abelian covering quiver. This is joint work with Thorsten Weist.

---

Thursday

## Periodic flat modules and $K(R\text{-Proj})$

Xianhui Fu

Northeast Normal University

Let  $R$  be an associative ring with unit and denote by  $K(R\text{-Proj})$  the homotopy category of complexes of projective left  $R$ -modules. In this talk, we draw the connection between Neeman's theorem that  $K(R\text{-Proj})$  is  $\aleph_1$ -compactly generated and the theorem of Benson and Goodearl that every periodic flat module is projective.

---

## Representation finite $m$ -cluster tilted algebras of Euclidean type

Ana Garcia Elsener

Universidad Nacional de Mar del Plata

Monday

This is a joint work with *Elsa Fernández and Sonia Trepode*. In this talk we note that, in contrast with 1-cluster tilted algebras, the type is not well defined for  $m$ -cluster tilted algebras. We also observe that, in contrast with 1-cluster tilted algebras,  $m$ -cluster tilted algebras arising from Euclidean  $m$ -cluster categories can be of finite representation type. Both remarks come from an example of an  $m$ -cluster tilted algebra of type  $A_n$  and  $\tilde{A}_n$ , shown by Viviana Gubitosi in her Ph.D. thesis. Recently, Sefi Ladkani has proved that any finite dimensional algebra is an  $m$ -Calabi Yau tilted algebra, for some  $m > 2$ .

We study when  $m$ -cluster tilted algebras arising from an Euclidean quiver are of finite representation type. For such algebras, we characterize representation finite type in terms of the position of the direct summands of the  $m$ -cluster tilting object in the  $m$ -cluster category. More precisely, we prove that an  $m$ -cluster tilted algebra is of finite representation type, if and only if, the  $m$ -cluster tilting object has non-zero direct summands in two different transjective components of the Auslander-Reiten quiver of the  $m$ -cluster category.

Describing a tilting object giving an  $m$ -cluster tilted algebra is not an easy task. We consider the problem in the case  $\tilde{A}_n$ . Using the geometrical model (Torkildsen, Gubitosi), we get the description of representation finite type in terms of  $m + 2$ -angulations of a surface. It is possible to read from the  $m + 2$ -angulation, the position of the direct summands of the associated tilting object in the Auslander-Reiten quiver of the  $m$ -cluster category. Also, it is possible to distinguish which  $m$ -cluster tilted algebras of type  $\tilde{A}_n$  will be at the same time  $m$ -cluster tilted algebras of type  $A_n$ .

## Noncrossing tree partitions and tiling algebras

Alexander Garver

UQAM and Sherbrooke

Tuesday

We introduce noncrossing tree partitions which are certain noncrossing collections of curves on a tree embedded in a disk. These generalize the classical type A noncrossing partitions, and, as in the classical case, they form a lattice whose partial order is given by refinement. The data of a tree embedded in disk also defines a finite dimensional algebra called a tiling algebra by Coelho Simões and Parsons. Examples of such algebras are type A Jacobian algebras and type A  $m$ -cluster-tilted algebras, which arise in the context of cluster algebras. Simple-minded collections for finite dimensional algebras are important representation theoretic objects. For example, such objects have been used to construct derived equivalences for symmetric algebras by Rickard. Our main result is a combinatorial classification of 2-term simple-minded collections for tiling algebras in terms of noncrossing tree partitions. This is joint work with Thomas McConville.

Wednesday

## Quivers with relations for symmetrizable Cartan Matrices - change of symmetrizer

Christof Geiss

Instituto de Matematicas, UNAM

This is joint work with B. Leclerc and J. Schröer. We introduced in previous work a class of 1-Gorenstein algebras, defined in terms of quiver with admissible relations, associated to a symmetrizable Cartan matrix, a symmetrizer and an orientation. The modules of finite projective dimension behave in many aspects like the representations of the corresponding species. Their normalized dimension vectors are called rank vectors. In this talk we show that the variety of those modules with a given rank vector is irreducible, and that the generic decomposition of it does not depend on the symmetrizer. Similarly, for a rigid module of finite projective dimension, it makes sense to study the quiver Grassmannian of submodules of finite projective dimension of a given rank vector. These varieties are smooth and irreducible, and their Euler characteristic does not depend on the symmetrizer.

Monday

## The $A_\infty$ -centre and the characteristic map on Hochschild Cohomology, with applications to Topology

Vincent Gelinias

University of Toronto

This is part two of a talk on joint work with Benjamin Briggs. For augmented dg  $k$ -algebras  $A$  in char. 0, the characteristic homomorphism  $\mathrm{HH}^*(A, A) \rightarrow \mathrm{Ext}_A^*(k, k)$  provides an algebraic model for a geometrically defined map of algebras, first studied by Chas and Sullivan, between homologies of the free and based loop spaces  $H_{*+n}(\mathrm{LX}; k) \rightarrow H_*(\Omega X; k)$  of a simply-connected  $n$ -manifold  $X$ . Our purely algebraic result describes the image of this map as the  $A_\infty$ -centre of  $H_*(\Omega X; k)$ , with its  $A_\infty$ -algebra structure coming from loop concatenation on  $X$ . As corollaries, this recovers previous structural results due to Félix, Thomas and Vigué-Poirrier, which are extended to  $k$ -algebras.

Time willing, we will use this to characterize  $E_2$  degeneration of a multiplicative spectral sequence converging to  $\mathrm{HH}^*(A, A)$  for  $k$ -algebras.

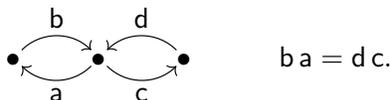
Monday

## Representation theory of the Gelfand quiver

Wassilij Gnedin

University of Stuttgart

At the ICM in 1970 Gelfand reduced the study of Harish-Chandra modules over the Lie group  $\mathrm{SL}(2, \mathbb{R})$  to the study of nilpotent representations over the quiver



Subsequently, the problem to classify the indecomposable representations of the Gelfand quiver attracted a lot of interest. Its completed path algebra  $\Lambda$  yields a paradigm of a *nodal order*, an infinite-dimensional analogue of a skew-gentle algebra.

By [BD04] the indecomposable objects in the derived category of any nodal order are given by *usual*, *special* and *bispecial strings*, and *bands*. These notions are defined in purely combinatorial terms.

In my talk, I will present the main results of my thesis [G16] and my joint work with Igor Burban (University of Cologne) on the Gelfand quiver:

- (1) A *homological characterization* of the four classes of strings and bands.
- (2) The computation of the *derived Auslander-Reiten translation* on strings and bands.
- (3) An explicit description of the *projective resolutions* of indecomposable  $\Lambda$ -modules, their contragredient duals and their main homological invariants (like Jordan-Hölder multiplicities, top and socle).

At the end, I will discuss generalizations of these results to nodal orders.

### References

- [BD04] I. Burban, Yu. Drozd, *Derived categories of nodal algebras*, J. Algebra (2004), no. 272: 46–94.  
 [G16] W. Gnedin, *Tame matrix problems in Lie theory and commutative algebra*, PhD thesis, University of Cologne (2016), 313 pages.

## The Nakayama automorphism for self-injective preprojective algebras

Monday

Joseph Grant

University of East Anglia

Given a finite graph we can define an algebra known as the preprojective algebra. This algebra was originally defined by Gelfand and Ponomarev using generators and relations, but Baer, Geigle, and Lenzing showed how to construct this algebra from the representation theory of a quiver obtained by choosing an orientation on the graph. I will revise this theory, illustrated explicitly using a small example. The preprojective algebra of a graph is finite-dimensional if and only if the graph is Dynkin, and it is known in this case that the preprojective algebra is self-injective. I will discuss this self-injectivity and a related symmetry known as the Nakayama automorphism, which was originally described by Brenner, Butler, and King. This construction generalizes to the higher preprojective algebras defined using Iyama’s higher dimensional Auslander-Reiten theory and studied by Iyama with Herschend and Oppermann. I will also discuss an open question in this theory.

## Thick subcategories and non-crossing partitions

Monday

Sira Gratz

University of Oxford

In joint work with Greg Stevenson we describe the lattice of thick subcategories in the bounded derived category of graded modules over the dual numbers. Despite the representation theory of the dual numbers being rather simple, classifying thick subcategories in this category proves to be combinatorially very interesting. In fact, they can be classified via non-crossing partitions of an infinity-gon, thus providing an example of an infinite version of the classification of thick subcategories in bounded derived categories of Dynkin quivers via non-crossing partitions by Ingalls and Thomas.

Thursday

## Brauer Configuration Algebras and Multiserial Algebras

Edward Green

Virginia Tech

In joint work with Sibylle Schroll (Univ. of Leicester), we introduce a generalization of Brauer graph algebras which we call Brauer configuration algebras. These will be defined in the talk. Brauer graph algebras are the symmetric special biserial algebras and are currently under active investigation. Defining an algebra  $KQ/I$  to be *special multiserial* if, for each arrow  $a$  in the quiver, there is at most one arrow  $b$  such that  $ab \notin I$  and at most one arrow  $c$  such that  $ca \notin I$ , we show that  $KQ/I$  is a symmetric multiserial algebra if and only if it is a Brauer configuration algebra.

An algebra is called *multiserial* if the Jacobson radical as a left and as a right module is a sum  $\sum_i U_i$  of uniserial modules  $U_i$  such that the intersection of any two is either (0) or a simple module. We will present a number of results, including the following

- (1) A special multiserial algebra is multiserial.
- (2) The trivial extension of an almost gentle algebra by its dual is a Brauer configuration algebra.
- (3) Every symmetric radical cubed zero algebra is a Brauer configuration algebra.
- (4) Every special multiserial algebra is the quotient of a Brauer configuration algebra.

We say a module  $M$  is *multiserial* if  $\text{rad}(M)$  is a sum  $\sum_i U_i$  of uniserial modules  $U_i$  such that the intersection of any two is either (0) or a simple module. Although special multiserial algebras are usually of wild representation type, we have the following surprising result which indicates that although wild, the representation theory is worth studying.

**Theorem** *If  $\Lambda$  is a special multiserial algebra and  $M$  is a finitely generated  $\Lambda$ -module, then  $M$  is a multiserial module.*

Tuesday

## Tame canonical algebras have decidable theory of modules

Lorna Gregory

The University of Manchester

A long standing conjecture of Mike Prest claims that a finite-dimensional algebra has decidable theory of modules if and only if it is of tame representation type. Up until recently, all known examples of finite-dimensional algebras with decidable theory of modules were of tame domestic representation type. In this talk, I will explain what it means for a theory of modules to be decidable and give some explanation of how to prove that all tame canonical algebras over algebraically closed fields have decidable theory of modules. Tame canonical algebras are tame non-domestic of linear growth.

## Periodicity of Cluster Tilting objects

Benedikte Grimeland

University College of Sogn og Fjordane

Let  $\mathcal{T}$  be a locally finite triangulated category with an autoequivalence  $F$  such that the orbit category  $\mathcal{T}/F$  is triangulated. We show that if  $\mathcal{X}$  is an  $m$ -cluster tilting subcategory, then the image of  $\mathcal{X}$  in  $\mathcal{T}/F$  is an  $m$ -cluster tilting subcategory if and only if  $\mathcal{X}$  is  $F$ -periodic.

We show that for path-algebras of Dynkin quivers  $\Delta$  one may study the periodic properties of  $n$ -cluster tilting objects in the  $n$ -cluster category  $\mathcal{C}_n(k\Delta)$  to obtain information on periodicity of the preimage as  $n$ -cluster tilting subcategories of  $\mathcal{D}^b(k\Delta)$ .

Finally we classify the periodic properties of all 2-cluster tilting objects  $T$  of Dynkin quivers, in terms of symmetric properties of the quivers of the corresponding cluster tilted algebras  $\text{End}_{\mathcal{C}_2}(T)^{op}$ . This gives a complete overview of all 2-cluster tilting objects of all orbit categories of Dynkin diagrams.

Monday

## A construction of dualizing categories by tensor products of categories

Yang Han

Chinese Academy of Sciences

Let  $k$  be a commutative artin ring. Dualizing  $k$ -categories or dualizing  $k$ -varieties were introduced by Auslander and Reiten as a generalization of artin  $k$ -algebras. A  $k$ -category  $\mathcal{A}$  being dualizing ensures that the category  $\text{mod}\mathcal{A}$  of finitely presented functors in  $\text{Mod}\mathcal{A}$  has almost split sequences. From a given dualizing  $k$ -category  $\mathcal{A}$ , there are some known constructions of dualizing  $k$ -categories such as  $\text{mod}\mathcal{A}$ , the functorially finite subcategories of  $\text{mod}\mathcal{A}$ , and the residue categories  $\mathcal{A}/(1_A)$  of  $\mathcal{A}$  modulo the ideal  $(1_A)$  of  $\mathcal{A}$  generated by the identity morphism  $1_A$  of an object  $A$  in  $\mathcal{A}$ . In this talk, we will introduce a construction of dualizing  $k$ -categories by tensor products of categories. Let  $Q$  be a locally finite quiver,  $kQ$  the  $k$ -category of paths of  $Q$ ,  $I$  an admissible ideal of  $kQ$  generated by a set of paths in  $Q$ ,  $\mathcal{B} := kQ/I$  the residue category of  $kQ$  modulo  $I$ , and  $\mathcal{A}$  a dualizing  $k$ -category. It is shown that, the idempotent completion  $|\oplus(\mathcal{B} \otimes_k \mathcal{A})$  of the additive hull  $\oplus(\mathcal{B} \otimes_k \mathcal{A})$  of the tensor product  $\mathcal{B} \otimes_k \mathcal{A}$  of the categories  $\mathcal{B}$  and  $\mathcal{A}$ , is a dualizing  $k$ -category. Furthermore,  $\text{mod}(\mathcal{B} \otimes_k \mathcal{A})$  is a dualizing  $k$ -category and has almost split sequences. As applications, all kinds of categories of complexes such as the category  $C_N^b(\text{mod}\mathcal{A})$  of bounded  $N$ -complexes over  $\text{mod}\mathcal{A}$  and the category  $C_{\mathbb{Z}_N}(\text{mod}\mathcal{A})$  of  $N$ -cyclic complexes over  $\text{mod}\mathcal{A}$  have almost split sequences. This is a joint work with Ningmei Zhang.

Wednesday

## Polygonal deformations and maximal green sequences in tame type

Stephen Hermes

Harvard University

Maximal green sequences are particular sequences of quiver mutations which have been gaining interest in recent years, due in part to their applicability to algebraic combinatorics, representation theory and theoretical physics. The “No Gap Conjecture” for maximal green sequences, formulated by Brüstle-Dupont-Pérotin, states that the set of lengths of maximal green sequences for an acyclic quiver forms an interval of integers. We give a proof of this Conjecture in tame type using the semi-invariant pictures of Igusa-Orr-Todorov-Weyman. This talk is based off of joint work with K. Igusa, and joint work with Th. Brüstle, K. I. and G. Todorov.

Tuesday

Monday

---

## Quasi hereditary algebras, tilting on surfaces, spherical modules, and matrix problems

Lutz Hille

WWU Münster

Any rational surface admits a tilting bundle (as shown in a joint work with Perling), the endomorphism algebra of such a tilting bundle is of global dimension two or three (Ballard, Favero) and might be chosen to be quasi-hereditary. In this talk we start to describe such algebras and study their properties from a representation theoretic point of view. This includes several applications.

- (1) In a joint work with Ploog we describe the derived category of an abelian category of global dimension two using matrix problems.
- (2) In a joint work with Buchweitz and Iyama we describe vector bundles on surfaces with a tilting bundle, whose endomorphism algebra is of global dimension two.
- (3) For some algebras appearing in this context, we classify all exceptional and all spherical modules.
- (4) We describe exact tilting, that is, we obtain equivalences, even of the underlying abelian categories. This allows to compare the classification in (3) with already existing results for algebraic surfaces.

The talk starts with the main result in (1), illustrated by a well understood example, the Auslander algebra of the truncated polynomial ring  $k[T]/T^n$ . Then we consider this 'local' problem in a global context using ideas from cluster algebras, as proposed in (2). In the next part, we motivate the relevance of spherical modules, they give rise to new and unexpected automorphisms of the derived category. In some examples we classify those modules and state some open conjectures for spherical complexes. In the last part, we relate the results to exact tilting, that induces equivalences between abelian categories.

---

Thursday

## Relations for Grothendieck groups of Gorenstein rings

Naoya Hiramatsu

National Institute of Technology, Kure College

Let  $(R, \mathfrak{m})$  be a commutative Cohen-Macaulay complete ring with the residue field  $k$ . We denote by  $\text{mod}(R)$  the category of finitely generated  $R$ -modules with  $R$ -homomorphisms and by  $\text{CM}(R)$  the full subcategory of  $\text{mod}(R)$  consisting of all Cohen-Macaulay  $R$ -modules.

Set  $G(\text{CM}(R)) = \bigoplus_{X \in \text{indCM}(R)} \mathbb{Z} \cdot [X]$ , which is a free abelian group generated by isomorphism classes of indecomposable objects in  $\text{CM}(R)$ . We denote by  $\text{EX}(\text{CM}(R))$  a subgroup of  $G(\text{CM}(R))$  generated by

$$\{[X] + [Z] - [Y] \mid \text{there is an exact sequence } 0 \rightarrow Z \rightarrow Y \rightarrow X \rightarrow 0 \text{ in } \text{CM}(R)\}.$$

We also denote by  $\text{AR}(\text{CM}(R))$  a subgroup of  $G(\text{CM}(R))$  generated by

$$\{[X] + [Z] - [Y] \mid \text{there is an AR sequence } 0 \rightarrow Z \rightarrow Y \rightarrow X \rightarrow 0 \text{ in } \text{CM}(R)\}.$$

Let  $K_0(\text{CM}(R))$  be a Grothendieck group of  $\text{CM}(R)$ . By the definition,  $K_0(\text{CM}(R)) = G(\text{CM}(R))/\text{EX}(\text{CM}(R))$ . Since  $K_0(\text{CM}(R)) = K_0(\text{mod}(R))$ , it is important to investigate  $K_0(\text{CM}(R))$  for the study of K-theory of  $\text{mod}(R)$ .

On the relation for Grothendieck groups, Butler[3], Auslander-Reiten[2], and Yoshino[5] prove the following theorem.

**Theorem 1.** [3, 1, 2, 5] *If  $R$  is of finite representation type then  $\text{EX}(\text{CM}(R)) = \text{AR}(\text{CM}(R))$ .*

Here we say that  $R$  is of finite representation type if there are only a finite number of isomorphism classes of indecomposable Cohen-Macaulay  $R$ -modules.

In this talk we consider the converse of Theorem 1. Actually we shall show the following theorem.

**Theorem 2.** [4] *Let  $R$  be a complete Gorenstein local ring with an isolated singularity and with algebraically closed residue field. If  $\text{EX}(\text{CM}(R)) = \text{AR}(\text{CM}(R))$ , then  $R$  is of finite representation type.*

Auslander conjectured the converse of Theorem 1 is true. It has been proved by Auslander[1] for Artin algebras and by Auslander-Reiten[2] for complete one dimensional domain. Our theorem gives an affirmative answer to his conjecture for the case of complete Gorenstein local rings with an isolated singularity.

### References

- [1] M. AUSLANDER, *Relations for Grothendieck groups of Artin algebras*. Proc. Amer. Math. Soc. **91** (1984), no. 3, 336–340.
- [2] M. AUSLANDER and I. REITEN, *Grothendieck groups of algebras and orders*. J. Pure Appl. Algebra **39** (1986), 1–51.
- [3] M. C. R. BUTLER, *Grothendieck groups and almost split sequences*, Lecture Notes in Math., vol. 822, Springer-Verlag, Berlin and New York, 1981.
- [4] N. HIRAMATSU, *Relations for Grothendieck groups of Gorenstein rings*, Proc. Amer. Math. Soc., to appear.
- [5] Y. YOSHINO, *Cohen-Macaulay Modules over Cohen-Macaulay Rings*, London Mathematical Society Lecture Note Series **146**. Cambridge University Press, Cambridge, 1990. viii+177 pp.

## $n$ -tilting classes over commutative rings

Monday

Michal Hrbek

Charles University

The tilting theory of a commutative ring is quite different from the classical setting of artin algebras. For example, any finitely generated ( $n$ -)tilting module is projective, and thus only the infinitely generated ones are of interest. The Finite type Theorem [Bazzoni-Herbera, Bazzoni-Šťovíček] says that, nevertheless, (large) tilting modules correspond to resolving subcategories of small modules of bounded projective dimension. Also, through the work of many authors, tilting theory of an arbitrary ring is tied closely to various notions of localization. Recently, tilting classes over a commutative noetherian ring were classified in terms of characteristic sequences of specialization closed subsets of the Zariski spectrum [Angeleri-Pospíšil-Šťovíček-Trlifaj '14]. We generalize this result to an arbitrary commutative ring  $R$ , by constructing a bijection between the equivalence classes of (large, finite projective dimension) tilting  $R$ -modules, and characteristic sequences of Thomason subsets of  $\text{Spec}(R)$ .

## Totally sign-skew-symmetric cluster algebras via unfolding method and applications to related topics

Monday

Min Huang

Zhejiang University

This talk is about unfolding theory for totally sign-skew-symmetric cluster algebras. We proved all acyclic totally sign-skew-symmetric cluster algebras admit unfolding. As applications, the positivity conjecture is proved for the acyclic case, the linear independence of cluster monomials is proved as well. As byproduct, we showed that all acyclic sign-skew-symmetric matrix is totally sign-skew-symmetric. This talk is a report on joint work with Professor Fang Li.

Tuesday

## Euler characteristics of quiver Grassmannians

Andrew Hubery

University of Bielefeld

We show how to define an Euler characteristic for the Grassmannian of submodules of a rigid module, for any finite-dimensional hereditary algebra over a finite field. Moreover, we prove that this number is positive whenever the Grassmannian is non-empty, generalising the known case for quiver Grassmannians. As an application, this proves that, for any symmetrisable acyclic cluster algebra, the Laurent expansion of a cluster variable always has non-negative coefficients.

Wednesday

## An approach to a categorification of infinite dimensional modules for $\mathfrak{sl}_2$

Mee Seong Im

United States Military Academy

Combining diagrammatic algebras by Khovanov and Licata-Savage, Chuang-Rouquier's categorification of finite-dimensional  $\mathfrak{sl}_2$ -representations, and Enright's decomposition of the tensor product of certain representations, we construct a categorification of Verma modules for  $\mathfrak{sl}_2$ . I will give key techniques of our construction. This is joint with B. Cox.

Wednesday

## A novel combinatorial construction of representations and open questions of Auslander, Reiten and Smalø

Miodrag Iovanov

University of Iowa

We introduce a new way of constructing uniserial representations, a method which extends to other types of representations as well. In doing this, we use the action of the path algebra  $K[Q]$  on the path coalgebra  $KQ$  of a quiver  $Q$ , and at the same time, the multiplication on  $KQ$  as a formal multiplication, leading to a combinatorial way of constructing representations. Specifically, we show how any uniserial module has a canonical basis (unique up to simultaneous multiplication by a scalar) and a corresponding "coefficient space" with respect to which the action is particularly easy to understand in terms of this combinatorial data.

As a first application, we obtain complete invariants for uniserial modules, which can be regarded as a generalized form of row reduction (and it is a linear algebra process); this answers Open Question 1 from the textbook of Auslander, Reiten, Smalø [ARS], solving the isomorphism problem for uniserials. As second application, we characterize and classify finite dimensional algebras of finite uniserial type (having only finitely many uniserial modules), which is Open Problem 2 of [ARS]. The characterization is entirely in terms of generators and relations, and gives an easy direct way to decide this. We also recover other known results of Birge Huisgen Zimmermann and Klaus Bongartz, and answer another open question they pose in their remarkable five paper series on uniserial modules in the late 1990's and the 2000's: namely, we characterize completely what commutative local algebras appear as endomorphism rings of uniserial modules, and show they are semigroup algebras of semigroups which have structures close to the so called MV-algebras from logic.

Finally, as another application, we find a representation theoretic characterization of monomial algebras, which answers Open Question 5 of [ARS]. This is also done in terms of the existence of a special set of uniserial modules for the algebra. Time permitting, we will show how this method can apply to more general situations (for example, distributive modules, and in turn, algebras with

finitely many ideals and finite representation type), how it can be used to solve other two open problems of the field stated in [ARS] (Open Questions 3 and 4 of [ARS]), and how it leads to linear algorithms for working with (uniserial) representations.

### Finiteness condition (Fg) for self-injective Koszul algebras

Tuesday

Ayako Itaba  
Shizuoka University

Let  $k$  be an algebraically closed field and  $A = \mathcal{A}^!(E, \sigma)$  a cogeometric self-injective Koszul  $k$ -algebra such that the complexity of  $k$  is finite. In this talk, we show the following results for a relationship between a cogeometric pair  $(E, \sigma)$  defined by I. Mori and the finiteness condition (Fg) defined by Erdmann et al.

- (1) If  $A$  satisfies (Fg), then the order of  $\sigma$  is finite.
- (2) Also, in the case of  $E = \mathbb{P}^{n-1}$ ,  $A$  satisfies (Fg) if and only if the order of  $\sigma$  is finite.
- (3) Moreover, if  $A$  satisfies  $(\text{rad } A)^4 = 0$ , then  $A$  satisfies (Fg) if and only if the order of  $\sigma$  is finite.

### The Hochschild (co)homology of a monomial algebra given by a cyclic quiver and two zero-relations

Tuesday

Tomohiro Itagaki  
Tokyo University of Science

Let  $K$  be an algebraically closed field,  $s \geq 3$  a positive integer,  $\Gamma_s$  a cyclic quiver with  $s$  vertices and  $s$  arrows, and  $I$  an admissible ideal of  $K\Gamma_s$ . The cardinal number of the minimal set of paths in the generating set of  $I$  is equal to  $s$  if and only if  $K\Gamma_s/I$  is a truncated cycle algebra, and the module structure of the Hochschild (co)homology of a truncated cycle algebra is determined. On the other hand, for an algebra  $K\Gamma_s/I$  with an ideal  $I$  generated by only one path, Xu and Wang investigated its (co)Hochschild homology. In this talk, we determine the module structure of the Hochschild (co)homology of  $K\Gamma_s/I$ , where  $I$  is an ideal generated by two paths.

### Finiteness of global dimension of endomorphism algebras

Monday

Osamu Iyama  
Nagoya University

In representation theory, it is basic to study modules whose endomorphism algebras have finite global dimension. They appear naturally in many situations, e.g. Auslander correspondence and representation dimension, Dlab-Ringels approach to quasi-hereditary algebras of Cline-Parshall-Scott, Rouquier's dimensions of triangulated categories, and cluster tilting in higher dimensional Auslander-Reiten theory. Recently such modules are called non-commutative resolutions, and studied in commutative ring theory and algebraic geometry after Van den Berghs work in birational geometry. In this talk, I will show some of typical examples of non-commutative resolutions, including rings with Krull-dimension at most one, certain hypersurface singularities and Stanley-Reisner rings. Part of this talk is a joint project with H. Dao, S. Iyengar, R. Takahashi, M. Wemyss and Y. Yoshino in American Institute of Mathematics.

Tuesday

## Local Serre duality for modular representations of finite group schemes

Srikanth Iyengar

University of Utah

This talk will be about the representations of a finite group (or a finite group scheme)  $G$  defined over a field  $k$  of positive characteristic. My plan is to explain the statement and proof of a recent result (obtained in collaboration with Dave Benson, Henning Krause, and Julia Pevtsova) to the effect that the stable module category of finite dimensional representations of  $G$  has local Serre duality.

Monday

## Modules of finite projective dimension over a cluster-tilted algebra

Karin M Jacobsen

NTNU

We study the category  $\text{Pl}$  of modules of finite projective dimension over a gentle cluster-tilted algebra. This category is known to have AR-structure, by a result of Auslander and Smalø. Beaudet, Brüstle and Todorov gave a nice description of the modules of (in)finite projective dimension. We give a conjecture on the proper translation of this theorem to the marked surface representations of cluster categories.

For Dynkin type A, we show that the conjecture holds. We use it to give the number of irreducible modules in  $\text{Pl}$  and calculate the AR-translation.

Monday

## Reduction theorem for $\tau$ -rigid modules

Geoffrey Janssens

Vrije Universiteit Brussel

This is based on joint work with Florian Eisele and Theo Raedschelders [2].

Adachi, Iyama and Reiten introduced in [1] the theory of support  $\tau$ -tilting modules. In this talk we will be concerned with the problem of determining all support  $\tau$ -tilting modules (or equivalently all basic two-term silting complexes) for various finite dimensional algebras  $A$  over an algebraically closed field. To this end, I will discuss a reduction theorem that gives a bijection between the support  $\tau$ -tilting modules over a given finite-dimensional algebra  $A$  and the support  $\tau$ -tilting modules over  $A/I$ , where  $I$  is an ideal generated by central elements and contained in the Jacobson radical of  $A$ .

Also various instances of this result for blocks of group algebras and special biserial algebras will be presented. Among others we will explain that algebras of dihedral, semidihedral or quaternion type, which include all tame blocks of group algebras, are  $\tau$ -tilting finite. Also the facts that their  $g$ -vectors and Hasse quivers only depend on the Ext-quiver of their basic algebras and that further all tilting complexes can be obtained from  $A$  (as a module over itself) by iterated tilting mutation will be explained.

### References

- [1] T. Adachi, O. Iyama and I. Reiten  $\tau$ -tilting theory, *Compos. Math.* 150 (2014), no. 3, 415-452.  
 [2] F. Eisele, G. Janssens and T. Raedschelders, A reduction theorem for  $\tau$ -rigid modules, arXiv:1603.04293.

## Totally acyclic approximations

Tuesday

David Jorgensen

University of Texas at Arlington

Let  $R$  be a commutative local ring. We study the subcategory of the homotopy category of  $R$ -complexes consisting of the totally acyclic  $R$ -complexes. In particular, in the context where  $Q$  is Gorenstein and  $Q \rightarrow R$  is a surjective local ring homomorphism such that  $R$  has finite projective dimension over  $Q$ , we define an adjoint pair of triangle functors between the homotopy category of totally acyclic  $R$ -complexes and that of  $Q$ -complexes, which are analogous to the classical adjoint pair between the module categories of  $R$  and  $Q$ . We give detailed proofs of the adjunction in terms of the unit and counit. As a consequence, one obtains a precise notion of approximations of totally acyclic  $R$ -complexes by totally acyclic  $Q$ -complexes. This is based on joint work with Petter Bergh and Frank Moore.

## On modules of infinite reduced grade

Thursday

Noritsugu Kameyama

Salesian Polytechnic

This talk is based on joint work with Mitsuo Hoshino (University of Tsukuba) and Hirotaka Koga (Tokyo Denki University) [2].

Let  $R$  be a right Noetherian ring and  $A$  a certain kind of extension ring of  $R$ , which is finitely generated as a right  $R$ -module and hence right Noetherian. Our aim is to provide a sufficient condition for  $A$  to inherit certain kind of homological properties of  $R$ . Especially, we will show that if the generalized Nakayama conjecture is true for  $R$  then so is for  $A$ .

### References

- [1] M. Auslander and I. Reiten, On a generalized version of the Nakayama conjecture, Proc. Am. Math. Soc. **52**(1975), 69-74.
- [2] M. Hoshino, N. Kameyama and H. Koga, On modules of infinite reduced grade, in preparation.
- [3] M. Hoshino and H. Koga, Zaks' lemma for coherent rings, Algebras and Representation Theory **16** (2013), 1647–1660.

## Atom-molecule correspondence in Grothendieck categories

Thursday

Ryo Kanda

Osaka University

For a one-sided noetherian ring, Gabriel constructed two maps between the isomorphism classes of indecomposable injective modules and the two-sided prime ideals. We generalize these maps as maps between two spectra, the atom spectrum and the molecule spectrum, of a noetherian Grothendieck category with exact direct products. This generalization provides a categorical way to understand the construction of Gabriel's maps, and it is shown that the two maps induce a bijection between the minimal elements of the atom spectrum and those of the molecule spectrum. This theory gives an interpretation between one-sided notions and two-sided notions on noetherian rings, and has some applications to classical results such as Goldie's theorem on the existence of total quotient rings.

Monday

## Modules of small complexity over exterior algebras

Otto Kerner

Mathematisches Institut HHU Duesseldorf

*From a joint project with Dan Zacharia.*

Let  $R = \bigwedge V$  be the exterior algebra of an  $n + 1$  dimensional vector space. Giving the nonzero elements of  $V$  degree one, the algebra  $R$  becomes a graded algebra.  $\text{mod } R$  denotes the  $\mathbb{Z}$ -graded category of finite dimensional  $R$ -modules and degree 0 homomorphisms.

By a result of Eisenbud, any indecomposable  $R$ -module  $M$  of complexity one has a filtration by a single cyclic and linear module  $M_\xi = R/\langle \xi \rangle$  of complexity one for some  $0 \neq \xi \in V$ , and its degree shifts  $M_\xi(i)$ .

This can be used to describe abelian subcategories of  $\text{mod } R$  of linear modules of complexity one, and moreover the thick subcategories  $\mathcal{T}(M_\xi)$  of  $\underline{\text{mod}} R$  generated by  $M_\xi$ . It turns out that  $\mathcal{T}(M_\xi)$  has no proper thick subcategory generated by a nonzero linear module. If  $n = 2$  it has no proper thick subcategory at all.

Monday

## Tilting objects for preprojective algebras associated with Coxeter groups

Yuta Kimura

Nagoya University

Let  $Q$  be a finite acyclic quiver and  $W$  be the Coxeter group of  $Q$ . For each  $w \in W$ , Buan-Iyama-Reiten-Scott introduced an Iwanaga-Gorenstein algebra  $\Pi(w)$  and showed that the stable category of Gorenstein projective  $\Pi(w)$ -modules has cluster tilting objects. In this talk, we study the stable category of graded Gorenstein projective  $\Pi(w)$ -modules. We show that, for each reduced expression of  $w$ , the category has a silting object and give a sufficient condition on a reduced expression of  $w$  such that the silting object becomes a tilting object. Moreover, we study a relationship between triangle equivalences obtained by a tilting object and that shown by Amiot-Reiten-Todorov.

Tuesday

## $K$ -polynomials of type $A$ quiver orbit closures and lacing diagrams

Ryan Kinser

University of Iowa

Orbit closures of type  $A$  quiver representations are algebraic varieties that arise naturally in several areas of math: for example, in Lusztig's geometric realization of Ringel's work on quantum groups; as generalizations of determinantal varieties in commutative algebra; and in the theory of degeneracy loci of maps of vector bundles.

For equioriented type  $A$  quivers, a formula due to Knutson-Miller-Shimozono expresses the equivariant cohomology class of each orbit closure as a sum, over certain "lacing diagrams", of products of Schubert polynomials. Lacing diagrams were introduced by Abeasis and del Fra in 1982 to visualize direct sum decompositions of type  $A$  quiver representations.

In joint work with Allen Knutson and Jenna Rajchgot (arXiv:1503.05880), we proved a 2004 conjecture of Buch and Rimnyy that generalizes this formula in two ways: to arbitrarily oriented type  $A$  quivers, and to equivariant  $K$ -classes (a.k.a.  $K$ -polynomials), from which equivariant cohomology can be recovered.

The aim of this talk is to explain the combinatorics of ( $K$ -theoretic) lacing diagrams and carefully state the formula. Time permitting, I will give some idea of the Grobner degeneration technique used in the proof.

---

## Cyclic embeddings - geometry and combinatorics

Wednesday

Justyna Kosakowska

Nicolaus Copernicus University

Let  $A, B$  be finite length modules over a discrete valuation ring  $\Lambda$ . We study embeddings ( $A \subseteq B$ ) that are direct sums of cyclic embeddings (i.e.  $A$  is a cyclic  $\Lambda$ -module). One of the motivations are results given in Kaplansky's 1951 book where a combinatorial characterization of the isomorphism types of embeddings of a cyclic subgroup in a finite abelian group is given. We use combinatorial properties of Littlewood-Richardson tableaux to generalize this result to finite direct sums of such embeddings. As an application to invariant subspaces of nilpotent linear operators, we develop a criterion to decide if two irreducible components in the representation space are in the boundary partial order. This is a joint work with Markus Schmidmeier from Florida Atlantic University.

---

## Auslander-Reiten duality revisited

Tuesday

Henning Krause

Bielefeld University

The cornerstones of Auslander-Reiten duality are two formulas that relate for any module category the functors  $\text{Ext}$  and  $\text{Hom}$ . In my talk I'll explain how these formulas generalise to any Grothendieck abelian category having a sufficient supply of finitely presented objects. This general point of view provides a new interpretation of the dual of the transpose for a finitely presented module. Also, the connection with Serre duality for algebraic varieties is discussed.

---

## Quivers from Double Bruhat Cells of Kac-Moody Algebras

Thursday

Maitreyee Kulkarni

Louisiana State University

In this talk, I will describe Berenstein-Fomin-Zelevinsky cluster structures on Schubert cells of symmetrizable Kac-Moody algebras. Geiss-Leclerc-Schröer found an additive categorification of these cluster algebras via Frobenius categories constructed from representations of preprojective algebras. The talk will introduce the construction of quivers by building cylinders over Dynkin graphs, orientability of its faces, and the construction of nondegenerate potentials for categorification of these algebras with frozen variables via brane tilings.

---

Friday

## Higher Nakayama algebras

Julian Külshammer

University of Stuttgart

Nakayama algebras are among the best understood representation-finite algebras. They are defined as those algebras such that each indecomposable projective and each indecomposable injective module admits a unique composition series. An equivalent characterisation is that  $\tau^j S$  is simple (or zero) for all  $j \in \mathbb{Z}$  and every simple module  $S$ . Here,  $\tau$  denotes the Auslander–Reiten translation. Nakayama algebras can be classified by the sequence of lengths of their indecomposable projective modules, called the Kupisch series.

In this talk, we introduce a higher analogue of a Nakayama algebra for each Kupisch series  $\underline{\ell}$  in the sense of Iyama’s higher Auslander–Reiten theory. More precisely, (in type  $A$ ) the higher Nakayama algebra  $A_{\underline{\ell}}^{(d)}$  is a quotient of the higher Auslander algebra  $A_n^{(d)}$  of type  $A$ , constructed by Iyama and studied extensively by Oppermann and Thomas. In type  $\tilde{A}$ , one has to use an infinite version of  $A_n^{(d)}$ . The higher Nakayama algebra has a  $d$ -cluster-tilting module, i.e. a module  $M$  with

$$\begin{aligned} \text{add}(M) &= \{N \mid \text{Ext}^i(M, N) = 0 \forall i = 1, \dots, d-1\} \\ &= \{N \mid \text{Ext}^i(N, M) = 0 \forall i = 1, \dots, d-1\}. \end{aligned}$$

There are  $n$  simple modules in  $\text{add}(M)$  and they satisfy that  $\tau_d^j S$  is simple for all  $j \in \mathbb{Z}$  and every simple module  $S$  in  $\text{add}(M)$ , where  $\tau_d = \tau \Omega^{d-1}$  is Iyama’s higher Auslander–Reiten translation. This is joint work with Gustavo Jasso.

Thursday

## Gorenstein projective objects in functor categories via comonads and adjoint triples

Sondre Kvamme

Universität Bonn

Using comonads we generalize the monomorphism category of Ringel–Schmidmeier and Zhang to any functor category  $\text{Fun}_k(C, A)$ , where  $k$  is an arbitrary commutative ring,  $C$  is a small,  $k$ -linear, locally bounded, and hom-finite category, and  $A$  is any abelian category. Under some mild conditions on  $C$  we use this generalization to give a simpler description of the Gorenstein projective objects in  $\text{Fun}_k(C, A)$  when  $A$  has enough projectives.

Monday

## Indecomposable objects in the homotopy category of a derived-discrete algebra

Rosanna Laking

The University of Manchester

In this talk I will present joint work with K. Arnesen, D. Pauksztello and M. Prest. We classify the indecomposable pure-injective complexes in the homotopy category of projective modules  $\text{K}(\text{Proj} \Lambda)$  over a derived-discrete algebra  $\Lambda$ . The set of indecomposable pure-injective complexes are the points of a topological space known as the Ziegler spectrum. We give a complete description of the Ziegler topology and, making use of the interactions between this space and categories of functors, we prove that every indecomposable object in  $\text{K}(\text{Proj} \Lambda)$  is pure-injective.

## Maximum antichains in subrepresentation posets

Thursday

Philipp Lampe  
Bielefeld University

Let  $V$  be a representation of a Dynkin quiver with values in vector spaces or pointed sets. In this talk, we wish to discuss maximum antichains in the poset  $\text{Sub}(V)$  of subrepresentations of  $V$ . Firstly, we consider a representation  $V$  of a linearly oriented quiver of type  $A$  with values in pointed sets. A ranked partially ordered set is called (strongly) Sperner if one (every) maximum antichain contains only elements of the same rank. We give conditions for  $\text{Sub}(V)$  to be Sperner. Secondly, we study maximum antichains in subrepresentation posets of indecomposable representations of Dynkin quivers with values in vector spaces. This is work in progress, partially joint with Florian Gellert.

## Cluster algebras and representations of Borel subalgebras of quantum loop algebras

Friday

Bernard Leclerc  
Université de Caen

In 2012, Hernandez and Jimbo introduced a new tensor category of representations of a Borel subalgebra of a quantum loop algebra, and classified its simple objects. This category contains the finite-dimensional representations of the quantum loop algebra, together with some new infinite dimensional representations. The motivation of Hernandez and Jimbo came from mathematical physics, in particular from papers of Bazhanov et al. where some examples of these new representations were used to define analogs of Baxter's  $Q$ -operators in conformal field theory. Recently, using this new category, Frenkel and Hernandez were able to prove a long-standing conjecture of Frenkel and Reshetikhin on the spectra of the transfer matrices of some quantum integrable systems associated with quantum loop algebras. In this talk, I will explain that the new category of Hernandez and Jimbo fits very well with cluster algebras. More precisely I will show that cluster structures occur naturally in its Grothendieck ring, and can be helpful in finding new interesting functional relations. This is a joint work with David Hernandez.

## Positivity for cluster algebras

Tuesday

Kyungyong Lee  
University of Nebraska-Lincoln

Cluster algebras were first introduced by Fomin and Zelevinsky to design an algebraic framework for understanding total positivity and canonical bases for quantum groups. A cluster algebra is a subring of a rational function field generated by a distinguished set of Laurent polynomials called cluster variables. The Positivity Conjecture, which is now a theorem, asserts that the coefficients in any cluster variable are positive. One proof was given by Schiffler and the speaker, and another proof was obtained by Gross, Hacking, Keel and Kontsevich. We outline the idea of our proof.

Monday

**Affine flag varieties and quantum symmetric pairs**

Yiqiang Li

SUNY Buffalo

The quantum groups of finite and affine type A admit geometric realizations via partial flag varieties of type A. Recently, the quantum group behind partial flag varieties of type B/C is shown to be a coideal subalgebra of the quantum group of type A. In this talk, I'll report recent progress on the structures of Schur algebras and Lusztig algebras associated with affine partial flag varieties of type A and C. This is a joint work with Z. Fan, C. Lai, L. Luo and W. Wang.

---

Tuesday

**Trace ideals and the centers of endomorphism rings**

Haydee Lindo

University of Utah and Williams College

The goal of this talk will be to present some new results relating the center of the endomorphism ring of a module  $M$ , over a commutative noetherian ring, to the endomorphism ring of the trace ideal of  $M$ . These results have been presented in arXiv:1603.08576.

---

Monday

**Loop algebra filtrations associated to meromorphic connections**

Neal Livesay

Louisiana State University

Meromorphic  $G$ -bundles have been studied extensively due to their relationship with the geometric Langland's correspondence. In a recent series of papers, C. Bremer and D. Sage use a systematic analysis of filtrations of the general linear loop algebra to demonstrate explicit normal forms for  $GL$ -bundles with "toral" singularities, and construct well-behaved moduli spaces. We will discuss current work on generalizing this theory for  $Sp$ -bundles, and illustrate the theory for some small rank examples.

---

Tuesday

**Filtrations in abelian categories determined by a tilting object**

Dag Oskar Madsen

Nord University

A tilting object of projective dimension one in an abelian category determines a torsion pair and consequently every object has a two-step filtration. In this talk we will discuss a generalization to the case when the tilting object has arbitrary finite projective dimension. In particular we will show that if the projective dimension is two, there is a unique way to define extension-closed subcategories such that every object has a three-step filtration with the right properties. This is joint work with Bernt Tore Jensen and Xuiping Su.

---

## Polynomial degree bounds for matrix semi-invariants

Monday

Viswambhara Makam  
University of Michigan

We study the left-right action of  $SL_n \times SL_n$  on  $m$ -tuples of  $n \times n$  matrices with entries in an infinite field. We show that invariants of degree  $n^2 - n$  define the null cone. Consequently, invariants of degree  $\leq n^6$  generate the ring of invariants in char 0. We generalize our results to rings of semi-invariants for quivers.

For the proofs, we use new techniques such as the regularity lemma by Ivanyos, Qiao and Subrahmanyam, and the concavity property of the tensor blow-ups of matrix spaces.

Our bounds have several applications to algebraic complexity theory, such as a deterministic polynomial time algorithm for non-commutative rational identity testing, and the existence of small division-free formulas for non-commutative polynomials.

This is joint work with Harm Derksen.

## Invariant of Group Actions by automorphism of a free category

Thursday

Eduardo Marcos  
Universidade de São Paulo

This is a joint work with Claude Cibils. We show that the invariant ring of an action of a free  $k$ -category is also a free category. We also show that if the category is finitely of finite type or finitely of tame type. The same holds for the invariant category.

## Linkage principle for supergroups in positive characteristics

Monday

Frantisek Marko  
Penn State Hazleton

We report on results related to the linkage principle for supergroups in positive characteristic  $p \neq 2$  using a modification of the approach of Doty. We describe the linkage principle for the general linear supergroups and investigate the linkage for orthosymplectic supergroups. In the case when the characteristic is zero, the linkage is determined by odd isotropic roots only. However, in the case of positive characteristic, non-isotropic roots also play a role. We demonstrate this on the supergroup  $G = SpO(2|1)$ . If char  $K = 0$ , then the category of  $G$ -supermodules is semi-simple (because the root system of  $SpO(2|1)$  has no (odd) isotropic root). If char  $K = p > 2$ , then this category is no longer semi-simple.

This is a joint work with Alexandr N. Zubkov.

Tuesday

## The asymptotic stabilization and the Auslander-Reiten formula

Alex Martsinkovsky  
Northeastern University

A popular approach to Auslander-Reiten theory is based on the Auslander-Reiten formula. In an effort to extend the theory from categories of modules to other categories, it is natural to ask whether an Auslander-Reiten formula should be constructed first. While such a formula would undoubtedly depend on the type of the underlying category, if it can be constructed first, then it should also give an indication as to what type of categories are involved. In this lecture, I will follow this philosophy by subjecting the original Auslander-Reiten formula to a process of stabilization. This should be viewed as a first step toward a “stable” Auslander-Reiten theory. The notion of stabilization will be illustrated on the functors Hom and tensor product. Parts of this talk are based on unpublished joint work with Idun Reiten and more recent joint work with Jeremy Russell.

Monday

## Derived geometric Satake equivalence, Springer correspondence, and small representations

Jacob Matherne  
Louisiana State University

Two major theorems in geometric representation theory are the geometric Satake equivalence and the Springer correspondence, which state: 1. For  $G$  a semisimple algebraic group, we can realize  $\text{Rep}(G)$  as intersection cohomology of the affine Grassmannian for the Langlands dual group. 2. For  $W$  a Weyl group, we can realize  $\text{Rep}(W)$  as intersection cohomology of the nilpotent cone. In the late 90s, M. Reeder computed the Weyl group action on the zero weight space of the irreducible representations of  $G$ , thereby relating  $\text{Rep}(G)$  to  $\text{Rep}(W)$ . More recently, P. Achar, A. Henderson, and S. Riche have established a functorial relationship between the two phenomena above. In my talk, I will discuss my thesis work which extends their functorial relationship to the setting of mixed, derived categories.

Tuesday

## Classifying dense subcategories of exact categories via Grothendieck groups

Hiroki Matsui  
Nagoya University

Classification problems of subcategories have been deeply considered so far, e.g., Serre subcategories of module categories by Gabriel, thick subcategories of perfect complexes by Hopkins-Neeman. They classified such subcategories via the spectra of noetherian commutative rings. On the other hand, Thomason classified dense triangulated subcategories of triangulated categories via their Grothendieck groups. In this talk, we discuss classifying dense resolving subcategories of exact categories via their Grothendieck groups.

## Nilpotent operators of vector spaces with invariant subspaces

Hagen Meltzer

Szczecin University

This is a report on joint work with Piotr Dowbor and Markus Schmidmeier. Let  $S(n)$  be the category of finite dimensional vector spaces equipped with a nilpotent operator of nilpotence degree  $n$  and an invariant subspace. For  $n = 6$  this category is known to be of tubular type. We study exceptional objects in this situation. In particular we calculate their dimension vectors and show that they can be exhibited by matrices having a coefficients 0 and 1.

Tuesday

## Universal deformation rings and groups with faithful irreducible complex representations

David Meyer

University of Missouri

Universal deformation rings convey information about the characteristic 0 representations associated to characteristic  $p$  representations of an algebra. Let  $\Gamma$  be a finite group, and let  $V$  be an absolutely irreducible  $\mathbb{F}_p\Gamma$ -module. We consider the function which assigns to  $V$  its universal deformation ring  $R(\Gamma, V)$ . We show that when this function is nonconstant, we can use its graph to determine information about the internal structure of the group  $\Gamma$ . Specifically, we connect the fusion of certain subgroups  $N$  of  $\Gamma$ , to the kernels of those representations whose corresponding modules are a level set of the function  $V \rightarrow R(\Gamma, V)$ . We consider groups  $\Gamma$  which are extensions of finite irreducible subgroups of  $GL_2(\mathbb{C})$  by elementary abelian  $p$ -groups of rank 2.

Tuesday

## Tilting bundles on (Anti-)Fano algebras

Hiroyuki Minamoto

Osaka Prefecture University

This talk is based on a joint work with Osamu Iyama. We will introduce and discuss tilting bundles on Fano algebras. An algebra which is derived equivalent to a Fano algebra is not necessarily Fano. So we would like to know that under what kind of derived equivalence Fano-ness is preserved. One answer is that of induced by tilting bundles. More precisely, we show that the endomorphism algebra of a tilting bundle on a Fano algebra is always Fano. Herschend-Iyama-Oppermann showed that  $n$ -APR tilting preserves  $n$ -representation infiniteness. Recently, Mizuno-Yamaura generalize this result. They showed that for  $0 < m < n + 1$ ,  $m$ -APR tilting preserves  $n$ -representation infiniteness. In case of  $n$ -APR tilting modules, it is easy to see that the noncommutative projective scheme of the  $n + 1$  preprojective algebra is preserved under derived equivalence induced by  $n$ -APR tilting module. It was not verified that  $m$ -APR tilting preserves the noncommutative projective scheme for  $0 < m < n$ . Since  $m$ -APR tilting module is an example of a tilting bundle. One of our aim to study tilting bundles on Fano algebras was to solve this problem. We can prove that the derived equivalence induced by a tilting bundle on a Fano algebra preserves the noncommutative projective scheme. We see by example that derived equivalence tilting module which is not tilting bundle does not necessarily preserve Fano-ness. A celebrated result by Bondal-Orlov states that (anti-)Fano variety determined by its derived category. Our example shows that Bondal-Orlov theorem does not true for non-commutative projective schemes.

Tuesday

Monday

## Tilting complexes of preprojective algebras of Dynkin type

Yuya Mizuno

Nagoya University

It is well-known that tilting complexes are essential objects to understand derived equivalence classes of algebras by Rickard's result. In this talk, we discuss tilting complexes of preprojective algebras of Dynkin type. We classify them by giving a bijection with elements of the braid group of the corresponding folded graph. This is based on joint work with Aihara.

---

Tuesday

## Derived equivalences induced by silting complexes

George Ciprian Modoi

Babes-Bolyai University

Let  $T$  be a module over a ring  $A$ , and let  $B$  be its endomorphism ring. Recall that if  $T$  is a classical tilting module then the derived categories over  $A$  and  $B$  are equivalent, by a celebrated result of Rickard. Generalizing this, Bazzoni, Mantese and Tonolo (Proc. Amer. Math. Soc. 139 (2011), 4225-4234) showed that if  $T$  is a "good" tilting module, there is an equivalence between the derived category over  $A$  and a subcategory of the derived category over  $B$ . We report some recent progresses concerning a further generalization of this equivalence, where the tilting module is replaced by a silting complex.

---

Monday

## Combinatorics of Gentle Algebras

Kaveh Mousavand

Université du Québec à Montréal (UQAM)

String algebras and gentle algebras are known to feature rich combinatorics. For instance, the celebrated work of M. Butler and C. M. Ringel describes the behavior of Auslander-Reiten translation on the module category of these algebras. Moreover, in the work of W. Crawley-Boevey and J. Schröer, a set of basis elements of  $\text{Hom}_\Lambda(X, Y)$  for a pair of strings  $X$  and  $Y$  over the string algebra  $\Lambda$  is given in terms of a combinatorial description.

In this talk, starting from an arbitrary gentle algebra  $\Lambda$ , by means of moving to an associated gentle algebra in a canonical way, we introduce a method for computing a basis of  $\text{Hom}_\Lambda(X, \tau_\Lambda Y)$ , for a pair of strings  $X$  and  $Y$ . Moreover, by characterizing which of the basis elements of  $\text{Hom}_\Lambda(X, \tau_\Lambda Y)$  factor through injectives, we derive a combinatorial description for  $\text{Ext}_\Lambda^1(Y, X)$ .

As a byproduct of our approach, if time permits, we also show that the Grid-Tamari poset, introduced by Thomas McConville as a certain generalization of the Tamari lattices, can be realized as the poset of torsion classes of a certain class of representation-finite gentle algebras, for which it is clear that the poset of torsion classes forms a lattice. This gives a conceptual explanation for McConville's result.

This talk is a report on the ongoing collective work of LaCIM Representation Working Group.

---

## Principle of local duality and generalization of Grothendieck's vanishing theorem

Thursday

Tsutomu Nakamura  
Okayama University

This talk is based on a joint work with Prof. Yuji Yoshino. Let  $R$  be a commutative noetherian ring. For the unbounded derived category  $D(R)$ , it is known that there exists a canonical bijection between the set of subsets  $W$  of  $\text{Spec } R$  and the set of localizing subcategories  $L_W$  of  $D(R)$ . Moreover, by a classical argument of the localization theory of triangulated categories, there exists a right adjoint functor to the inclusion functor from  $L_W$  to  $D(R)$ , which we call the local cohomology functor  $\gamma_W$ . If  $W$  is a specialization-closed subset of  $\text{Spec } R$ , then  $\gamma_W$  coincides with the ordinary local cohomology functor  $\text{R}\Gamma_W$ . In this talk, I will propose a general principle behind the local duality, and report that Grothendieck's vanishing theorem holds for any subset  $W$  of  $\text{Spec } R$  provided that  $R$  admits a dualizing complex.

## Mutation via Hovey twin cotorsion pairs and model structures in extriangulated categories

Thursday

Hiroyuki Nakaoka  
Kagoshima University

We give a simultaneous generalization of exact categories and triangulated categories, which is suitable for considering cotorsion pairs, and which we call extriangulated categories. Extension-closed, full subcategories of triangulated categories are examples of extriangulated categories. We give a bijective correspondence between some pairs of cotorsion pairs which we call Hovey twin cotorsion pairs, and admissible model structures. As a consequence, these model structures relate certain localizations with certain ideal quotients, via the homotopy category which can be given a triangulated structure. This gives a natural framework to formulate reduction and mutation of cotorsion pairs, applicable to both exact categories and triangulated categories. These results can be thought of as arguments towards the view that extriangulated categories are a convenient setup for writing down proofs which apply to both exact categories and (extension-closed subcategories of) triangulated categories. This is a joint work with Yann Palu.

## Non-commutative Discriminant and Connections to Poisson Geometry

Monday

Bach Nguyen  
Louisiana State University

In this talk, we will present a general method for computing discriminant of non-commutative algebras via Poisson primes. It will be illustrated with the specializations of the algebras of quantum matrices at roots of unity. If time permits, we'll also discuss a more general case, the quantum Schubert cell algebras. This is a joint work with Kurt Trampel and Milen Yakimov.

Monday

## On the Gerstenhaber structure of twisted tensor products

Van Nguyen

Northeastern University

The Hochschild cohomology of an associative algebra over a field  $k$  has a cup product and a bracket product which satisfy some compatibility conditions, making it a Gerstenhaber algebra. Let  $R$  and  $S$  be associative graded  $k$ -algebras and consider their twisted tensor product  $R \otimes_k^t S$ . In this talk, we investigate the Gerstenhaber structure of the Hochschild cohomology ring,  $HH^*(R \otimes_k^t S)$ , of this twisted tensor product. This study allows us to compute the Gerstenhaber brackets for some quantum complete intersections. Moreover, given  $R$  or  $S$  is finite dimensional, we are able to break down the Gerstenhaber algebra structure of a particular subalgebra of  $HH^*(R \otimes_k^t S)$ . This is a joint work with L. Grimley and S. Witherspoon.

Thursday

## Auslander-Reiten Theory in Triangulated Categories

Hongwei Niu

Université de Sherbrooke

In this talk, we will discuss the existence of Auslander-Reiten triangles in triangulated categories. Let  $\mathcal{A}$  be a triangulated category and let  $\mathcal{C}$  be an extension-closed subcategory of  $\mathcal{A}$ . First, we give some new characterizations of an Auslander-Reiten triangle in  $\mathcal{C}$ , which yields some necessary and sufficient conditions for  $\mathcal{C}$  to have Auslander-Reiten triangles. Next, we study when an Auslander-Reiten triangle in  $\mathcal{A}$  induces an Auslander-Reiten triangle in  $\mathcal{C}$ . As an application, we study Auslander-Reiten triangles in a triangulated category with a  $t$ -structure. In case the  $t$ -structure has a  $t$ -hereditary heart, we establish the connection between the Auslander-Reiten triangles in  $\mathcal{A}$  and the Auslander-Reiten sequences in the heart. Finally, we specialize to the bounded derived category of all modules of a noetherian algebra over a complete local noetherian commutative ring. Our result generalizes the corresponding result of Happel's in the bounded derived category of finite dimensional modules of a finite dimensional algebra over an algebraically closed field.

Tuesday

## Auslander's formula via recollements

Yasuaki Ogawa

Nagoya University

Fix a commutative field  $k$ . A Krull-Schmidt Hom-finite  $k$ -linear category  $\mathcal{A}$  is said to be a dualizing  $k$ -variety if the standard  $k$ -duality  $D := \text{Hom}_k(-, k)$  induces the duality  $D : \text{mod}\mathcal{A} \rightarrow \text{mod}\mathcal{A}^{\text{op}}$ , where  $\text{mod}\mathcal{A}$  stands for the category of finitely presented contravariant functors from  $\mathcal{A}$  to the category of all  $k$ -modules. Our main result is as follows:

**Theorem.** Let  $(\mathcal{A}, \mathcal{B})$  be the pair of a dualizing  $k$ -variety  $\mathcal{A}$  and its functorially finite subcategory  $\mathcal{B}$ . Then there exists the following recollement

$$\text{mod}(\mathcal{A}/[\mathcal{B}]) \rightleftarrows \text{mod}\mathcal{A} \rightleftarrows \text{mod}\mathcal{B},$$

where  $\mathcal{A}/[\mathcal{B}]$  the ideal quotient category of  $\mathcal{A}$  with respect to the collection of morphisms in  $\mathcal{A}$  that factor through some objects in  $\mathcal{B}$ .

A typical example of dualizing  $k$ -varieties is the category  $\text{mod}R$  of finite dimensional modules over a finite dimensional  $k$ -algebra  $R$ . Applying our theorem to the pair  $(\text{mod}R, \text{proj}R)$  yields the equivalence

$$\frac{\text{mod}(\text{mod}R)}{\text{mod}(\underline{\text{mod}}R)} \xrightarrow{\sim} \text{mod}R,$$

where  $\underline{\text{mod}}R$  is the projectively stable category. This is the classical result known as Auslander's formula [1] (see also [3, 6]). Our theorem enables us to construct another version of Auslander's formula:

**Corollary.** Let  $\mathcal{A}$  be an  $n$ -cluster tilting subcategory in  $\text{mod}R$ , introduced in [4, 5], and  $\mathcal{B} := \text{proj}R$ . Then we have an equivalence

$$\frac{\text{mod}\mathcal{A}}{\text{mod}\underline{\mathcal{A}}} \xrightarrow{\sim} \text{mod}R,$$

where  $\underline{\mathcal{A}} := \mathcal{A}/[\mathcal{B}]$ .

### References

- [1] M. Auslander, *Coherent functors*, In Proc. Conf. Categorical Algebra (La Jolla, Calif., 1965), pages 189231. Springer, New York, 1966.
- [3] H. Krause, *Deriving Auslander's formula*, Doc. Math. 20 (2015), 669–688.
- [4] O. Iyama, *Auslander correspondence*, Adv. Math., 210(1):5182, March 2007.
- [5] O. Iyama, *Higher-dimensional Auslander-Reiten theory on maximal orthogonal subcategories*, Adv. Math., 210(1):2250, March 2007.
- [6] J. Russell, *Applications of the defect of a finitely presented functor*, arXiv:1211.0054, October 2012.

## On the general principle behind Auslander-Reiten duality

Wednesday

Maiko Ono

Okayama University

Through this talk, a ring  $R$  means a commutative Noetherian ring. Auslander-Reiten (AR) duality is one of the most important theorem in the theory of maximal Cohen-Macaulay modules. Prof. Iyama and Prof. Wemyss generalized the AR duality in the case of codimension one singular locus. In this talk, I will discuss the generalization of AR duality in the derived category of unbounded chain complexes of  $R$ -modules. It is the most general form of the theorem which naturally leads us to the classical AR duality and its generalizations. This is a joint work with Prof. Yuji Yoshino.

## Spherical Objects and Simple Curves

Tuesday

Sebastian Opper

University of Cologne

A theorem by Burban and Drozd (2011) states that the category  $\text{Perf } E_n$  of perfect complexes over a cycle of projective lines  $E_n$  ( $n \in \mathbb{N}$ ) can be modeled by a subcategory of  $\mathcal{D}^b(\Gamma_n)$ , the bounded derived category of finitely generated modules over a certain gentle algebra  $\Gamma_n$ . In particular, questions about spherical objects in  $\text{Perf } E_n$  and their associated spherical twists can be studied by means of the gentle algebra. Inspired by the Homological Mirror Symmetry Conjecture, I will establish a connection between homotopy bands of  $\Gamma_n$  in the sense of Bekkert and Merklen (2003) and certain curves on the torus with  $n$  punctures. I will explain how the combinatorics of morphisms, mapping cones and spherical twists in  $\mathcal{D}^b(\Gamma)$  are connected to intersection points, surgeries and Dehn twists by simple curves. Finally, I will talk about applications to spherical objects in  $\text{Perf } E_n$ .

Tuesday

---

### ***d*-tilting bundles for Geigle-Lenzing weighted projective spaces**

Steffen Oppermann

NTNU

This talk is based on joint work with Martin Herschend, Osamu Iyama, and Hiroyuki Minamoto. Classically, the classes of tame (representation infinite, connected) hereditary algebras and Fano Geigle-Lenzing weighted projective lines coincide up to derived equivalence. With the development of Iyama's higher AR-theory, and our work on Geigle-Lenzing projective spaces, it has become natural to ask if there is a higher dimensional analog of this fact. Here dimension refers to, on the one side the global dimension of the algebra, and on the other side the dimension of the space. Unfortunately, so far a general answer (or general strategy) is elusive. In my talk I will focus on the hyper surface case, and more specifically certain weight sequences within the hyper surface case. For these, I will explain how one may find suitable tilting bundles on the Geigle-Lenzing weighted projective space.

---

Wednesday

### **Idempotent subalgebras and homological dimensions**

Charles Paquette

University of Connecticut

Let  $A$  be a finite dimensional algebra over a field and  $e \in A$  an idempotent. Consider the algebra  $\Gamma = (1 - e)A(1 - e)$ . In general,  $A$  and  $\Gamma$  are very different from the homological point of view. One general goal is to find an  $A$ -module  $S_e$  that controls the relationship between the homological dimensions of  $A$  and those of  $\Gamma$ . The semi-simple module  $S_e = eA/e\text{rad}A$  is a good candidate for this. If  $e$  is primitive, then consider the following three conditions. (1)  $\text{gl.dim}A < \infty$ ; (2)  $\text{gl.dim}\Gamma < \infty$ ; (3)  $\text{Ext}_A^i(S_e, S_e) = 0$  for all  $i > 0$ . In a past project, we proved that any two of these conditions imply the third. If  $e$  is not primitive, then condition (3) needs to be replaced by another homological condition (3'). In this talk, we show that if (3') holds, then (1) is equivalent to (2). As a consequence, this yields a new way to approach the so-called Cartan Determinant Conjecture. This is joint work with Colin Ingalls.

---

Thursday

### **Tensor products of higher almost split sequences**

Andrea Pasquali

Uppsala Universitet

Under some conditions found by Herschend and Iyama, the tensor product of an  $n$ - and an  $m$ -representation finite algebra is  $(n + m)$ -representation finite. In this case, I will describe the  $(n + m)$ -almost split sequences over the product in terms of the  $n$ - and  $m$ -almost split sequences over the factors. I will also show a more general setting in which this construction works.

---

## Extensions and mapping cones for gentle algebras

Thursday

David Pauksztello

The University of Manchester

Gentle algebras are a particularly nice class of algebra for which the indecomposable complexes in the bounded derived category can be completely described in terms of string and band combinatorics. This means that gentle algebras provide a natural laboratory in which to study the homological properties of finite-dimensional algebras concretely. In this talk, we shall describe the classification of indecomposable complexes in the bounded derived category, a basis of morphisms between indecomposable complexes and describe a graphical calculus that computes the mapping cones of these morphisms. As an application, we shall give a complete description of the middle terms of extensions for a basis of the Ext space between any two string or band modules over a gentle algebra. The talk will be based on joint works with Kristin Arnesen and Rosanna Laking, and Ilke Canakci and Sibylle Schroll.

## Separable extensions and modular representation theory

Tuesday

Bregje Pauwels

Australian National University

In this talk, I will consider separable (commutative) monoids in a symmetric monoidal category and show how they pop up in various settings. In modular representation theory, for instance, restriction to a subgroup can be thought of as extension along a separable monoid in the (stable or derived) module category. In algebraic geometry, they appear as finite étale extensions of affine schemes. But separable monoids are nice for various reasons, beyond the analogy with étale topology; they allow for a notion of degree, have splitting ring extensions, and one can define (quasi)-Galois extensions. I will present a version of quasi-Galois-descent and discuss applications in modular representation theory.

## Internally Calabi-Yau algebras

Monday

Matthew Pressland

Max-Planck-Institut für Mathematik, Bonn

I will define what it means for an algebra to be internally Calabi-Yau with respect to an idempotent. This generalises the definition of a Calabi-Yau algebra by allowing the required Ext-group symmetries for modules to have a "restricted support". I will explain how internally Calabi-Yau algebras are related to cluster-tilting objects in certain stably Calabi-Yau Frobenius categories, thus providing a link to the categorification programme for cluster algebras with frozen variables.

## Abelian categories and definable additive categories

Mike Prest

University of Manchester

Associated to any representation is the definable category that it generates and the associated small abelian functor category. This is part of a 2-category equivalence between small abelian categories and definable additive categories which suggests that we take seriously the view of modules as exact functors on abelian categories ([3], [4], [5], [6]). I will use a range of examples to illustrate that these categories often may be computed. I will also indicate a surprising example, from [1] (see also [2]), with the category of Nori motives, constructed by Caramello using categorical logic, appearing as the small abelian category associated to a representation of a (rather large) quiver.

### References

- [1] L. Barbieri-Viale, O. Caramello & L. Lafforgue: Syntactic categories for Nori motives, arXiv:1506.06113, 2015
- [2] L. Barbieri-Viale and M. Prest, Definable categories and T-motives, arXiv:1604.00153, 2016
- [3] I. Herzog, The Ziegler spectrum of a locally coherent Grothendieck category, Proc. London Math. Soc., 74(3) (1997), 503-558.
- [4] H. Krause, Exactly definable categories, J. Algebra, 201 (1998), 456-492.
- [5] M. Prest, Abelian categories and definable additive categories, arXiv:1202.0426, 2012.
- [6] M. Prest, Categories of imaginaries for definable additive categories, arXiv:1202.0427, 2012.

## Recollements of Derived Module Categories

Chrysostomos Psaroudakis

NTNU

Recollements of abelian/triangulated categories are exact sequences of abelian/triangulated categories where both the inclusion and the quotient functors have left and right adjoints. They appear quite naturally in various settings and are omnipresent in representation theory. Recollements in which all categories involved are module categories (abelian case) or derived categories of module categories (triangulated case) are of particular interest. In the abelian case, the standard example is the recollement induced by the module category of a ring  $R$  with an idempotent element  $e$ , and in the triangulated case the standard example is given as the derived counterpart of this recollement of module categories when the ideal  $ReR$  is stratifying. The latter recollement is called stratifying. The aim of this talk is two-fold. First, we classify, up to equivalence, recollements of abelian categories whose terms are equivalent to module categories. Then, we provide necessary and sufficient conditions for a recollement of derived categories of module categories to be equivalent to a stratifying one. In particular, we show that every derived recollement of a finite dimensional hereditary algebra is equivalent to a stratifying one. This is joint work with Jorge Vitória (arXiv:1304.2692, arXiv:1511.02677).

## BGG algebras with indecomposable faithful modules

Tuesday

Daiva Pucinskaite

Florida Atlantic University

Schur Weyl duality connecting Schur algebras and algebras of symmetric groups or 'Soergel Struktursatz' showing the connection between the representation theory of Lie algebras and associative algebras are prominent examples of the relationship between the structure of modules and their endomorphism rings. An algebra describing a block of Bernstein-Gelfand-Gelfand category  $O(\mathfrak{g})$  is related to the coinvariant algebra (of the Weyl group) which is the endomorphism ring of a faithful module. In this talk, we discuss the relationship between the partial order of some BGG algebras and the structure of some faithful modules as well as their endomorphism ring. This also expose a relationship between the coinvariant algebra and the Bruhat order.

## Symmetries and connected components of the AR-quiver

Tuesday

Tony Puthenpurakal

IIT-Bombay

Let  $(A, \mathfrak{m})$  be a commutative complete equicharacteristic Gorenstein isolated singularity of dimension  $d$  with  $k = A/\mathfrak{m}$  algebraically closed. Let  $\Gamma(A)$  be the AR (Auslander-Reiten) quiver of  $A$ . Let  $\mathcal{P}$  be a property of maximal CM  $A$ -modules. We show that some naturally defined properties  $\mathcal{P}$  define a union of connected components of  $\Gamma(A)$ . So in this case if there is a maximal CM module satisfying  $\mathcal{P}$  and if  $A$  is not of finite representation type then there exists a family  $\{M_n\}_{n \geq 1}$  of maximal Cohen-Macaulay indecomposable modules satisfying  $\mathcal{P}$  with multiplicity  $e(M_n) \geq n$ . Let  $\underline{\Gamma}(A)$  be the stable quiver. We show that there are many symmetries in  $\underline{\Gamma}(A)$ . Furthermore  $\underline{\Gamma}(A)$  is isomorphic to its reverse graph. As an application we show that if  $(A, \mathfrak{m})$  is a two dimensional Gorenstein isolated singularity with multiplicity  $e(A) \geq 3$  then for all  $n \geq 1$  there exists an indecomposable self-dual maximal Cohen-Macaulay  $A$ -module of rank  $n$ .

## Cluster algebras, triangular bases and monoidal categorification

Tuesday

Fan Qin

Université de Strasbourg

We give an introduction of the categorification of cluster algebras by monoidal categories in representation theory. This approach allows us to use monoidal categories to study cluster algebras and, conversely, reveals new phenomena in representation theory. We shall construct the triangular bases of such quantum cluster algebras, parametrized by the tropical points of cluster varieties, which turn out to be the dual canonical bases or the sets of the finite dimensional simple modules. This construction implies the Hernandez-Leclerc monoidal categorification conjecture and, in this situation, the Fock-Goncharov conjecture.

Thursday

**Mirabolic quantum  $\mathfrak{sl}_n$** 

Daniele Rosso

University of California, Riverside

Beilinson-Lusztig-MacPherson constructed the quantum enveloping algebra  $U_q(\mathfrak{sl}_n)$  (and the  $q$ -Schur algebras) as a convolution algebra over the space of pairs of partial  $n$ -step flags over a finite field. We will explain how to expand the construction to the mirabolic setting of triples of two partial flags and a vector, and examine the resulting convolution algebra. We give a classification of its finite dimensional irreducible representations and we describe a mirabolic version of the quantum Schur-Weyl duality.

Thursday

**Hall polynomials for tame type**

Shiquan Ruan

Yau Mathematical Sciences Center of Tsinghua University

This is joint work with Bangming Deng. In this talk we will show that Hall polynomial exists for each triple of decomposition sequences which parameterize isomorphism classes of coherent sheaves of a domestic weighted projective line  $X$  over finite fields. These polynomials are then used to define the generic Ringel–Hall algebra of  $X$  as well as its Drinfeld double. Combining this construction with a result of Cramer, we show that Hall polynomials exist for tame quivers, which not only refines a result of Hubery, but also confirms a conjecture of Berenstein and Greenstein.

Tuesday

**Weakly based modules over right perfect rings and Dedekind domains**

Pavel Ruzicka

Charles University

A *weak basis* of a module is a generating set of the module minimal with respect to inclusion. A module is said to be *weakly based* if it contains a weak basis and the module is said to be *regularly weakly based* provided that each of its generating sets contains a weak basis. We will discuss the problem of Nashiers and Nichols to characterize rings over which all modules are regularly weakly based and study weakly based (respective regularly weakly based) modules over Dedekind domains. *This a joint work with Michal Hrbek.*

Monday

**Logarithmic D-Modules on the Wonderful Compactification**

Sergei Sagatov

University of Chicago

The complement of a semisimple algebraic group  $G$  in its wonderful compactification  $X$  is a divisor  $Y$  with normal crossings, so we can consider the sheaf of logarithmic differential operators  $\mathcal{D}_{X,Y}$  on  $X$ . These are the differential operators that preserve the filtration of  $\mathcal{O}_X$  by powers of the ideal sheaf of  $Y$ , and they can be related to the Lie algebra of  $G$ . This approach allows one to use representation theory to study modules over  $\mathcal{D}_{X,Y}$ . In particular, we discuss conditions on such “logarithmic D-modules” that ensure the vanishing of their higher cohomology groups.

## Moduli spaces of irregular singular connections

Monday

Daniel Sage

Louisiana State University

In recent years, there has been increasing interest in flat vector bundles on curves with irregular singularities. While the primary motivation for much of this work has come from the geometric Langlands program, there have also been some intriguing connections with the representation theory of algebras. For example, Boalch has constructed symplectic moduli spaces of meromorphic flat vector bundles on  $\mathbb{CP}^1$  for which the connection matrix at each singularity – an element of the formal loop algebra  $\mathfrak{gl}_n(\mathbb{C}((t)))$  – has diagonalizable leading term. In favorable situations, he has shown that these moduli spaces are Nakajima quiver varieties. Moreover, the isomonodromy equations for certain connections of this type appear in the work of Bridgeland and Toledano Laredo on stability conditions on the category of modules over a complex, finite-dimensional algebra.

In this talk, I describe a new approach to the study of irregular singular flat vector bundles (or more generally, to flat  $G$ -bundles) using methods of representation theory. This approach is based on a geometric version of the Moy-Prasad theory of minimal  $K$ -types (or fundamental strata) for representations of  $p$ -adic groups. In the geometric theory, one associates a fundamental stratum – data involving an appropriate filtration on the loop algebra – to a formal flat vector bundle. Intuitively, this stratum plays the role of the “leading term” of the flat vector bundle and can be used to define its slope, an invariant measuring the degree of irregularity of the connection. I will explain how these ideas can be used to construct symplectic moduli spaces of meromorphic connections on  $\mathbb{CP}^1$  with irregular singularities that are not necessarily formally diagonalizable. I will also show how to realize the isomonodromy equations for such connections as an explicit integrable system. This is joint work with C. Bremer.

## Noetherian properties in representation theory

Thursday

Steven Sam

University of Wisconsin, Madison

I’ll explain some recent applications of “categorical symmetries” in topology, algebraic geometry, and group theory. The general idea is to find an action of a category on the object of interest, prove some niceness property (like finite generation), and then deduce consequences from the general properties of the category.

## Silting theory and the modular condition of the heart of a $t$ -structure

Tuesday

Manuel Saorín

Universidad de Murcia

In the talk we will show how a suitable extension of silting theory, as introduced by Aihara and Iyama, to the general context of triangulated categories with arbitrary (set-indexed) coproducts allows to tackle the question of when the heart of a  $t$ -structure in such a triangulated category is the category of all modules over an (associative unital) algebra or, more generally, a Grothendieck category.

Monday

**“Shifting” algebras of positive dominant dimension**

Julia Sauter

Bielefeld University

This is joint work with Matthew Pressland. Every finite-dimensional algebra of positive dominant dimension has a tilting module (called shifted module) given by the cosyzygy of the algebra plus the projective-injectives. We call its endomorphism algebra a shifted algebra. If the dominant dimension is at least two, we find a recollement of the shifted algebra realizing the dual of the shifted module as an intermediate extension. This recollement has a different description in terms of certain homotopy categories which leads to a realization of arbitrary rank varieties (in the representation space of a finite-dimensional algebra) as affine quotient varieties. This work generalizes partly earlier work of Crawley-Boevey and the second author which itself is a generalization of work of Cerulli-Irelli, Feigin and Reineke.

Tuesday

**Hammocks via the defect of a short exact sequence**

Markus Schmidmeier

Florida Atlantic University

The defect of a short exact sequence at a module can provide meaningful data about the structure of the module. In this talk we investigate hammock functions given by the dimension of the defect, and describe the roles played by the various terms in the sequence. Examples of hammock functions visualize how indecomposable modules change across the Auslander-Reiten quiver.

Thursday

**Singularities of dual varieties associated to exterior representations**

Emre Sen

Northeastern University

For a given irreducible projective variety  $X$ , the closure of the set of all hyperplanes containing tangents to  $X$  is the projectively dual variety  $X^*$ . We study the singular locus of projectively dual varieties of certain Segre-Plücker embeddings. We give a complete classification of the irreducible components of the singular locus of several representation classes. Basically, they admit two types of singularities: cusp type and node type which are degeneracies of a certain Hessian matrix, and the closure of the set of tangent planes having more than one critical point respectively. In particular, our results include a description of singularities of dual Grassmannian varieties.

## Mutation of $A_n$ friezes

Tuesday

Khrystyna Serhiyenko

University of California, Berkeley

A frieze is a grid of positive integers with a finite number of infinite rows satisfying a certain rule. Introduced in 1970's, friezes gained fresh interest in the last decade in relation to cluster theory. In particular, there exists a bijection between friezes and cluster-tilted algebras of type A. An operation called mutation is the key notion in cluster theory, and we study mutations of friezes which are compatible with mutations of the associated cluster-tilted algebras. We also provide a formula for the number of submodules (up to isomorphisms) of a given module over a cluster-tilted algebra of type A. In this case, it coincides with the specialized Caldero Chapoton map applied to a given module, which provides a way to pass from a cluster-tilted algebra to the associated frieze. This is joint work with K. Baur, E. Faber, S. Gratz, and G. Todorov.

## Lie algebras arising from 1-cyclic complexes of projective $kQ$ -modules

Monday

Jie Sheng

China Agricultural University

Let  $kQ$  be the path algebra of a Dynkin quiver  $Q$  over a finite field  $k$  of  $q$  elements. Consider the category of 1-cyclic complexes over projective  $kQ$ -modules, whose homotopy category is triangle equivalent to the orbit category of the derived category of  $kQ$ -modules modulo the shift. We will show the existence of Hall polynomials therein and construct a Lie algebra using Hall polynomials evaluated at 1. If  $Q$  is bipartite, the resulting Lie algebra is isomorphic to the positive part of the corresponding simple Lie algebra.

## Very Flat, Locally Very Flat, and Contraadjusted Modules

Tuesday

Alexander Slavik

Charles University

We study the approximation properties of classes of very flat and contraadjusted modules, introduced by Positselski [[arXiv:1209.2995](https://arxiv.org/abs/1209.2995)]. Over a Noetherian ring  $R$ , the following are shown to be equivalent:

- the class of all very flat modules being covering,
- the class of all contraadjusted modules being enveloping,
- the spectrum of  $R$  being finite.

Further, we introduce locally very flat modules, an analogue to flat Mittag-Leffler modules. We show that the propositions above are also equivalent to

- the class of all locally very flat modules being precovering.

Joint work with Jan Trlifaj.

Monday

## The triangulated hull of periodic complexes

Torkil Stai

NTNU

For an automorphism  $F$  of  $D = D^b(\text{mod } \Lambda)$  satisfying mild hypotheses, Keller devises a triangulated hull for the orbit category  $D/F$ , i.e. a triangulated category  $D_F$  and a fully faithful embedding  $\Delta_F: D/F \rightarrow D_F$  with a certain universal property. Determining whether  $D/F$  inherits a triangulated structure from  $D$  thus reduces to checking if  $\Delta_F$  is surjective on objects. Keller has shown that  $\Delta_F$  is dense if  $\Lambda$  is piecewise hereditary, but it is not clear to what extent this condition is necessary.

Denote by  $\Sigma$  the suspension functor on  $D$  and let  $n$  be a positive integer.  $D_{\Sigma^n}$  can be realized as a derived category of  $n$ -periodic complexes over  $\Lambda$ , while  $\Delta_{\Sigma^n}$  is essentially a forgetful functor. This description can be used to show that if  $\Lambda$  is non-triangular, then the orbit category  $D/\Sigma^n$  is never triangulated. Moreover, for certain quadratic monomial algebras one can show that  $D/\Sigma^n$  is triangulated only if  $\Lambda$  is piecewise hereditary. As a final application, we manifest the phenomenon of an automorphism not inducing the identity functor on its associated orbit category.

Wednesday

## Orders and Non-Commutative Crepant Resolutions

Joshua Stangle

Syracuse University

In 2004, Van den Bergh defined a non-commutative (crepant) resolution (NCCR) of singularities for a Gorenstein normal domain,  $R$ . The definition leads to many strong theorems and connections between commutative algebra and algebraic geometry. Additionally, theorems of Auslander give a constructive analog: NCCRs can be realized as endomorphism rings over  $R$  which are maximal Cohen-Macaulay  $R$ -modules and have finite global dimension. One goal of current research is to find a definition in the case of Cohen-Macaulay normal domains which replicates some of these strong results and possesses a constructive analog. We will discuss the Gorenstein case and introduce some possible definitions (and obstructions) in the non-Gorenstein case.

Monday

## A triangulated Eilenberg–Watts theorem

Johan Steen

NTNU

The ordinary Eilenberg–Watts theorem states that right exact functors preserving coproducts between module categories are given by tensoring with a bimodule.

In this talk I will describe how a variant of this theorem looks in the realm of triangulated categories. More precisely, we replace right exact functors between abelian module categories with exact functors between certain triangulated module categories, which naturally leads us to consider enriched categories and functors.

This is joint work with Greg Stevenson (arXiv:1604.00880).

## Categories with sufficiently many exact sequences

Friday

Greg Stevenson

University of Bielefeld

I'll talk around some joint work with Ivo Dell'Ambrogio and Jan Stovicek on the role of Gorenstein module categories in homological algebra. The idea is to reduce understanding universal coefficient theorems to very concrete questions about when a small category is Gorenstein and how one can detect when a representation has finite projective dimension.

---

## Schur-Weyl dualities in non-semisimple cases

Wednesday

Catharina Stroppel

Universität Bonn

“Schur-Weyl duality” is often used to describe a concept in representation theory involving two kinds of symmetry that determine each other. In its original form it goes back to Schur and Weyl (around 1930) and describes an important interplay between the representation theory of the general linear and the symmetric group over the complex numbers. In this talk we will describe some generalizations of this phenomenon with a focus on modern, still open or recently solved questions. In particular we are interested in situations, where the involved algebras are not semisimple. We will indicate the origin of filtrations, homological properties and hidden gradings on the involved algebras and applications to the representation theory of Lie superalgebras.

---

## Tensor product of higher preprojective algebras

Thursday

Louis-Philippe Thibault

University of Toronto

In the setting of Iyama's higher Auslander-Reiten theory, preprojective algebras, as well as representation-finite and representation-infinite hereditary algebras, were generalized to algebras of higher global dimension. In their 2014 paper, M. Herschend, O. Iyama and S. Oppermann showed that the tensor product of two higher representation-infinite algebras is again higher representation-infinite. It is natural to ask whether the same is true for the tensor product of higher preprojective algebras. In this talk, we explain that if these algebras are Koszul, then their tensor product cannot be endowed with a grading as required for a preprojective algebra. We then give applications to skew-group algebras that arise from a finite subgroup of  $SL(n, k)$  acting on a polynomial ring. In the classical case  $n = 2$ , every skew-group algebra is Morita equivalent to a preprojective algebra. It is not true when  $n > 2$ : we describe a class of subgroups of  $SL(n, k)$  for which the skew-group algebra is not Morita equivalent to a higher preprojective algebra.

---

Monday

## Semistable subcategories for preprojective algebras

Hugh Thomas

Université du Québec à Montréal

A linear form  $\phi$  on the Grothendieck group of an algebra determines a abelian, extension-closed subcategory of its finite length modules: the  $\phi$ -semistable subcategory (in the sense of King). This subcategory is abelian and extension-closed. As  $\phi$  varies, the subcategories picked out exhibit a wall-and-chamber structure. If the algebra is hereditary and finite type, we recover the combinatorics of Igusa-Orr-Weyman-Todorov pictures, or, equivalently, of the cluster complex. It turns out that for finite-type preprojective algebras, we obtain combinatorics described by Nathan Reading's "shards" (originally introduced by Reading to study the combinatorics of weak order on the associated Coxeter group). Shards provide a beautiful picture from which we can recover the combinatorics for any quotient of the preprojective algebra, including the hereditary cases. Time permitting, I will also say something about affine type. This project is joint work with David Speyer, and also draws on previous joint work with Osamu Iyama, Nathan Reading, and Idun Reiten.

Monday

## Stabilization and cup products for polynomial representations of $GL_n(k)$

Antoine Touzé

Université Lille

It is known for a long time that polynomial representations of  $GL_n(k)$  stabilize when  $n$  grows, i.e. schur algebras  $S(n, d)$  are all Morita equivalent when  $n \geq d$ . A model of the category of stable polynomial representations is given by the strict polynomial functors of Friedlander and Suslin. Using the formalism of strict polynomial functors, we prove a rather counter-intuitive results on cup products, namely that the cup product

$$\mathrm{Ext}^*(M, N) \otimes \mathrm{Ext}^*(P^{(r)}, Q^{(r)}) \rightarrow \mathrm{Ext}^*(M \otimes P^{(r)}, N \otimes Q^{(r)})$$

induces an isomorphism in low degrees when  $M, N, P, Q$  are stable polynomial representations. We shall explain some consequences of these results (including a new proof of the Steinberg tensor product theorem, as well as more general structure theorems which generalize it) and connections with the cohomology of the symmetric group.

Thursday

## $\tau$ -Tilting Theory and $\tau$ -Slices

Hipolito Treffinger

Université de Sherbrooke

One of the main results in tilting theory is the Tilting Theorem, proved by Brenner and Butler in the early eighties. In this talk, we state an extension of this theorem in the context of the  $\tau$ -tilting theory. Afterwards we introduce the notion of  $\tau$ -slices. We show that  $\tau$ -slices are examples of support  $\tau$ -tilting modules satisfying the hypotheses of the preceding theorem. Also we state some results connecting the  $\tau$ -slices with the tilted and cluster tilted algebras.

## Tree modules, and limits of the approximation theory

Friday

Jan Trlifaj

MFF, Univerzita Karlova, Praha

Classes of modules closed under transfinite extensions often provide for precovers, and hence fit in the machinery of relative homological algebra. However, there are important exceptions: the Whitehead groups [3], and flat Mittag-Leffler modules over non-perfect rings [1]. The latter class is just the zero dimensional instance (for  $T = R$  and  $n = 0$ ) of non-precovering of the class of all locally  $T$ -free modules, where  $T$  is any  $n$ -tilting module which is not  $\sum$ -pure split. The phenomenon occurs even for finite dimensional algebras, when  $R$  is hereditary of infinite representation type, and  $T$  is the Lukas tilting module. The key tools here are the tree modules from [5], which have recently been generalized in [4] in order to solve Auslander's problem on the existence of almost split sequences [2].

### References

- [1] L. Angeleri Hügel, J. Šaroch, J. Trlifaj, *Approximations and Mittag-Leffler conditions*, available at <https://www.researchgate.net/publication/280494406> Approximations and Mittag-Leffler conditions.
- [2] M. Auslander, *Existence theorems for almost split sequences*, Ring theory II (Proc. Conf. Univ. Oklahoma, 1975), 1-44. Lecture Notes in Pure and Appl. Math., Vol. 26, Dekker, New York, 1977.
- [3] P. C. Eklof, S. Shelah, *On the existence of precovers*, Illinois J. Math. 47(2003), 173-188.
- [4] J. Šaroch, *On the non-existence of right almost split maps*, available at arXiv: 1504.01631v4.
- [5] A. Slávik, J. Trlifaj, *Approximations and locally free modules*, Bull. London Math. Soc. 46(2014), 76-90.

## Gabriel-Roiter Measures for Struwelpeter Algebras

Tuesday

Helene Tyler

Manhattan College

The Gabriel-Roiter measure has been studied extensively for finite type algebras and for algebras of type  $k\tilde{A}_n$ . It has been shown by others and by us how the Gabriel-Roiter measure provides a blueprint for the module category. We extend the study of Gabriel-Roiter measures to modules over “Struwelpeter algebras”, a class of gentle algebras containing  $k\tilde{A}_n$  as a subalgebra. We track changes in the rhombic picture and associate these changes to combinatorial features of the quiver. Our study sheds light on theorems of Ringel and Chen, which relate the preprojective and preinjective components to the take-off and landing parts of the module category. This talk reflects joint work with Markus Schmidmeier.

## Graded Representations of the Generalized Clifford Algebra

Monday

Charlotte Ure

Michigan State University

Let  $f$  be a homogeneous form of degree  $d$  in  $n$  variables. The generalized Clifford algebra  $C_f$  associated to  $f$  has a natural  $\mathbb{Z}/d\mathbb{Z}$ -grading. The case of the Clifford algebra for quadratic forms is classical and well-understood. My talk will be concerned with the construction of graded simple quotients of  $C_f$  that are graded central simple algebras of arbitrarily high dimension in the case  $n = d = 3$ . This is joint work in progress with Adam Chapman, Casey Machen and Rajesh Kulkarni.

Thursday

**Triangle-free cluster categories**

Adam-Christiaan van Roosmalen

Hasselt University

This is joint work with Jan Stovicek. A Krull-Schmidt 2-Calabi-Yau category with a cluster-tilting object is called acyclic if the quiver of the cluster-tilting object is acyclic. In this talk, we will discuss an infinite version, replacing the cluster-tilting object with a cluster-tilting subcategory, and replacing the acyclicity condition with a triangle-free condition. We will consider some examples where one can use combinatorics to describe the cluster-tilting subcategories, as is done by Holm and Jørgensen in the case of the infinite Dynkin quiver  $A_\infty$  using triangulations of the  $\infty$ -gon. We will use these descriptions to find a criterion for the existence of a Caldero-Chapoton map defined on all exceptional objects.

---

Thursday

 **$n$ -cluster tilting subcategories of Nakayama algebras**

Laertis Vaso

Uppsala University

In Iyama's higher dimensional Auslander-Reiten theory an important problem is to find algebras admitting  $n$ -cluster tilting subcategories. In my talk I will present a classification of Nakayama algebras of global dimension  $d$  which admit  $d$ -cluster tilting subcategories. I will also give a construction for a large but not exhaustive list of Nakayama algebras admitting  $n$ -cluster tilting subcategories for  $n < d$ .

---

Tuesday

**Gerstenhaber bracket via arbitrary resolution**

Yury Volkov

Sao Paulo University

Hochschild cohomology is an interesting derived invariant of an algebra. It is well known that it has a structure of a Gerstenhaber algebra, which includes the cup product and the Gerstenhaber bracket. There are some well known formulas for cup product via an arbitrary bimodule projective resolution of an algebra under consideration. One interesting formula for the Gerstenhaber bracket appeared recently in a work of C. Negron and S. Witherspoon. There the correctness of this formula is proved for a resolution with some restrictive properties. In the current talk we will see how to modify this formula in such a way that it becomes correct for any bimodule projective resolution. Also we represent some other interesting formulas and algorithms for computing the Gerstenhaber bracket on Hochschild cohomology of an algebra.

---

## Singular equivalences of Morita type and universal deformation rings for Gorenstein algebras

Wednesday

Jose Velez-Marulanda

Valdosta State University

Let  $\mathbf{k}$  be an algebraically closed field and let  $\Lambda$  be a Gorenstein  $\mathbf{k}$ -algebra. We show that if  $V$  is a Cohen-Macaulay  $\Lambda$ -module whose stable endomorphism ring is isomorphic to  $\mathbf{k}$ , then  $V$  has a well-defined universal deformation ring  $R(\Lambda, V)$  which is a complete local commutative Noetherian  $\mathbf{k}$ -algebra with residue field  $\mathbf{k}$ , and which is also stable under taking syzygies. We also show that the isomorphism class of  $R(\Lambda, V)$  is preserved by singular equivalences of Morita type as introduced by X. W. Chen and L. G. Sun in a preprint in 2012 and then discussed later by G. Zhou and A. Zimmermann in the article entitled “On singular equivalences of Morita type”, which was published in *J. Algebra* during 2013.

## Versal deformation rings and Brauer tree algebras

Tuesday

Daniel Wackwitz

University of Wisconsin-Platteville

Let  $k$  be an algebraically closed field of arbitrary characteristic. Suppose  $A$  is a Brauer tree algebra over  $k$  and  $V$  is a finitely generated indecomposable  $A$ -module. The versal deformation ring  $R(A, V)$  of  $V$  is characterized by the property that every lift of  $V$  over a complete local commutative Noetherian  $k$ -algebra  $R$  with residue field  $k$  is, up to isomorphism, determined by a (not necessarily unique) local ring homomorphism from  $R(A, V)$  to  $R$ . In this talk, I will present the classification of the versal deformation rings of all indecomposable  $A$ -modules for any Brauer tree algebra  $A$ .

## On the construction of indecomposable representations of quivers

Tuesday

Thorsten Weist

Bergische Universitaet Wuppertal

For a fixed root of a quiver, it is a very hard problem to classify the indecomposable representations. It seems that there are roots which behave better than others. This means that for these roots there are methods which can be used to construct as many isomorphism classes of indecomposable representations as predicted by Kac’s Theorem. Apart from Schur roots, it turns out that there is a huge class of other roots for which these techniques apply. We explain several recursive constructions, but we also show how methods from intersection theory can be used for this purposes. We end up with a discussion about the roots under consideration.

Thursday

## Ringel-Hall algebras beyond their quantum groups

Jie Xiao

Tsinghua University

This is joint work with Fan Xu and Minghui Zhao. The aim of this talk is to clarify the relations between two definitions of comultiplications given by Lusztig and Green respectively. We construct the geometric analog of Green's theorem on the comultiplication of a Ringel-Hall algebra. It is an extension version of the comultiplication of a quantum group defined by Lusztig. As an application, we show that the Hopf structure of a Ringel-Hall algebra can be categorified under Lusztig's framework.

Thursday

## Maximal rigid subcategories and cluster-tilting subcategories in 2-CY categories

Jinde Xu

Université de Sherbrooke

Let  $\mathcal{C}$  be a connected Hom-finite triangulated 2-CY category. We prove that if  $\mathcal{T}$  a functorially finite maximal rigid subcategory of  $\mathcal{C}$  without loops in its quiver, then  $\mathcal{T}$  is cluster-tilting. In particular, this gives a positive answer to a conjecture proposed in [A.B. Buan, O. Iyama, I. Reiten, J. Scott, Cluster structures for 2-Calabi-Yau categories and unipotent groups, *Compo. Math.* 145 (4) (2009) 1035-1079].

Thursday

## The thickness of Schubert cells

Jon Xu

University of Melbourne

In finite geometry, an  $(N, d)$ -arc is a set  $\mathcal{O}$  of  $N$ -points such that the thickness of  $\mathcal{O}$  is  $\leq d$ . In my talk, I will outline a method of calculating the thickness of Schubert cells of flag varieties. I will demonstrate how this calculation uncovers a large class of examples of  $(N, d)$ -arcs of Schubert cells, and is therefore a first step in bringing together the fields of Schubert calculus and finite geometry. This is joint work with Arun Ram and John Bamberg.

Thursday

## On a cluster category of type $D_\infty$

Yichao Yang

University of Sherbrooke

We study the canonical orbit category of the bounded derived category of finite dimensional representations of the quiver of type  $D_\infty$ . We prove that this orbit category is a cluster category, that is, its cluster-tilting subcategories form a cluster structure.

## Coxeter transformation of the poset of order ideals in a grid

Emine Yıldırım

UQAM

Let  $P_{k,n}$  be a grid poset, i.e., the product of two chains, of length  $k$  and  $n$ . Let  $J(P_{k,n})$  be the poset of poset ideals of  $P_{k,n}$  and  $D^b(J(P_{k,n}))$  be the bounded derived category of the incidence algebra of  $J(P_{k,n})$ . Auslander-Reiten translation  $\tau$  on the bounded derived category defines an action on the Grothendieck group which is called the Coxeter transformation. Chapoton conjectures that  $\tau$  has finite order on the Grothendieck group of  $D^b(J(R))$  (and, further, that  $D^b(J(R))$  is fractionally Calabi-Yau) when  $R$  is the poset of positive roots of a finite root system. We show that Coxeter transformation has finite order for  $D^b(J(P_{k,n}))$  when  $k = 2, 3$ . Grid posets which we consider arise from a type A root system as the complement of a maximal parabolic subroot system, so our results can be viewed as a step towards establishing a parabolic version of Chapoton's conjecture.

Thursday

## Monic representations

Pu Zhang

Shanghai Jiao Tong University

For a  $k$ -algebra  $A$ , a quiver  $Q$ , and a monomial ideal  $I$  of  $kQ$ , let  $\Lambda := A \otimes_k kQ/I$ . Given a subcategory  $\mathcal{X}$  of  $A$ -mod, we introduce the monomorphism category  $\text{mon}(Q, I, \mathcal{X})$ . If  $Q = A_2$  and  $\mathcal{X} = A$ -mod, it is exactly the submodule category, studied by C.M.Ringel and M.Schmidmeier, D.Simson, D.Kussin, H.Lenzing and H.Meltzer, and so on.

We prove that  $\text{mon}(Q, I, \mathcal{X})$  is resolving and contravariantly finite if so is  $\mathcal{X}$ . A  $\Lambda$ -module  $M$  is Gorenstein-projective if and only if  $M \in \text{mon}(Q, I, \mathcal{GP}(A))$ , where  $\mathcal{GP}(A)$  the subcategory of Gorenstein-projective  $A$ -module. As consequences, the monic  $\Lambda$ -modules are exactly the projective  $\Lambda$ -modules if and only if  $A$  is semisimple; and they are exactly the Gorenstein-projective  $\Lambda$ -modules if and only if  $A$  is selfinjective, and if and only if  $\text{mon}(Q, I, A)$  is Frobenius. For an  $A$ -module  $T$ ,  $\text{mon}(Q, I, {}^\perp T) = \text{mon}(Q, I, A\text{-mod}) \cap {}^\perp(T \otimes kQ/I)$ ; and if  $T$  is cotilting then  $\text{mon}(Q, I, {}^\perp T) = {}^\perp(T \otimes kQ/I)$ . As an application,  $\text{mon}(Q, I, \mathcal{X})$  has Auslander-Reiten sequences, if  $\mathcal{X}$  is resolving and contravariantly finite.

This is based on joint works with X.H.Luo and C.M.Ringel.

Wednesday

## Endomorphism category of an abelian category

Yuehui Zhang

Shanghai Jiao Tong University

Let  $\mathcal{C}$  be an additive category. Denote by  $\text{End}(\mathcal{C})$  the endomorphism category of  $\mathcal{C}$ , i.e. the objects in  $\text{End}(\mathcal{C})$  are pairs  $(C, c)$  with  $C \in \mathcal{C}, c \in \text{End}_{\mathcal{C}}(C)$ , and a morphism  $f : (C, c) \rightarrow (D, d)$  is a morphism  $f \in \text{Hom}_{\mathcal{C}}(C, D)$  satisfying  $fc = df$ . This paper is devoted to an approach of the general theory of the endomorphism category of an arbitrary additive category. It is proved that the endomorphism category of an abelian category is again abelian with an induced structure without nontrivial projective or injective objects. Furthermore, the endomorphism category of any nontrivial abelian category is nonsemisimple and of infinite representation type. As an application, we show that two unital rings are Morita equivalent if and only the endomorphism categories of their module categories are equivalent.

Wednesday

Tuesday

## The Associated Permutations of Mutation Sequences

Ying Zhou

Brandeis University

Associated permutations are defined naturally on reddening sequences and especially maximal green sequences. We define mutation systems and extend the definition of associated permutations from these special mutation sequences to arbitrary mutation sequences. As a result formulas of the associated permutations in any quiver of Type An are given.

Tuesday

## Endomorphism algebras of 2-term silting complexes

Yu Zhou

NTNU

Let  $A$  be a finite dimensional algebra over a field  $k$ . Denote by

- $K(A)$ : the homotopy category of bounded complexes of finitely generated projective  $A$ -modules;
- $\text{mod}(A)$ : the category of finitely generated  $A$ -modules; and
- $D(A)$ : the bounded derived category of  $\text{mod}(A)$ . Let  $P$  be a 2-term silting complex in  $K(A)$  and  $B = \text{End}(P)$  the endomorphism algebra of  $P$ . It is known that  $P$  induces a bounded  $t$ -structure in  $D(A)$  whose heart is equivalent to  $\text{mod}(B)$ .

In this talk, I will compare representation theory of  $B$  with that of  $A$ . First, I will describe a way to relate  $\text{mod}(A)$  and  $\text{mod}(B)$  as a generalization of classical tilting theory. Second, I will show that when  $A$  is hereditary,  $B$  has a nice homological property that for any indecomposable  $B$ -module  $M$ , either its projective dimension is at most one, or its injective dimension is at most one. Moreover, any algebra with such property can be obtained in this way. Third, possible values of  $B$  will be discussed.

Thursday

## Ghost-tilting objects in triangulated categories

Bin Zhu

Tsinghua University

Assume that  $\mathcal{C}$  is a Krull-Schmidt, Hom-finite triangulated category with a Serre functor and a cluster-tilting object  $T$ . We introduce the notion of ghost-tilting objects, and  $T[1]$ -tilting objects in  $\mathcal{C}$ , which are a generalization of cluster-tilting objects. When  $\mathcal{C}$  is 2-Calabi-Yau, the ghost-tilting objects are cluster-tilting. Let  $\Lambda = \text{End}_{\mathcal{C}}^{op}(T)$  be the endomorphism algebra of  $T$ . We show that there exists a bijection between  $T[1]$ -tilting objects in  $\mathcal{C}$  and support  $\tau$ -tilting  $\Lambda$ -modules, which generalizes a result of Adachi-Iyama-Reiten. We develop a basic theory on  $T[1]$ -tilting objects. In particular, we introduce a partial order on the set of  $T[1]$ -tilting objects and mutation of  $T[1]$ -tilting objects, which can be regarded as a generalization of ‘cluster-tilting mutation’.

## Presenting hyperoctahedral Schur algebras

Monday

Jieru Zhu

University of Oklahoma

A classical result states that the action of  $gl(V)$  and the symmetric group on  $d$  letters mutually centralize each other on the  $d$ -fold tensor of  $V$ . If  $V$  admits an action by  $\mathbb{Z}/r\mathbb{Z}$ , it induces an action of the wreath product of  $\mathbb{Z}/r\mathbb{Z}$  and the symmetric group on  $d$  letters. A Levi Lie subalgebra of  $gl(V)$  gives the full centralizer of this action, and we showed a presentation for the centralizing algebra (the cyclotomic Schur algebra.) When  $r = 2$ , this becomes a presentation for the Type B hyperoctahedral Schur algebra defined by Richard Green.

## Morphisms determined by objects in abelian categories

Thursday

Shije Zhu

Northeastern University

The concept of morphisms determined by objects was introduced by Auslander in the Philadelphia notes 1979. We study morphisms determined by objects in various categories and find that the existence of minimal right determiner is closely related with the existence of almost split sequences. We show that in a Hom-finite abelian hereditary category with enough projectives, a morphism  $f$  has a minimal right determiner if and only if the minimal right determiner formula  $\tau^- \text{Ker} f \oplus P(\text{soc coker} f)$  is “well defined” in that category. i.e. each indecomposable summand of  $\text{Ker} f$  is the starting term of an almost split sequence and  $\text{soc coker} f$  is essential. It is also worth mentioning several interesting applications to investigate the non-existence of almost split sequence: 1. In the category of finitely presented representations of strongly locally finite quivers. 2. In continuous cluster categories.

## Vector invariants of $G_2$ and $\text{Spin}_7$ in positive characteristic

Monday

Alexandr Zubkov

Sobolev Institute of Mathematics (SORAN), Omsk branch

The algebraic groups  $G_2$  and  $\text{Spin}_7$  act naturally on the octonion algebra  $\mathbf{O}$  in such a way that  $G_2 = \text{Aut}(\mathbf{O})$  and  $\mathbf{O}$  can be identified with 8-dimensional spinor representation of  $\text{Spin}_7$  respectively. The invariants of  $G_2$  and  $\text{Spin}_7$ , acting diagonally on several copies of  $\mathbf{O}$ , were first described by G. Schwarz over a field of zero characteristic. The corresponding algebras of invariants are generated by the invariants of degree at most 4. In my talk I am going to present the following result (proven in collaboration with Ivan Shestakov): over any infinite field of odd characteristic invariants of several octonions, with respect to the action of  $G_2$  and  $\text{Spin}_7$  just mentioned, are generated by the same invariants of degree at most 4. The idea of our proof is completely different from Schwarz's one. It uses two new tricks, which are interesting on their own.

## Glueing silting objects revisited

Alexandra Zvonareva

University of Stuttgart

This is a joint work with Manuel Saorín. Silting objects play an important role in the study of finite dimensional algebras. As it was shown by Koenig and Yang for a finite dimensional algebra  $A$  over a field there is a bijection between equivalence classes of silting objects in  $K^b(\text{proj-}A)$ , equivalence classes of simple-minded collections in  $D^b(\text{mod-}A)$ , bounded  $t$ -structures on  $D^b(\text{mod-}A)$  with length hearts and bounded co- $t$ -structures on  $K^b(\text{proj-}A)$ . Glueing techniques with respect to a recollement have been introduced by Beilinson, Bernstein and Deligne and studied by many authors, they provide a way to build large and complicated triangulated categories from smaller ones. Thus it is natural to ask, how to glue silting objects with respect to a recollement. In fact, this problem has been already studied by Liu, Vitoria and Yang, who describe the silting object corresponding to a glued co- $t$ -structure. In this talk I will show, how to construct the silting object corresponding to a glued  $t$ -structure.

---