Program on Representations of Lie Algebras

December 16, 2019 – January 17, 2020

Sichuan University, Chengdu, China

Contents

1 General information

The aim of the program is to bring together specialists in the area of representations of Lie algebras and related areas and to discuss current developments. The mini-courses and talks will focus on different aspects of the representation theory of finite and infinite dimensional Lie algebras and their deep connections with other fields of mathematics and physics.

Scientific Committee

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2 Minicourse (December 16, 2019-January 17, 2020)

2.1 Lie algebras of vector fields on algebraic varieties

Lecturer: Vyacheslav Futorny (University of São Paolo, Brazil)

Time: 14:00-16:30, December 16-20, 2019.

Venue: W303 School of Mathematics, Sichuan University.

We are going to discuss the representation theory of Lie algebras of polynomial vector fields on algebraic varieties. Classical examples include Virasoro and Witt algebras which correspond to the case of the torus. These algebras play an important role in different areas of Mathematics and Physics. In recent years there has been a growing interest to the study of representation of Lie algebras of derivations of rings of functions on more general algebraic varieties, this will be the focus of our lectures. In the first lecture we will discuss Lie algebras of differential operators and derivation algebras and consider examples. In the second lecture we focus on representation theory of Virasoro and Witt algebras, in particular on the classification of irreducible Harish-Chandra modules for these algebras based on the results of O. Mathieu and joint results with Y. Billig. In the third lecture we will establish the simplicity criterion for the Lie algebras of vector fields and consider examples. Finally, in the fourth lecture we will discuss new constructions of Rudakov and Gauge representations in the case of arbitrary varieties based on the results of Y. Billig, J. Nilsen, A. Zaidan.

2.2 Representations of rational Cherednik algebras

Lecturer: João Schwarz (University of São Paolo, Brazil)

Time: 14:00-16:00, December 23-27, 2019.

Venue: W303 School of Mathematics, Sichuan University.

In this minicourse we will study some introductory aspects of the rich representation theory of rational Cherednik algebras. Our scope will be modest, given the very technical aspect of parts of the subject matter. In particular, we work only with complex reection groups which are finite Coxeter groups. After defining our main object, we discuss some structural aspects of our algebra such as the PBW theorem; and we introduce the important spherical subalgebra. Then we move to the study of the category O for rational Cherednik algebras, pointing the analogies with the similar category of modules for semi-simple Lie algebras introduced by Bernstein-Gelfand-Gelfand. We discuss some of its basic properties, such as decomposition in blocks, standard modules and their irreducible subquotients (in parallel with the situation of Verma modules in Lie theory). Essential use is made of the grading element (a deformation of the Euler vector field). We also discuss the category O in the context of a highest weight category [5], and see that it is generically semissimple.

Then we discuss Dunkl operators and the Dunkl embedding, which together with the idea of monodromy representation of the braid group permits us to introduce the Knizhnik-Zamolodchikov (KZ) functor relating the category O with the category of modules for the Hecke-Iwahori algebra associated with the Coxeter group. Finally, we briefly discuss the notion of Harish-Chandra bimodules, introduced in [1], to analyze simplicity and Morita Equivalence of a rational Cherednik algebra and its spherical subalgebra. Main sources of the material are [3], [1], [5] and [2], and references therein. Surveys and lecture notes useful for the purpose of this minicourse are [4] and [6].

References

[1] Y. Berest, P. Etingof and V. Ginzburg, Cherednik algebras and differential operators on quasi-invariants, Duke Math. J. 118 (2003), 279-337.

[2] C.F. Dunkl and E. Opdam, Dunkl operators for complex reection groups, Proc. London Math. Soc. 86 (2003), 70-108.

[3] P. Etingof and V. Ginzburg, Symplectic reection algebras, Calogero-Moser space and deformed Harish-Chandra homomorphism, Inv. Math. 147 (2002), 243-348.

[4] P. Etingof, X. Ma. Lecture notes on rational Cherednik algebras. arXiv:1001:0432.

[5] V. Ginzburg, N. Guay, E. Opdam, and R. Rouquier, On the category O for rational Cherednik algebras, Inventiones Math. 154 (2003), 617-651.

[6] R. Rouquier, Representations of rational Cherednik algebras. arXiv:math/0504600.

2.3 Surfaces and representation theory

Lecturer: Sibylle Schroll (U Leicester, UK)

Time: January 5: 10:00-12:00

January 6 & 9: 08:00-09:30

January 10: 20:00-22:00

Venue: W303 School of Mathematics, Sichuan University.

We will begin with an overview of the advent of surfaces in representation theory in recent years, focussing on algebras and categories in the context of cluster algebras. We introduce Jacobian algebras of quivers arising from triangulations of marked bounded oriented surfaces, and their representation theory in terms of the surface. In particular, if the surface has no marked points in its interior, the Jacobian algebra associated to any triangulation is gentle and much information about the algebra is known in terms of the surface. In the second part of the course, we will focus on gentle algebras in general. This well-studied class of algebras has recently received renewed interest in particular in connection with Fukaya categories of surfaces with boundaries and stops in the work of Haiden, Katzarkov and Kontsevich. We will give a geometric model for the bounded derived category of a

gentle algebra and in the case of finite global dimension, we will link it with the partially wrapped Fukaya categories in Haiden, Katzarkov and Kontsevich's work. Finally, we give a complete invariant in terms of the surface to distinguish between derived equivalence classes of gentle algebras.

1. Cluster algebras and their classification.

2. Jacobian algebras of quiver with potential from triangulations of surfaces and cluster categories.

3. Gentle algebras.

4. Derived model for gentle algebras and link with partially wrapped Fukaya categories of surfaces with stops.

5. Winding numbers, Arf invariants and derived invariants.

2.4 Hierarchies of soliton equations and symmetric functions

Lecturer: Natalia Rozhkovskaya (Kansas State U, USA)

Time: January 5: 16:00-18:00

January 6: 20:00-22:00

January 7 & 10: 08:00-09:30

Venue: W303 School of Mathematics, Sichuan University.

There exists a class of partial differential equations that possess a family of exact solutions with remarkable properties. It turns out that complete integrability of these equations is implied by the presence of symmetries that are broadly studied in other areas of mathematics. In this course we will trace a connection between solitons, representations of infinite-dimensional structures, and symmetric functions. Suggested topics to be covered in the proposed course:

1. Examples of soliton equations: KdV and KP equations

2. Symmetric functions and their properties

3. Infinite-dimensional algebraic structures: Heiseinberg algebra, fermions, Virasoro algebra, Lie algebra $\mathfrak{gl}_\infty$.

4. Hirota derivatives

5. Bilinear form of KP hierarchy

6. Schur functions as solutions of KP hierarchy

7. Boson-Fermion correspondence

8. Action of infinite-dimensional algebraic structures on the Fock space of symmetric functions

9. Vertex operator presentations of several famous families of symmetric fucntions and

other hierarchies.

2.5 The Gerstenhaber bracket in the first Hochschild cohomology space

Lecturer: Andrea Solotar (U de Buenos Aires, Argentina)

Time: 14:00-16:00, January 13-17

Venue: W303 School of Mathematics, Sichuan University.

Homological methods provide important information about the structure of associative algebras, revealing sometimes hidden connections amongst them. This course will be about an invariant preserved by derived equivalences: the Gerstenhaber bracket in the first Hochschild cohomology space of unital associative algebras over a field k. There has been a significant amount of effort expended by many authors in order to study this structure, especially in recent times. The first Hochschild cohomology space of an algebra A is the quotient of the k-linear derivations of A by the inner derivations, and the Gerstenhaber bracket provides it of a Lie algebra structure. Recent work in this area has been devoted to describe which Lie algebras appear in this way, and in particular to conditions on the algebra implying the solvability of $\mathrm{HH}^1(A)$ as Lie algebra. I will start by describing in detail $\mathrm{HH}^1(A)$, paying particular interest to its Lie structure, then treat some families of examples and finally give criteria on the algebra A to imply solvability of $\mathrm{HH}^1(A)$.

3 Conference on Lie and Jordan Algebras, Their Representations and Applications-IX (January 6-11, 2020)

3.1 List of Speakers

Tomoyuki Arakawa (Japan)
Agustin Moreno Cañadas (Bogotá-Colombia)
Kevin Coulembier (Australia)
Maria Gorelik (Israel)
Jonas Hartwig (USA)
Dijana Jakelic (USA)
Libor Krizka (Czech)
Olivier Mathieu (France)
Adriano Moura (Brazil)
Victor Petrogradsky (Brazil)
Elena Poletaeva (USA)
Li Ren (China)
João Schwarz (Brazil)
Andrea Solotar (Argentina)
Efim Zelmanov (USA)
Shavkat Ayupov (Uzbekistan)
Marc Colarusso (USA)
Faber Gomez (Colombia)
William Hardesty (USA)
Kostyantyn Iusenko (Brazil)
Pavel Kolesnikov (Russia)
Ming Lu (China)
Alexander Molev (Australia)
Daniel Nakano (USA)
Julia Pevtsova (USA)
Luis Enrique Ramirez (Brazil)
Gus Schrader (USA)
Vera Serganova (USA)
Raul Velasquez (Colombia)
Ilia Zharkov (USA)

3.2 Schedule

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Opening	Serganova		Arakawa	Molev	Petrogradsky
Zelmanov	Pevtsova		Kolesnikov	Ren	Ramirez
Mathieu	Ayupov		Gorelik	Nakano	
Poletaeva	Jakelic		Moura	Solotar	
Colarusso	Krizka		Coulembier	Grantcharov	
Cañadas	Iusenko		Lu	Zharkov	
Schwarz	Schrader		Hartwig	Gomez	
			Velasquez	Hardesty	

MONDAY January 6

09:30 - 10:00	Opening
10:00 - 10:50	Efim Zelmanov (UC San Diego, USA) Finitely Presented Algebras
10:50 - 11:10	Coffee Break
11:10 - 12:00	Olivier Mathieu (U Lyon 1, France) Hidden Symmetries of Jordan algebras
12:30 - 14:30	Lunch
14:30 - 15:10	Elena Poletaeva (U Texas Rio Grande Valley, USA) On representations of finite W-algebras
15:15 - 15:55	Marc Colarusso (U South Alabama, USA) Orbits of Multiplicity free spherical subgroups on the flag variety
15:55 - 16:20	Coffee Break
16:20 - 17:00	Agustin M Cañadas (U Nacional de Colombia-Colombia) On some relationships between Brauer configuration algebras and Lie algebras
17:05 - 17:45	João Schwarz (U de São Paolo, Brazil) A Case of Naive Noncommutative Birational Equivalence

TUESDAY January 7

09:30 - 10:20	Vera Serganova (UC Berkeley, USA) Superdimension of irreducible representations of the periplectice Lie superalgebras
10:20 - 10:40	Coffee Break
10:40 - 11:30	Julia Pevtsova (U Washington, USA) Cohomology of finite dimensional Hopf algebras
11:40 - 12:30	Shavkat Ayupov (Uzbekistan Academy of Sciences) Local and 2-local derivations and automorphisms of Lie algebras
12:30 - 14:30	Lunch
14:30 - 15:10	Dijana Jakelic (U North Carolina Wilmington, USA) Reducibility of Tensor Products of Kirillov-Reshetikhin Modules via Duality
15:15 - 15:55	Libor Krizka (Czech Republic)

	Twisting functors and Gelfand–Tsetlin modules
15:55 - 16:20	Coffee Break
16:20 - 17:00	Kostyantyn Iusenko (U de São Paolo, Brazil) The path algebra as a left adjoint functor
17:05 - 17:45	Gus Schrader (Columbia U, USA) Coulomb branches and cluster algebras
18:30 - 20:30	Conference Banquet

WEDNESDAY January 8

	Free discussion

THURSDAY January 9

09:30 - 10:20	Tomoyuki Arakawa (U Kyoto, Japan) 4D/2D duality and representation theory
10:20 - 10:40	Coffee Break
10:40 - 11:30	Pavel Kolesnikov (Sobolev Inst Math, Russia) Gel'fand–Dorfman algebras, conformal algebras, and derived identities
11:40 - 12:30	Maria Gorelik (Weizmann Inst, Israel) Gruson-Serganova character formula and Duflo-Serganova functor
12:30 - 14:30	Lunch
14:30 - 15:10	Adriano Moura (Unicamp, Brazil) A graph approach to prime simple modules for quantum affine algebras
15:15 - 15:55	Kevin Coulembier (U Sydney, Australia) Classification of blocks in BGG category O
15:55 - 16:20	Coffee Break
16:20 - 17:00	Ming Lu (Sichuan University, China) A Serre presentation of i-quantum groups
17:05 - 17:45	Jonas Hartwig (Iowa State U, USA) Hopf Galois orders and related algebras
17:50 - 18:30	Raul Velasquez (U Antioquia, Colombia)

	Derivations of Loday Algebras

FRIDAY January 10

09:30 - 10:20	Alexander Molev (U Sydney, Australia) Center at the critical level for centralizers in type A
10:20 - 10:40	Coffee Break
10:40 - 11:30	Li Ren (Sichuan U, China) Parafermion vertex operator algebras
11:40 - 12:30	Daniel Nakano (U Georgia, USA) On Donkin's Conjectures with Counterexamples
12:30 - 14:30	Lunch
14:30 - 15:10	Andrea Solotar (U de Buenos Aires, Argentina) On the Lie algebra structure of the first Hochschild cohomology of gentle algebras
15:15 - 15:55	Dimitar Grantcharov (U Texas at Arlington, USA) Simple bounded weight modules of direct limit Lie algebras
15:55 - 16:20	Coffee Break
16:20 - 17:00	Ilya Zharkov (Kansas State U, USA) Tailoring a pair-of-pants
17:05 - 17:45	Faber Gomez (U Antioquia, Colombia) The second cohomology group for Jordan superalgebras of type Superform
17:50 - 18:30	William Hardesty (Lousiana State U, USA) Co-t-structures on derived categories of coherent sheaves

SATURDAY January 11

09:30 - 10:20	Viktor Petrogradsky (U Brasilia, Brazil) Nil Lie algebras of oscillating growth
10:20 - 10:40	Coffee Break
10:40 - 11:30	Luis E. Ramirez (UFABC, Brazil) Gelfand-Tsetlin modules for $\mathfrak{gl}(n)$

*All talks will take place at Rm 207 East Second Teaching Building, Sichuan University（四川大学东二教 207）.

3.3 Titles and abstracts

Tomoyuki Arakawa (U Kyoto, Japan)

Title: 4D/2D duality and representation theory

Abstract: The 4D/2D correspondence recently discovered in physics constructs representation theoretical objects, such as representations of an affine Lie algebra, as an invariant of the 4 dimensional superconformal field theory with N = 2 supersymmetry. Furthermore, it is predicted that a remarkable duality exists between the representation theoretical objects constructed in this way and the geometric invariant of the original 4 dimensional theory. In this talk, I will explain the duality between representation theoretical objects and geometric objects conjectured in the 4D/2D correspondence from a mathematical perspective.

Shavkat Ayupov (Uzbekistan Academy of Sciences)

Title: Local and 2-local derivations and automorphisms of Lie algebras

Abstract: The talk is devoted to investigations of local and 2-local derivations and automorphisms of finite- and infinite dimensional Lie algebras. We start by a survey of the finite-dimensional cases and then we show that on some classical infinite-dimensional Lie algebras-Witt algebras, Virasoro algebras, generalized Witt algebras etc., every 2-local derivation is a global derivation. We also give an example of an infinite-dimensional Lie algebra which admits a 2-local derivation which is not a derivation.

Agustin Moreno Cañadas (Universidad Nacional de Colombia-Colombia)

Title: On Some Relationships Between Brauer Configuration Algebras and Lie Algebras

Abstract: In this talk, we interpret Gelfand-Tsetlin patterns over the Lie algebra gl_n as indecomposable projective modules over some suitable Brauer configuration algebras which have been introduced recently by Green and Schroll in order to investigate algebras of wild representation type.

We also define integer sequences $m, m-2, \ldots, -m+2, -m$ associated to irreducible representations of the Lie algebra $sl(2, \mathbb{C})$ as specializations of Brauer configuration algebras defined by lattice paths in some quantum-Feynman regions.

References

[1] E.L. Green and S. Schroll, Brauer configuration algebras; A generalization of Brauer graph algebras, Bull. Sci. Math 141 (2017), 539-572.

[2] J. Kocik, Krawtchouk matrices from the Feynman path integral and from the split quater- nions, Arxiv: 1604.00109 1 (2016).

Marc Colarusso (**U South Alabama, USA**)

Title: Orbits of Multiplicity free spherical subgroups on the flag variety

Abstract: Let G be an algebraic group over $\mathbb{C}$, and let $K = G^\theta$ be a symmetric subgroup. The theory of K-orbits on the flag variety G/B of G was studied extensively by Richardson and Springer. The geometry of these orbits plays a central role in the construction of classical Harish-Chadra modules via the Beilinson-Bernstein correspondence. Much less is known about the theory of K-orbits on G/B when K is a *spherical* subgroup of G. In this talk, we describe geometric and combinatorial properties of the K-action on G/B, when (G, K) is a multiplicity free spherical pair. Using an analogue of the Beilinson-Bernstein correspondence, the geometry of these orbits can be used to construct a certain category of generalized Harish-Chandra modules related to the category of Gelfand-Zeitlin modules which quantize the Gelfand-Zeitlin integrable system. This is joint work with Sam Evens.

Kevin Coulembier (**U Sydney, Australia**)

Title: Classification of blocks in BGG category O

Abstract: Work of Jantzen, Soergel and others established many equivalences between blocks in category O for semisimple Lie algebras. We will turn those results into a full classification, up to equivalence, of all the categories which appear as indecomposable blocks in category O ranging over all reductive Lie algebras. This is obtained by establishing abstract results about highest weight categories and about combinatorics of Coxeter groups.

Faber Gomez (**U Antioquia, Colombia**)

Title: The second cohomology group for Jordan superalgebras of type Superform or Grassmann Poisson Bracket

Abstract: We consider a finite dimensional Jordan superalgebra A over an algebraically closed field of characteristic zero $\mathbb{F}$, N it is the solvable radical of A such that $N^2 = 0$ and A/N is a simple Jordan superalgebra of one of the simple Jordan superalgebras of superform $J(V, f)$ or Jordan superalgebra of Grassmann Poisson bracket $\mathrm{kan}(2)$. We study the second cohomology group and we prove that $H_2(J, C_n/C_{n-2}) = 0 \oplus \mathbb{F}$, $H_2(\mathrm{kan}_2, V(v, \alpha))$ is trivial.

Maria Gorelik (**Weizmann Inst, Israel**)

Title: Gruson-Serganova character formula and Duflo-Serganova functor

Abstract: The Dulfo-Serganova functor is a cohomology functor relating representation theory of Lie superalgebras of different ranks. This is a tensor functor preserving superdimension. Serganova conjectured that the image of a finite-dimensional simple module is semisimple. This conjecture for gl-type was established by Heidersdorf and Weissauer. I will sketch a proof of this result for osp-type. A key ingredient is the fact that we can define a parity for each finite-dimensional simple module in such a way that the Serre sub-

category generated by even modules is semisimple and that the Dulfo-Serganova functor preserves these subcategories. Using the same parity we show that the supercharacter ring admits a basis consisting of Kac-Wakimoto type elements with the following property: the coefficients of the supercharacter of each simple module written in this basis have the same sign. This is a joint project with Thorsten Heidersdorf.

Dimitar Grantcharov (U Texas at Arlington, USA)

Title: Simple bounded weight modules of direct limit Lie algebras

Abstract: In this talk we will discuss recent results on the category of weight modules with bounded sets of weight multiplicities of the direct limit Lie algebras $\mathfrak{sl}(\infty)$, $\mathfrak{o}(\infty)$, and $\mathfrak{sp}(\infty)$. Classification of the simple objects and properties of the category will be provided. This is a joint work with I. Penkov.

William Hardesty (Lousiana State U, USA)

Title: Co-t-structures on derived categories of coherent sheaves and the cohomology of tilting modules

Abstract: Since the mid 1990s, understanding the "Frobenius kernel cohomology" of tilting modules has been an important area of research in modular representation theory. Another important area of research, which is sometimes called "coherent Springer theory", involves the study of derived equivariant coherent sheaves on the nilpotent cone and the Springer resolution. Due to the work of Achar and Riche, we now know that both of these topics are related by a derived equivalence. In particular, the cohomology of a tilting module is given by the global sections of a corresponding (derived) equivariant coherent sheaf on nilpotent cone. In this talk, I will present recent joint work with Pramod Achar, where we intrinsically characterize these sheaves as the indecomposable objects in the "co-heart" of a certain non-trivial "co-t-structure" on the equivariant derived category of coherent sheaves on the nilpotent cone. I will also discuss some additional exciting progress that we have towards the study of tilting module cohomology by employing the framework of co-t-structures. This includes a new proof of the "Humphreys conjecture on support varieties" for SL_n, as well as a conjecture which alternatively characterizes these sheaves as extensions of "tilting bundles" on nilpotent orbits.

Jonas Hartwig (Iowa State U, USA)

Title: Hopf Galois orders and related algebras

Abstract: Galois orders, introduced by Futorny and Ovsienko, form a class of associative algebras which includes the (quantized) enveloping algebra of the general linear Lie algebra and related Yangians and finite W-algebras as well as generalized Weyl algebras and trigonometric Cherednik algebras. I will discuss a generalization of Galois orders which replaces a certain monoid in their definition by a bialgebra. This allows for new settings

including differential operator analogs of Galois orders. Examples here include the rational Cherednik algebra via Dunkl-Opdam differential-reflection operators. We show that important theorems from the classical theory carries over to this more general setting. Part of this talk is joint with Erich Jauch.

Kostyantyn Iusenko (**USP, Brazil**)

Title: The path algebra as a left adjoint functor

Abstract: In my talk I will revise the Gabriel quiver construction for algebras. We will see how to define the path algebra and Gabriel quiver as functors between the category of k-quivers and the category of pointed pseudocompact k-algebras, for k a field. Defining a congruence relation on the algebra side, we will prove that the Gabriel k-quiver functor is right adjoint to the corresponding path algebra functor obtaining an informative adjunction. As application, we discuss to what extent presentations of algebras in terms of path objects are unique (based on joint work with John Macquarrie).

Dijana Jakelic (**U North Carolina Wilmington, USA**)

Title: Reducibility of Tensor Products of Kirillov-Reshetikhin Modules via Duality

Abstract: Although the finite-dimensional representation theory of quantum affine algebras has been actively studied since the early 1990's, the question about reducibility of tensor products of its simple objects remains unanswered.

In the classical context, the answer has been given in terms of evaluation modules. However, in the quantum setting, evaluation modules exist only if the underlying finite-dimensional simple Lie algebra is of type A and, furthermore, a complete answer to the reducibility question is known only for type A_1. One approach to the problem comes from the R-matrix perspective relating this question to the origins of quantum group theory in mathematical physics and integrable systems. Namely, since an early work of Akasaka and Kashiwara, it is known that the reducibility of a tensor product of simple objects is related to the singularities of the R-matrix.

In this talk, we will address the problem of reducibility of tensor products of Kirillov-Reshetikhin (KR) modules utilizing duality. The KR modules may be considered, from a certain point of view, the most elementary class of irreducible modules in the category. We obtain the answer by essentially exploring effects of the basic fact that the trivial representation is embedded in the tensor product of a module with its dual. This is an ongoing joint project with A. Moura.

Pavel Kolesnikov (**Sobolev Inst Math, Russia**)

Title: Gel'fand–Dorfman algebras, conformal algebras, and derived identities

Abstract: A Lie algebra V (over a field $\Bbbk$ of characteristic zero) is said to be a *Gel'fand–*

Dorfman algebra (GD-algebra) if there is a binary linear operation $\circ : V \otimes V \to V$ such that

$$(a \circ b) \circ c - a \circ (b \circ c) = (b \circ a) \circ c - b \circ (a \circ c),$$
$$(a \circ b) \circ c = (a \circ c) \circ b,$$
$$[a, b \circ c] - [c, b \circ a] + [b, a] \circ c - [b, c] \circ a - b \circ [a, c] = 0.$$

Therefore, GD-algebra is a "breed" of Lie and Novikov algebra structures in a way similar to what happens with Lie and commutative structures in Poisson algebras. GD-algebras were introduced by I. Gel'fand and I. Dorfman (1979) in a relation to Hamiltonian operators in formal variational calculus. In the talk, we discuss the role of the operad GD and its Koszul dual $GD^!$ in the combinatorial theory of algebras with a derivation (joint work with B. Sartayev and A. Orazgaliev). Namely, the set of identities satisfied for operations $x \prec y = xd(y)$, $x \succ y = d(x)y$ on a differential algebra from a variety Var (with a derivation d) coincides with the defining relations of the Manin white product of operads $\mathrm{Var} \circ GD^!$.

GD-algebras attracted special attention after X. Xu (2000). In particular, every GD-algebra V gives rise to a Lie conformal algebra (V. Kac, 1996)

$$L(V) = \Bbbk[\partial] \otimes V$$

with the following formal λ-bracket:

$$[a_{(\lambda)}b] = [a, b] + \partial \otimes (b \circ a) + \lambda(a \circ b + b \circ a), \quad a, b \in V.$$

A GD-algebra V is said to be *special* if it can be embedded into a Poisson algebra P with a derivation d in such a way that $a \circ b = ad(b)$ for $a, b \in V$. Special GD-algebras form a proper sub-variety in the variety of all GD-algebras. In particular, for every Novikov algebra V with a product $\circ : V \otimes V \to V$, the system $(V, [\,], \circ)$, $[x, y] = x \circ y - y \circ x$, is a special GD-algebra. We prove that if a GD-algebra V is special then so is its Lie conformal algebra $L(V)$, i.e., the latter can be embedded into an associative conformal algebra (joint work with R. Kozlov and A. Panasenko).

References

[1] I. M. Gelfand, I. Ya. Dorfman, Hamilton operators and associated algebraic structures, Functional analysis and its application **13** (1979) (4) 13–30.

[2] V. G. Kac, Vertex Algebras for Beginners. University Lecture Series, **10**, 2nd edn. American Mathematical Society, Providence, 1996 (1998).

[3] P. S. Kolesnikov, B. Sartayev, A. Orazgaliev, Gelfand–Dorfman algebras, derived identities, and the Manin product of operads, Journal of Algebra 539 (2019) 260–284.

[4] P.S. Kolesnikov, R.A. Kozlov, A.S. Panasenko, Quadratic Lie conformal superalgebras related to Novikov superalgebras, arXiv:1912.03943.

[5] X. Xu, Quadratic Conformal Superalgebras, J. Algebra **231** (2000), 1–38.

Libor Krizka (**U de São Paolo, Brazil**)

Title: Twisting functors and Gelfand–Tsetlin modules

Abstract: We will discuss the Arkhipov's twisting functor associated to a positive root of a complex semisimple finite-dimensional Lie algebra $\mathfrak{g}$. By applying this functor for a non-simple root on Verma modules we obtain the so-called partial Gelfand–Tsetlin modules being outside the category $\mathcal{O}(\mathfrak{g})$. These $\mathfrak{g}$-modules are cyclic weight modules with central character and infinite-dimensional weight spaces. We will also describe a geometric realization of such modules through $\mathcal{D}$-modules on the corresponding flag variety. Moreover, they enable us to construct a new class of positive energy representations of simple affine vertex algebras of admissible levels. This talk is based on a joint work with Vyacheslav Futorny.

Ming Lu (**Sichuan U, China**)

Title: A Serre presentation of i-quantum groups

Abstract: A quantum symmetric pair consists of a quantum group and its coideal subalgebra (called an i-quantum group). In this talk, we present an explicit Serre presentation of quasi-split i-quantum groups and explain its related combinatorics. Following Lusztig, we also give the higher order Serre relations and the braid group actions of i-quantum groups. This is joint work with Xinhong Chen and Weiqiang Wang.

Olivier Mathieu (**U Lyon, France**)

Title: Hidden Symmetries of Jordan algebras

Abstract:

Alexander Molev (**U Sydney, Australia**)

Title: Center at the critical level for centralizers in type A

Abstract: By a celebrated theorem of Feigin and Frenkel (1992), the center of the affine vertex algebra at the critical level, associated with a simple Lie algebra $\mathfrak{g}$, is an algebra of polynomials in infinitely many variables. This theorem was extended in a recent work by Arakawa and Premet (2017) to the case where $\mathfrak{g}$ is replaced by the centralizer $\mathfrak{g}^e$ of a nilpotent element $e \in \mathfrak{g}$. We construct a family of free generators of the center for $\mathfrak{g} = \mathfrak{gl}_N$ and an arbitrary nilpotent element e.

Adriano Moura (**Unicamp, Brazil**)

Title: A Graph Approach to Prime Simple Modules for Quantum Affine Algebras

Abstract: It is well known that the tensor products of two simple finite-dimensional representations for the quantum affine algebras are almost always irreducible.

Thus, it is natural to seek for the classification of the simple prime modules, i.e., those which cannot be expressed as a non-trivial tensor product of other simple modules. The classification is known only in the case the underlying simple Lie algebra is of rank one. In higher rank, only a few families of prime modules are known, such as the minimal affinizations (including the Kirillov-Reshetikhin modules), the minimal affinizations by parts, the prime snake modules introduced by Mukhin and Young, a list of primes in type A_2 described by Chari and Pressley, and a few others which have been explicitly identified inside Hernandez-Leclerc subcategories. However, even for type A_2, it is clear that we are still far from a complete classification.

We will introduce the concept of q-factorization graph of a simple object which is based on the determination of when the tensor product of two Kirillov-Reshetikhin modules is reducible. We propose this as a natural language for describing the Drinfeld polynomials of the simple prime modules.

We end the talk presenting a few partial results in the direction of classifying the simple prime modules which, in particular, extend the list of known simple prime modules. The talk is based on an ongoing joint work with Clayton Silva.

Daniel Nakano (U Georgia, USA)

Title: On Donkin's Conjectures with Counterexamples

Abstract: Let G be a simple, simply connected algebraic group over an algebraically closed field of prime characteristic. Recent work of Kildetoft and Nakano and of Sobaje has shown close connections between two long-standing conjectures of Donkin: one on tilting modules and the lifting of projective modules for Frobenius kernels of G and another on the existence of certain filtrations of G-modules.

In this talk, I will survey recent results in this area and present new results where we verify the one direction of Donkin's (p, r) Filtration Conjecture for rank 2 groups for all primes. I will also show a recently discovered counterexample to the Tilting Module Conjecture.

These results represent joint work with Christopher Bendel, Cornelius Pillen and Paul Sobaje.

Victor Petrogradsky (U Brasilia, Brazil)

Title: Nil Lie algebras of oscillating growth

Abstract: The Grigorchuk and Gupta-Sidki groups play fundamental role in modern group theory. They are natural examples of self-similar finitely generated periodic groups. The author constructed their analogue in case of restricted Lie algebras of characteristic 2 [3], Shestakov and Zelmanov extended this construction to an arbitrary positive charac-

teristic [6].

In characteristic zero, similar examples of Lie algebras do not exist [1]. But there are analogues of the Grigorchuk and Gupta-Sidki groups in the world of Lie superalgebras of an arbitrary characteristic [4]. In these examples, $\operatorname{ad} a$ is nilpotent, a being even or odd with respect to $\mathbb{Z}_2$-grading as Lie superalgebras. This property is an analogue of periodicity of the Grigorchuk and Gupta-Sidki groups. So, we get an example of a nil finely-graded Lie superalgebra of slow polynomial growth, which shows that an extension of a theorem due to Martinez and Zelmanov [1] for the Lie superalgebras of characteristic zero is not valid.

The author constructed a family of 2-generated restricted Lie algebras of slow polynomial growth with a nil p-mapping, a field of positive characteristic being arbitrary. In particular, we obtain a continuum subfamily of nil restricted Lie algebras having Gelfand-Kirillov dimension one but the growth is not linear [5].

The present research is motivated by a recent construction of groups of oscillating intermediate growth [2], (where nothing is claimed on periodicity). Now, for any prime $p \geq 2$, we construct a family of 3-generated restricted Lie algebras of intermediate oscillating growth. We call them *Phoenix algebras* because, for infinitely many periods, the algebra is "almost dying" by having "almost linear" growth, more precisely, the lower Gelfand-Kirillov dimension is one. On the other hand, for infinitely many n the growth function behaves like $\exp(n/(\ln n)^{\lambda})$, λ being a constant for the algebra, for such periods the algebra is "resuscitating". These restricted Lie algebras have a nil p-mapping.

References

[1] Martinez C., Zelmanov E., Nil algebras and unipotent groups of finite width. *Adv. Math.* **147**, (1999) No.2, 328–344.

[2] Kassabov M., Pak, I., Groups of oscillating intermediate growth. *Ann. Math.* (2) **177**, (2013) No. 3, 1113–1145.

[3] Petrogradsky V.M., Examples of self-iterating Lie algebras, *J. Algebra*, **302** (2006), no. 2, 881–886.

[4] Petrogradsky V., Fractal nil graded Lie superalgebras, *J. Algebra*, **466** (2016), 229–283.

[5] Petrogradsky V., Nil Lie p-algebras of slow growth, *Comm. Algebra.* **45**, (2017), no. 7, 2912–2941.

[6] Shestakov I.P. and Zelmanov E., Some examples of nil Lie algebras. *J. Eur. Math. Soc. (JEMS)* **10** (2008), no. 2, 391–398.

Julia Pevtsova (U Washington, USA)

Title: Cohomology of finite dimensional Hopf algebras

Abstract: This is a report on the ongoing project with Nicolás Andruskiewitsch, Iván Angiono, and Sarah Witherspoon in which we aim to prove that cohomology of a finite

dimensional Nichols algebras of diagonal type is a finitely generated algebra. I'll give an overview of the history of the problem of finite generation of cohomology for Hopf algebras and outline some of the current progress.

Elena Poletaeva (**U Texas Rio Grande Valley, USA**)

Title: On representations of finite W-algebras

Abstract: Let $\mathfrak{g}$ be the queer Lie superalgebra $Q(n)$ or a basic Lie superalgebra. Let W be the finite W-algebra for $\mathfrak{g}$ associated with the principal even nilpotent coadjoint orbit. Simple W-modules are all finite-dimensional. We describe simple W-modules for $Q(n)$ and study blocks in the category of finite-dimensional W-modules.

This is a joint work with V. Serganova.

Luis Enrique Ramirez (**UFABC, Brazil**)

Title: Gelfand-Tsetlin modules for $\mathfrak{gl}(n)$

Abstract: In 1950 I. Gelfand and M. Tsetlin constructed bases and explicit formulas for the action of $\mathfrak{gl}(n)$ for every irreducible finite dimensional $\mathfrak{gl}(n)$-module. The bases are parameterized by combinatoric objects called Gelfand-Tsetlin tableaux. In this talk we describe two different approaches that generalize the construction of Gelfand and Tsetlin.

Joint work with V. Futorny, D. Grantcharov, P. Zadunaisky, and J. Zhang

Li Ren (**Sichuan U, China**)

Title: Parafermion vertex operator algebras

Abstract: The rationality of the parafermion vertex operator algebra $K(\mathfrak{g}, k)$ associated to any finite dimensional simple Lie algebra $\mathfrak{g}$ and any nonnegative integer k is established and the irreducible modules are classified. Use the trace function for the affine vertex operator algebras and lattice vertex operator algebras to study the trace functions for the parafermion vertex operator algebras.

Gus Schrader (**Columbia U, USA**)

Title: Coulomb branches and cluster algebras

Abstract: Braverman, Finkelberg and Nakajima have recently proposed a mathematical definition of the Coulomb branch of a 4d N=2 gauge theory of cotangent type, associating to each such theory a family of associative algebras deforming the algebra of functions on an affine Poisson variety. In this talk I will discuss joint work with Alexander Shapiro (arxiv 1910.03186) in which we confirm, in the case of gauge theories determined by quivers without loops, Gaiotto's prediction that the Coulomb branch algebra should embed into the quantum cluster algebra determined by the BPS quiver of the theory. Our proof is based on identifying the so-called 'total DT-invariant' associated to this cluster algebra,

which leads to an explicit identification of the monopole operators corresponding to minuscule coweights with certain cluster monomials.

João Schwarz (**U de São Paolo, Brazil**)

Title: A Case of Naive Noncommutative Birational Equivalence

Abstract: It is well known that the question of whether two affine algebraic varieties are birationally equivalent is equal to the question of whether their function fields are isomorphic. If we stick with the correspondence between varieties and their rings of regular functions in the setting of noncommutative Ore domains, then a natural and very simple notion of noncommutative birational equivalence arises: that being the case if we have isomorphic division rings of fractions. This is the idea behind the celebrated and influential Gelfand-Kirillov Conjecture. It highlights the role of the Weyl Fields in noncommutative division rings. Based on this, Alev and Dumas in 2006 introduced an analogue of Noether's Problem – the question of rationality of quotients of the affine space – for the Weyl Algebra. We discuss the striking similarity between the original Noether's Problem and its version for the Weyl Algebra. This talk is based in joint work with V. Futorny.

Vera Serganova (**UC Berkeley, USA**)

Title: Superdimension of irreducible representations of the periplectice Lie superalgebras

Abstract: We will give a combinatorial formula for the superdimension of any irreducible representation of the Lie superalgebra $P(n)$. This formula is obtained by induction on n and by computation of DS functor, the tensor functor from the category of representations of $P(n)$ to the category of representations of $P(n-1)$. This is a joint work with Inna Entova-Aizenbud.

Andrea Solotar (**U de Buenos Aires, Argentina**)

Title: On the Lie algebra structure of the first Hochschild cohomology of gentle algebras and Brauer graph algebras

Abstract: In this talk I will explain how to determine the first Hochschild homology and cohomology with different coefficients for gentle algebras and a geometrical interpretation of these (co)homologies using the ribbon graph of a gentle algebra as defined in earlier work by S. Schroll. I will give an explicit description of the Lie algebra structure of the first Hochschild cohomology of gentle and Brauer graph algebras (with multiplicity one) based on trivial extensions of gentle algebras and I will show how the Hochschild cohomology is encoded in the Brauer graph. In particular, we will see that except in one low-dimensional case, the resulting Lie algebras are all solvable.

Raul Velasquez (**U Antioquia, Colombia**)

Title: Derivations of Loday Algebras

Abstract: In the talk we review the notions of derivations in Loday algebras and we show general properties. We also introduce one interesting class of tensor associative dialgebras and we characterize their derivations.

Joint work with José Gregorio Rodríguez-Nieto and Olga P. Salazar-Díaz, Escuela de Matemáticas, Univ. Nacional de Colombia, sede Medellín, Colombia.

Efim Zelmanov (**UC San Diego, USA**)

Title: Finitely Presented Algebras

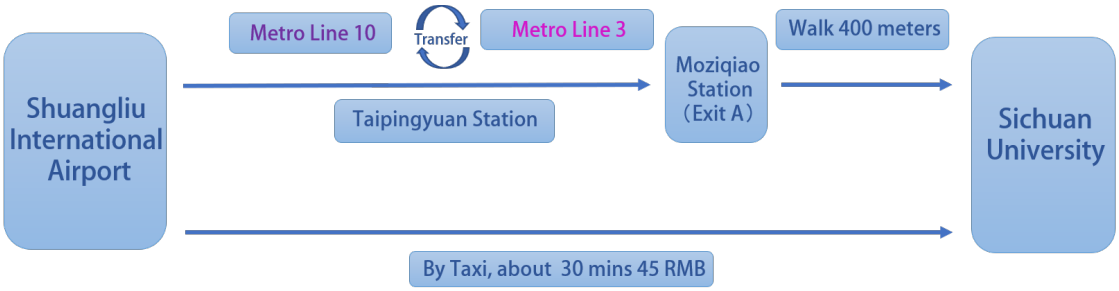
Abstract: We discuss finite presentability of important classes of infinite dimensional Lie and Jordan algebras.

Ilia Zharkov (**Kansas State U, USA**)

Title: Tailoring a pair-of-pants

Abstract: I will describe a regular CW structure on any complex hyperplane arrangment (the Salvetti complex) and compare it with the Orlik-Solomon algebra. On the other hand I will propose a polyhedral object, the ober-tropical hyperplane arrangement, which sits in the product of the two skeleta (the amoeba's and the coamoeba's) and has the same regular CW structure, and hence the same topology. I will mostly discuss the example of pair-of-pants, and perhaps, lines in the plane.

Transportation route



Hotel information

All participants will be accommodated in the following two hotels:

1. Cynn Hotel (in Chinese: 世外桃源酒店)

Address: 69 Kehua North Road, Wuhou District, Chengdu, P. R. China
(in Chinese: 成都市武侯区科华北路 69 号)

Phone: (+86) 28-8558 9999

Website: http://www.cynn.cn

2. Kehua Yuan Hotel (in Chinese: 科华苑宾馆)

Address: 141 Kehua North Road, Wuhou District, Chengdu, P. R. China
(in Chinese: 成都市武侯区科华北路 141 号)

Phone: (+86) 28-8546 2555

Website: http://1367390.hotel.cthy.com

Campus map


四川大学望江校区平面示意图
N
成都地铁 CHENGDU METRO
Moziqiao Station
NORTH GATE
北大门
EAST GATE
东大门
SOUTH GATE
南大门
WEST GATE
西大门
TMCSC
2nd Teaching Bldg
科华北路
一环路南一段
二环路南一段
新南路
锦江
九眼桥
1 CYNN HOTEL（世外桃源）
2 JINJIANG INN HOTEL（锦江之星）
3 KEHUAYUAN HOTEL（科华苑宾馆）
4 BEIYUAN HOTEL（北苑宾馆）
5 HONGWA HOTEL（红瓦宾馆）
6 MOZIQIAO STATION（磨子桥地铁站）
FROM WEST GATE/SOUTH GATE TO TMCSC
2nd Teaching Bldg