REPRESENTATION THEORY XVI

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Organizers:

Dražen Adamović, Andrej Dujella, Hrvoje Kraljević, Antun Milas,

Pavle Pandžić, Mirko Primc, David Vogan

ABSTRACTS OF TALKS

Znanstveni centar izvrsnosti za kvantne i kompleksne sustave te reprezentacije Liejevih algebri

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Real Groups Section

Hodge Theory and Unitary Representations

Jeffrey Adams, University of Maryland

Irreducible representations of a reductive group carry a canonical Hodge filtration. Wilfried Schmid and Kari Vilonen have a precise conjecture relating this filtration to the signature of the canonical form on the representation which arises in the study of the unitary dual. We prove a weak form of their conjecture: roughly speaking the c-form is the reduction of the Hodge filtration modulo 2. This is joint work with Peter Trapa and David Vogan.

Quantum Langlands duality of representations of W-algebras

Tomoyuki Arakawa, RIMS, Kyoto

We prove duality isomorphisms of certain representations of W-algebras which play an essential role in the quantum geometric Langlands Program and some related results. This is a joint work with Edward Frenkel.

Dirac cohomology for complex classical groups

Dan Barbasch, Cornell University

In joint work with Daniel Wong and Chao-Ping Dong, we have classified the portion of the unitary dual with nontrivial Dirac cohomology. The results generalize the classification of unitary representations with nontrivial $(\mathfrak{g}, K)-$cohomology, and rely on earlier results joint with Pandžić.

Arakawa-Suzuki functors for Whittaker modules

Adam Brown, IST Austria

The Milicic-Soergel category of Whittaker modules is a category of Lie algebra representations which generalize other well-known categories, such as the Bernstein-Gelfand-Gelfand category O. In this talk (inspired by the work of Arakawa and Suzuki for category O) we will construct a family of exact functors from the category of Whittaker modules to the category of finite-dimensional graded affine Hecke algebra modules, for type A_n. These algebraically defined functors provide us with a representation theoretic analogue of certain geometric relationships, observed independently by Zelevinsky and Lusztig, between the flag variety and the variety of graded nilpotent classes. Using this geometric perspective and the Kazhdan-Lusztig conjectures for each category, we will prove that these functors map simple modules to simple modules (or zero).

Positive definite forms and semisimple Jacquet modules

Dan Ciubotaru (University of Oxford)

I will present several results, obtained partly in joint work with Dan Barbasch, regarding an analogue for p-adic groups and affine Hecke algebras of c-invariant forms, originally introduced in the setting of $(\mathfrak{g}, K)$-modules by Adams, Trapa, van Leeuwen, and Vogan. One observation in the setting of p-adic groups is that the positive definiteness of these forms relates to the semisimplicity of Jacquet modules.

The Racah algebra and multivariate Racah polynomials

Hendrik De Bie, Ghent University, Belgium

The rank one Racah algebra is the algebraic structure underlying the Racah polynomials, which are the most complicated univariate discrete orthogonal polynomials in the celebrated Askey scheme. Recent work has focused on extensions of this algebra to higher rank. I will explain the procedure and will highlight the connection with the multivariate Racah polynomials. If time allows, some remarks on bispectrality will be made.

This is joint work with Luc Vinet, Wouter van de Vijver and Plamen Iliev.

Generalized Fourier transforms arising from $sl(2)$-triples and Cartan involutions

Jing-Song Huang, HKUST

The Fourier transform on the n-dimensional Euclidean space can be identified as an element of the metaplectic group through the oscillator representation. We obtained several families of elements of the metaplectic group which have the important properties similar to the Fourier transform. This led us to consider the generalized Fourier transforms in more general setting of unitary representations of semisimple Lie groups. These generalized Fourier transforms arise from sl(2)-triples associated with nilpotent adjoint orbits and Cartan involutions.

On freeness of $U(\mathfrak{g})$ as the $U(\mathfrak{g})^K-$module and action of $K \times K$ on $U(\mathfrak{g})$ for real simple Lie algebra $\mathfrak{g}$

Hrvoje Kraljević, University of Zagreb

Let $\mathfrak{g}$ be a real noncompact simple Lie algebra, G its adjoint group, K a maximal compact subgroup of G, $U(\mathfrak{g})$ the universal enveloping algebra of the complexification $\mathfrak{g}^{\mathbb{C}}$, $P(\mathfrak{g})$ the polynomial algebra over $\mathfrak{g}^{\mathbb{C}}$ and let $U(\mathfrak{g})^K$ and $P(\mathfrak{g})^K$ be the subalgebras of $K-$invariants. Let $P_+(\mathfrak{g})^K = \{P \in P(\mathfrak{g})^K;\ P(0) = 0\}$ and $\mathcal{N}$ the zero set of $P_+(\mathfrak{g})^K$ in $\mathfrak{g}^{\mathbb{C}}$. Denote by $\mathcal{H}$ the subspace of $U(\mathfrak{g})$ spanned by all powers X^k, $X \in \mathcal{N}$, k nonnegative integers.

Using results of Kostant, Knopp and Chen-Bo Zhu we give rather strong evidence for the following conjectures:

1. $U(\mathfrak{g})$ is free $U(\mathfrak{g})^k-$module. In fact, the multiplication defines an isomorphism $U(\mathfrak{g})^K \otimes \mathcal{H} \to U(\mathfrak{g})$
2. As a $K-$module $\mathcal{H}$ is isomorphic to the space of regular functions $\mathcal{R}(K^{\mathbb{C}})$; thus, one can define an action of $K \times K$ on $U(\mathfrak{g})$ commuting with $U(\mathfrak{g})^K$ and as a $K \times K-$module $\mathcal{H}$ is a multiplicity free direct sum of all finite dimensional irreducible representations of $K \times K$.

Highest weight vectors in plethysms

Soo Teck Lee, National University of Singapore

We realize the $\mathrm{GL}_n(\mathbb{C})$-modules $S^k(S^m(\mathbb{C}^n))$ and $\Lambda^k(S^m(\mathbb{C}^n))$ as spaces of polynomial functions on $n \times k$ matrices. In the case $k = 3$, we describe explicitly all the $\mathrm{GL}_n(\mathbb{C})$ highest weight vectors which occur in $S^3(S^m(\mathbb{C}^n))$ and in $\Lambda^3(S^m(\mathbb{C}^n))$ respectively. This is joint work with Kazufumi Kimoto.

Unipotent Representations and Microlocalization

Lucas Mason-Brown, MIT

Unipotent representations are an important and mysterious class of unitary representations of a real reductive group. In a sense, they are the atoms of unitary representation theory. In a paper from 1991, David Vogan provides a conjectural formula for their K-types. In this talk, I will prove this formula in a large family of cases. The key ingredient is a theory of microlocalization for Harish-Chandra modules, inspired by Ivan Losev's work on W-modules and primitive ideals. Time permitting, I will conclude by formulating a conjectural formula for the K-types of the unipotent representations to which Vogan's formula does not apply (i.e. when the associated variety contains a K-orbit of codimension 1).

Spectrum of locally symmetric spaces and branching rules

Salah Mehdi, Université de Lorraine; Institut Elie Cartan de Lorraine - CNRS, France

We consider compact locally symmetric spaces $\Gamma\backslash G/H$ where G/H is a semisimple symmetric space and Γ a cocompact discrete subgroup of G. We study representation theoretic features of the spectrum of the algebra of invariant differential operators on G/H. In the Lorentzian case we obtain an explicit description of this spectrum. As a byproduct we deduce a branching rule for H-spherical representations of a large class of semisimple Lie groups G. This is joint work with Martin Olbrich.

A geometric formula for u-homology of representations and some applications

Dragan Miličić, University of Utah

We shall describe a simple geometric formula for Lie algebra homology of a representation of a complex semisimple Lie algebra with respect to the nilpotent radical of a parabolic subalgebra. In the case of finite-dimensional representations, it is equivalent to Kostant's generalized Borel-Weil-Bott theorem.

Then we shall discuss some simple consequences of that formula in the case of infinite-dimensional representations.

Singularities of nilpotent Slodowy slices and collapsing levels for W-algebras

Anne Moreau, University of Lille

Just as nilpotent orbit closures in simple Lie algebra, nilpotent Slodowy slices play a significant role in representation theory and in the theory of symplectic singularities. In other direction, it is known that they appear as associated variety of W-algebras. It is also known that they appear as the Higgs branches of the Argyres-Douglas theories in $4d$ $N = 2$ SCFTs.

In my talk, I will explain how these facts are related, and how we can use this to study collapsing levels for W-algebras, and related conjectures, thus extending works of Adamović, Kac, MÃ¶senender, Papi and Perše on collapsing levels for minimal W-algebras. This is based on a joint work in progress with Tomoyuki Arakawa.

Conformal embeddings in basic classical Lie superalgebras

Pierluigi Möseneder Frajria, Politecnico Milano

We will discuss the conformal embeddings between basic classical Lie superalgebras with emphasis on the case of the embedding of the even part in the whole Lie superalgebra. We classify such embeddings and in many relevant cases, we compute the decomposition of the affine vertex algebra of the ambient Lie superalgebra as a module for the affine vertex algebra of the embedded subalgebra. The main tool is a fusion rules argument that proves to be very powerful. Joint work with D. Adamović, V. Kac, P. Papi, O. Perše.

Steinberg theory for symmetric pairs

Kyo Nishiyama (Aoyamagakuin University)

Classical Steinberg theory provides a correspondence between the Weyl group and the set of nilpotent orbits. We discuss a generalization of the theory to symmetric pairs, and give a frame work to obtain various geometric/combinatorial correspondences. In principle, we consider a double flag variety X of finite type and establish a geometric map from orbit space on X and certain nilpotent orbits associated with the symmetric pair. I will explain it in type A and get a generalization of Robinson-Schensted correspondence. The talk is based on a joint work arXiv:1904.13156 with Lucas Fresse (IECL, Lorraine University).

Nilpotent Orbits in `atlas`

Annegret Paul, Western Michigan University

We describe and explain some recently added functionalities included in the Atlas software. In particular, we give examples and discuss the computation of complex and real nilpotent orbits in reductive Lie algebras, as well as some of their properties (such as the dimension), and a description of the component groups of their centralizers.

Sakellaridis-Venkatesh conjectures for the discrete spectrum of a real classical symmetric space

David Renard, Ecole Polytechnique

This is joint work with C. Moeglin. We check Sakellaridis-Venkatesh conjectures about the discrete spectrum of a spherical variety G/H when G is a classical real group and G/H is a symmetric space. These conjectures give a description of the discrete spectrum in the Arthur-Langlands formalism.

Hodge theory and unitary representations of reductive groups

Wilfried Schmid, Department of Mathematics, Harvard University

Understanding the irreducible unitary representations of reductive Lie groups is the major remaining problem in the representation theory of such groups. I shall describe an algebraic-geometric approach to the study of their unitary representations. This is joint work with Kari Vilonen.

On classification of unitary highest weight modules

Vít Tuček, University of Zagreb

We redo the classification of unitary highest weight modules combining ideas from previous works on the topic and the Dirac inequality. In particular, the Dirac inequality for the PRV components of the tensor product of the spinor representation with the lowest K-type gives insight into the interplay between unitarizablity and Weyl group chambers. Joint work in progress with Pavle PandÅŸiÄ and VladimÃr SouÄek.

The local Langlands conjecture for finite groups of Lie type

David Vogan, MIT

In the late 1960s, Langlands' study of automorphic forms led him to a remarkable conjecture about the representation theory of reductive groups over local fields. The simplest and most fundamental case of this conjecture says that if F is any local field, then the (infinite-dimensional) irreducible representations of $GL(n, F)$ are indexed (approximately) by the n-dimensional representations of the Galois group of F.

In the 1970s, Macdonald formulated and proved an analogue of Langlands' conjecture for the finite group $GL(n, \mathbb{F}_q)$. I will explain how one can extend Macdonald's formulation to any finite group of Lie type; what results of Lusztig and Shoji offer toward proof of this extension; and how these questions are related to Langlands' (still unproven!) conjecture about local fields.

On Indecomposable $\mathbb{N}$-graded Vertex Algebras

Gaywalee Yamskulna, Illinois State University

In this talk, I will discuss the algebraic structure of $\mathbb{N}$-graded vertex algebras $V = \oplus_{n=0}^{\infty} V_{(n)}$ such that dim $V_{(0)} \geq 2$ and $V_{(1)}$ is a (semi)simple Leibniz algebra that has sl_2 as its Levi factor.

Vertex Algebra Section

Quantum Langlands duality of representations of W-algebras

Tomoyuki Arakawa, RIMS, Kyoto

We prove duality isomorphisms of certain representations of W-algebras which play an essential role in the quantum geometric Langlands Program and some related results. This is a joint work with Edward Frenkel.

Orbifold deconstruction

Peter Bantay, EÃ¶tvÃ¶s LorÃ¡nd University, Budapest

We discuss the problem of orbifold deconstruction, i.e. how to recognize wether a conformal model is an orbifold of another one, and if so, how to identify the original model and the relevant twist group.

Higher Level Zhu algebras

Katrina Barron, University of Notre Dame, Notre Dame, Indiana USA

We discuss aspects of higher level Zhu algebras and applications to logarithmic conformal field theory.

Principal subspaces for the affine Lie algebras of type F, E and D

Marijana Butorac, University of Rijeka

In this talk we will describe combinatorial bases of principal subspaces of level $k \geqslant 1$ standard module $L(k\Lambda_0)$ and of the generalized Verma module $N(k\Lambda_0)$ for the untwisted affine Lie algebras in types D, E and F in terms of quasi-particles, originally used by G. Georgiev. We use these bases to derive presentations of the principal subspaces, calculate their character formulas and find some new combinatorial identities. This talk is based on a joint work with Slaven Kožić.

A factory of equivalences within the Landau-Ginzburg/conformal field theory correspondence

Ana Ros Camacho, Mathematisch Instituut, Universiteit Utrecht

In this talk, we will present a collection of examples of equivalences of categories within the context of the Landau-Ginzburg/conformal field theory correspondence. The way to obtain these is via a certain equivalence relation between potentials describing Landau-Ginzburg models. We will describe in detail this construction, how it has provided interesting examples involving representations of the N=2 superconformal vertex operator algebra, and some work in progress in this direction.

Equality of dimensions of Zhu's algebra and C_2 algebra for symplectic fermions

Ante Čeperić, University of Zagreb

It is proved by D. Adamović and A. Milas, Adv. Math. (2011) that for the triplet vertex algebras, the dimensions of Zhu's algebra and C_2 algebra coincide. We study these structures for other logarithmic vertex algebras. In this talk we prove the equality of dimensions of Zhu's algebra and C_2 algebra for $\mathbb{Z}_2$–orbifold of the symplectic fermion vertex algebra.

Weak quasi-Hopf algebras and vertex operator algebras

Sebastiano Carpi, "G. D'Annunzio" University of Chieti-Pescara

Weak quasi-Hopf algebras give a generalization of Drinfeldâs quasi-Hopf algebras. They were introduced by Mack and Schomerus in the early nineties in order to describe quantum symmetries of certain conformal field theories. Every fusion category, and in particular the representation category of a strongly regular vertex operator algebra, is tensor equivalent to the representation category of a weak quasi-Hopf algebra. In this talk I will discuss some aspects of the theory of weak quasi-Hopf algebras in connection with vertex operator and explain some applications. This talk is based on a joint work with S. Ciamprone and C. Pinzari.

A construction of twisted modules for grading-restricted vertex (super)algebras

Yi-Zhi Huang, Rutgers University

We give a general, direct and explicit construction of (generalized) twisted modules for a grading-restricted vertex (super)algebra V associated to an automorphism g of V. Even in the case that g is of finite order, finding such a construction has been a long-standing problem in the representation theory of vertex operator algebra and orbifold conformal field theory. Besides twisted vertex operators, one crucial ingredient in this construction is what we call the "twist vertex operators" or "twist fields." Assuming that a graded vector space W equipped with a set of twisted fields and a set of twist fields satisfy a weak commutativity for twisted fields, a generalized weak commutativity for one twisted field and one twist field and a number of other properties that are relatively easy to verify, we define a twisted vertex operator map for W and prove that W equipped with this twisted vertex operator map is a (generalized) g-twisted V-module. We also give an explicit construction of such a space W, a set of twisted fields and a set of twist fields and thus an explicit construction of a (generalized) g-twisted V-module satisfying a universal property.

Simplicity and rationality of moonshine type vertex operator algebras generated by Ising vectors of σ-type.

Cuibo Jiang, Shanghai Jiao Tong University

We prove in this paper that any moonshine-type vertex operator algebra generated by Ising vectors of σ-type is simple, rational and C_2-cofinite. Together with the results of [Jiang-Lam-Yamauchi, 2017] , [Lam-Sakuma-Yamauchi, 2007], and [Matsuo, 2005], we give the full classification and characterization of moonshine-type vertex operator algebras generated by Ising vectors of σ-type. This is a joint work with Ching Hung Lam and Hiroshi Yamauchi.

Cohomology of algebraic structures: from Lie algebras to vertex algebras

Victor Kac, MIT

In my talk I will explain the foundations of the cohomology theory of vertex algebras, developed recently with Bakalov, De Sole and Heluani, as well as some of the concrete computations.

Smith algebra and classification of irreducible modules for certain W-algebras

Ana Kontrec, University of Zagreb

We want to study the representation theory of some irrational affine W-algebras (joint project with D. Adamovic). In this talk, we study representations of Bershadsky-Polyakov algebra $W^k(sl_3, f_\theta)$, the minimal affine W-algebra associated to sl_3 at certain levels using two approaches: one which relies on number theoretical methods and another one which is based on the highest weight theory for modules of the Smith associative algebra. In particular, Zhu algebra of $W_k(sl_3, f_\theta)$ is realized as a quotient of the Smith algebra. We investigate this connection and use it to classify irreducible ordinary modules.

Quantum currents and quantum vertex algebras

Slaven Kožić, University of Zagreb

In this talk, we will discuss the notion of quantum current, as defined by N. Yu. Reshetikhin and M. A. Semenov-Tian-Shansky. We will focus on its role in the Etingof–Kazhdan's construction of quantum vertex algebras and on some further applications. Also, we will present the recent construction of h-adic quantum vertex algebras in types B, C and D, which is a joint work with M. Butorac and N. Jing.

Some Zhu reduction formula and applications

Matthew Krauel, California State University, Sacramento

Zhu's important paper on the modularity of n-point functions for rational and C_2-cofinite VOAs largely depends on a series of reduction formulas he developed. In this talk we explore the analogous reduction formulas for n-point functions of two-variables, focusing on some applications and consequences of these formula.

Automorphism groups of some orbifold models of lattice VOAs

Ching Hung Lam, Institute of Mathematics, Academia Sinica

Let L be an even lattice. Let $g \in O(L)$ be a fixed point free isometry of order n. We study the automorphism groups of the orbifold VOA $V_L^{\hat{g}}$, where $\hat{g}$ is a lift of g in $Aut(V_L)$. We noticed that $Aut(V_L^{\hat{g}})$ contains some extra automorphisms if L is a n-neighbor of a certain overlattice of a root lattice of type $A_{n_1}^{k_1} A_{n_2}^{k_2} \cdots A_{n_i}^{k_i}$, where $n_1+1 = n$ and $n_i + 1$ divides n.

We will discuss several explicit examples and use it to determine the full automorphism groups of some holomorphic VOAs of central charge 24.

Cosets of the large $N = 4$ superconformal algebra and the diagonal coset of sl_2

Andrew Linshaw, University of Denver

The affine VOA of $D(2, 1; \alpha)$, and its orbifolds, cosets, and quantum Hamiltonian reductions, are examples of two-parameter families of VOAs. Another class of two-parameter families is obtained by taking the diagonal coset of an affine VOA $V^{k_1+k_2}(g)$ inside $V^{k_1}(g) \otimes V^{k_2}(g)$, for some simple Lie algebra g. We show that the large $N = 4$ superconformal algebra, which is the minimal W-algebra of $D(2, 1; \alpha)$, has the following property. Its coset by its affine subVOA is isomorphic as a two-parameter family, to the diagonal coset of sl_2. We also show that at special points in the parameter space, the simple quotients of these cosets are isomorphic to various interesting structures, such as principal W-algebras of type C. As a corollary, we obtain the rationality of the principal W-algebra of sp_{2n} at level $k = -(n + 1) + \frac{2n-1}{4(n-1)}$ for all $n \geq 2$, which is a degenerate admissible level.

This is a joint work with Thomas Creutzig and Boris Feigin.

Conformal embeddings in basic classical Lie superalgebras

Pierluigi Möseneder Frajria, Politecnico Milano

We will discuss the conformal embeddings between basic classical Lie superalgebras with emphasis on the case of the embedding of the even part in the whole Lie superalgebra. We classify such embeddings and in many relevant cases, we compute the decomposition of the affine vertex algebra of the ambient Lie superalgebra as a module for the affine vertex algebra of the embedded subalgebra. The main tool is a fusion rules argument that proves to be very powerful. Joint work with D. Adamović, V. Kac, P. Papi, O. Perše.

On some q-series identities of Rogers-Ramanujan type

Antun Milas, University at Albany (SUNY)

I'll discuss new q-series identities motivated by studies of logarithmic vertex superalgebras.

On C_2-cofiniteness of Commutant subVOA

Masahiko Miyamoto, Academia Sinica and University of Tsukuba

We prove C_2-cofiniteness of a commutant subVOA $Com(U, V)$ for a C_2-cofinite VOA $V \cong V'$and its regular subVOA U under some conditions. This is a joint work with Toshiyuki Abe and Ching Hung Lam.

BRST Construction of 10 Borcherds-Kac-Moody Algebras

Sven Möller, Rutgers University

Borcherds-Kac-Moody algebras are natural generalisations of finite-dimensional simple Lie algebras. There are exactly 10 Borcherds-Kac-Moody algebras whose denominator identities are completely reflective automorphic products of singular weight on lattices of squarefree level (classified by Scheithauer). These belong to a larger class of Borcherds-Kac-Moody (super)algebras obtained by Borcherds by twisting the denominator identity of the Fake Monster Lie algebra. For the 10 Lie algebras we prove a conjecture by Borcherds that they can be realised uniformly as the physical states of bosonic strings moving on suitable spacetimes. This amounts to applying the BRST formalism to certain vertex algebras of central charge 26 obtained as graded tensor products of abelian intertwining algebras.

Singularities of nilpotent Slodowy slices and collapsing levels for W-algebras

Anne Moreau, University of Lille

Just as nilpotent orbit closures in simple Lie algebra, nilpotent Slodowy slices play a significant role in representation theory and in the theory of symplectic singularities. In other direction, it is known that they appear as associated variety of W-algebras. It is also known that they appear as the Higgs branches of the Argyres-Douglas theories in $4d$ $N = 2$ SCFTs.

In my talk, I will explain how these facts are related, and how we can use this to study collapsing levels for W-algebras, and related conjectures, thus extending works of Adamović, Kac, MÃ¶senender, Papi and Perše on collapsing levels for minimal W-algebras. This is based on a joint work in progress with Tomoyuki Arakawa.

On collapsing levels

Paolo Papi, La Sapienza, University of Rome

Let $\mathfrak{g}$ be a simple Lie algebra and W be the simple $\mathcal{W}$–algebra $W_k(\mathfrak{g}, \theta)$, associated to a minimal nilpotent element $e_{-\theta}$. A level k is called *collapsing* if W is isomorphic to its affine vertex subalgebra. Collapsing level are encoded by a certain degreee two polynomial $p_{\mathfrak{g}}(t)$. Victor Kac noticed that the same polynomial $p_{\mathfrak{g}}(t)$, in Drinfeld's theory of Yangians, is related the minimal quantization of the adjoint representation. I will discuss in detail some background results by Drinfeld on Yangians and fomulate a speculative connection with vertex operator algebras generated by fields of low conformal weight. This talk is based on a joint project with AdamoviÄ, Kac, Möseneder Frajria and Perše on studying collapsing levels in connection with the representation theory of the simple affine vertex algebras.

Orbifolds and $\mathcal{W}$-algebras

Michael Penn, Randolph College

Orbifolds and $\mathcal{W}$-algebras are two important examples of vertex operator algebras that have garnered significant attention recently. In this talk, we examine the S_3 orbifold of the rank three Heisenberg, free fermion, and symplectic

fermion algebras as well as the three fold tensor product of simple level 1 affine vertex algebra associated to $\mathfrak{sl}_2$. Further, we explore isomorphisms between orbifolds and $\mathcal{W}$-algebras associated to $\mathfrak{osp}(1|8)$ and $\mathfrak{sl}(4)$.

A part of this talk is based on joint paper with A. Milas and J. Wauschope and H. Shao.

On irreducibility of Whittaker modules for cyclic orbifold vertex algebras and application to the Weyl algebra

Veronika Pedić, University of Zagreb

Recently, modules of Whittaker type have attracted great interest in the representation theory of vertex algebras and infinite-dimensional Lie algebras. In the first part of the talk we present a new result on irreducibility of modules of Whittaker type for cyclic orbifold vertex algebra (joint work with Dražen Adamović, Ching Hung Lam, and Nina Yu). Then we apply this result to orbifolds of the Weyl vertex algebra.

A Kazhdan–Lusztig algorithm for Whittaker modules

Anna Romanov, University of Sydney

In 1997, MiliÄiÄ and Soergel introduced a category of Whittaker modules for a complex semisimple Lie algebra which generalizes Bernstein–Gelfand–Gelfandâs category $\mathcal{O}$ and displays similar structural properties. Using the localization theory of Beilinson–Bernstein, one obtains a beautiful geometric description of this category as a category of twisted sheaves of D-modules on the associated flag variety. This geometric setting can be used to develop an algorithm for computing the composition multiplicities of standard Whittaker modules, and it establishes that these multiplicities are determined by parabolic Kazhdan-Lusztig polynomials. In this talk, I will describe the two categories playing a role in this story and sketch the algorithm.

Principal subspaces of twisted modules for certain lattice vertex operator algebras

Christopher Sadowski, Ursinus College

Principal subspaces of standard modules for affine Lie algebras were originally defined and studied by Feigin and Stoyanovsky. Their work was later extended and generalized by many other others in several directions. In particular, Capparelli, Lepowsky, and Milas showed that the Rogers-Ramanujan and Rogers-Selberg recursions can be interpreted in terms of exact sequences among principal subspaces, and from these recursions one obtains that the characters of these principal subspaces are the sum-sides of the Andrews-Gordon identities. This work was later generalized by Penn for certain “commutative” lattice vertex operator algebras. In this talk, we further generalize the work of Penn to twisted modules for these lattice vertex operator algebras. We prove defining relations for the principal subspaces of these twisted modules and construct exact sequences among them. finally, in an example, we show that the sum-sides of some known and conjectured partition identities can be interpreted as characters of these principal subspaces.

This is joint work with Michael Penn and Gautam Webb.

Generalised deep holes in the vertex operator algebra associated with the Leech lattice

Nils Scheithauer, TU Darmstadt

The 23 Niemeier lattices with roots can be constructed out of the Leech lattice by the deep hole construction. We show that an analogous statement holds for vertex operator algebras. This is joint work with Sven Möller.

Vertex operator algebras on general genus Riemann surfaces

Michael Tuite, NUI Galway

This talk describes current work on the partition and n-point correlation functions for a vertex operator algebra on a general genus g Riemann surface. We describe these objects in the Schottky uniformization and derive a general Zhu recursion formula with universal convergent coefficients which have a specific geometrical meaning. A number of examples are discussed which give rise to new geometrical equations. This work is largely based on collaboration with my PhD student Michael Welby.

A Fusion rules for $\mathbb{Z}_2$-orbifolds of affine and parafermion vertex operator algebras of type $A_1^{(1)}$

Qing Wang, Xiamen University

In this talk, first I will present the classification of irreducible modules and fusion rules for the $\mathbb{Z}_2$-orbifold of the affine VOA of type $A_1^{(1)}$. Then I will explain how to classify the irreducible modules of the $\mathbb{Z}_2$-orbifold of the parafermion VOA of type $A_1^{(1)}$ and determine their fusion rules by applying the results of the $\mathbb{Z}_2$-orbifold of the affine VOA. These results are based on the joint works with Cuipo Jiang.

23 involutions, Fischer group fi_{23} and the moonshine VOA

Hiroshi Yamauchi (Tokyo Woman's Christian University)

I will give an explicit construction of the $2+23$ 2A-involutions of the Monster acting on the moonshine VOA $V^\natural$. The first two involutions generate a symmetric group S_3 and other 23 involutions generate an elementary abelian group H of order 2^{11}. The centralizer of this S_3 in the Monster is the Fischer group fi_{23}. Using our construction, we analyze fi_{23} based on VOA theory. This talk is based on a joint work with Thomas Creutzig and Ching Hung Lam.

On Indecomposable $\mathbb{N}$-graded Vertex Algebras

Gaywalee Yamskulna, Illinois State University

In this talk, I will discuss the algebraic structure of $\mathbb{N}$-graded vertex algebras $V = \oplus_{n=0}^{\infty} V_{(n)}$ such that dim $V_{(0)} \geq 2$ and $V_{(1)}$ is a (semi)simple Leibniz algebra that has sl_2 as its Levi factor.

$6A$-algbera and its representations

Nina Yu, Xiamen University

An Ising vector in a vertex operator algebra is a Virasoro vector which generates a subalgebra isomorphic to the Virasoro vertex operator algebra L(1/2,0). It is believed that any subVOA generated by two Ising vectors is uniquely determined by their inner products. In this talk, I will talk about the structure and representation of a 6A-algebra which is a vertex operator algebra generated by two Ising vectors e,f with inner product $< e, f >= \frac{5}{2^{10}}$. In particular, I will talk about the uniqueness of the vertex operator algebra structure of this 6A-algebra, classification of the irreducible modules, and the fusion rules. This is a joint work with C. Dong and X. Jiao.

Number Theory Section

Banach space representations of $SL(2, \mathbb{Q}_p)$

Dubravka Ban, Southern Illinois University

The p-adic Langlands correspondence for $GL(2, \mathbb{Q}_p)$ constructed by Colmez relates 2-dimensional p-adic Galois representations and p-adic Banach space representations of $GL(2, \mathbb{Q}_p)$. We study the corresponding objects for $SL(2, \mathbb{Q}_p)$. More specifically, we study the restriction to $SL(2, \mathbb{Q}_p)$ of the Banach representations of $GL(2, \mathbb{Q}_p)$ and the projective Galois representations. We develop methods for the Banach representations which have non-zero locally algebraic vectors and which correspond to trianguline Galois representations.

This is a joint work with Matthias Strauch.

Effective results for Diophantine equations over finitely generated domains

Attila Bérczes, University of Debrecen

Let $A := \mathbb{Z}[z_1, \ldots, z_r] \supset \mathbb{Z}$ be a finitely generated integral domain over $\mathbb{Z}$ and denote by K the quotient field of A. finiteness results for several kinds of Diophantine equations over A date back to the middle of the last century. S. Lang generalized several earlier results on Diophantine equations over the integers to results over A, including results concerning unit equations, Thue-equations and integral points on curves. However, all his results were ineffective.

The first effective results for Diophantine equations over finitely generated domains were published in the 1980's, when Győry developed his new effective specialization method. This enabled him to prove effective results over finitely generated domains of a special type.

In 2011 Evertse and Győry refined the method of Győry such that they were able to prove effective results for unit equations $ax + by = 1$ in $x, y \in A^*$ over arbitrary finitely generated domains A of characteristic 0. Later Bérczes, Evertse and Győry obtained effective results for Thue equations, hyper- and superelliptic equations and for the Schinzel-Tijdeman equation over arbitrary finitely generated domains.

In this talk I will present my effective results for equations $F(x, y) = 0$ in $x, y \in A^*$ for arbitrary finitely generated domains A, and for $F(x, y) = 0$ in $x, y \in \overline{\Gamma}$, where $F(X, Y)$ is a bivariate polynomial over A and $\overline{\Gamma}$ is the division group of a finitely generated subgroup Γ of K^*. These are the first effective versions of the famous corresponding ineffective results of Lang (1960) and Liardet (1974).

Extensions of a $D(4)$-triple

Marija Bliznac Trebješanin, University of Split

We call a set of positive integers $\{a, b, c\}$ a $D(4)$-triple if a product of each two elements of a triple increased by 4 is a perfect square. It is conjectured that a triple can be extended to a quadruple uniquely with an element $d > \max\{a, b, c\}$. In this talk, we present new results that support the conjecture, such as some new bounds on the elements of a triple for which we have proven that conjecture holds, and an upper bound on the number of possible extensions of a $D(4)$-triple to a $D(4)$-quadruple for remaining cases.

On the decimal expansion of $\log(2019/2018)$ and e

Yann Bugeaud, University of Strasbourg

It is commonly expected that e, $\log 2$, $\sqrt{2}$, among other "classical" numbers, behave, in many respects, like almost all real numbers. For instance, their decimal expansion should contain every finite block of digits from $\{0, \ldots, 9\}$. We are very far away from establishing such a strong assertion. However, there has been some small recent progress in that direction. Let ξ be an irrational real number. Its irrationality exponent, denoted by $\mu(\xi)$, is the supremum of the real numbers μ for which there are infinitely many integer pairs (p, q) such that $|\xi - \frac{p}{q}| < q^{-\mu}$. It measures the quality of approximation to ξ by rationals. We always have $\mu(\xi) \geq 2$, with equality for almost all real numbers and for irrational algebraic numbers (by Roth's theorem). We prove that, if the irrationality exponent of ξ is equal to 2 or slightly greater than 2, then the decimal expansion of ξ cannot be 'too simple', in a suitable sense. Our result applies, among other classical numbers, to badly approximable numbers, non-zero rational powers of e, and $\log(1+\frac{1}{a})$, provided that the integer a is sufficiently large. It establishes an unexpected connection between the irrationality exponent of a real number and its decimal expansion.

Composition series of a class of induced representations

Igor Ciganović, University of Zagreb

We determine compostion series of a class of parabolically induced representation $\delta([\nu^{-b}\rho,\nu^{c}\rho])\times\delta([\nu^{\frac{1}{2}}\rho,\nu^{a}\rho])\rtimes\sigma$ of p-adic symplectic group in terms of Mœglin-Tadić clasification. Here $\frac{1}{2}\leq a<b<c\in\frac{1}{2}\mathbb{Z}+1$ are half integers, $\nu=|\det|_F$ where F is a p-adic field, ρ is a cuspidal representation of a general linear group, σ is a cuspidal representation of a p-adic symplectic group such that $\nu^{\frac{1}{2}}\rho\rtimes\sigma$ reduces and $\delta([\nu^{x}\rho,\nu^{y}\rho])\hookrightarrow\nu^{y}\rho\times\cdots\times\nu^{x}\rho$ is a discrete series representation for $x\leq y\in\frac{1}{2}\mathbb{Z}+1$.

Report on $D(-1)$-quadruples

Mihai Cipu, Institute of Mathematics of the Romanian Academy

For n a non-zero integer, a set of positive integers $\{a_1,a_2,\ldots,a_m\}$ is called $D(n)-m$-set if a_ia_j+n is a perfect square for any $1\leq i<j\leq m$. Although more general notions are encountered in the literature, even the most conservative definition of the kind allows for many interesting problems, some of which are still open.

One natural question is to give sharp bounds for the cardinality of $D(n)-m$-sets. Upper bounds valid for arbitrary n have been provided by Dujella. A lot of work has been deployed in order to improve the general results for specific values of n. It is elementary to show that for $n\equiv 2 \pmod 4$ there is no $D(n)$-quadruple (i.e., $D(n)-4$-set). Dujella has shown that if $n\not\equiv 2 \pmod 4$ and $n\notin\mathcal{S}:=\{-4,-3-1,3,5,8,12,20\}$ then there exists at least one $D(n)$-quadruple. Moreover, he conjectured that for $n\in\mathcal{S}$ there is no $D(n)$-quadruple.

The talk is devoted to an ongoing study of hypothetical $D(-1)$-quadruples, whose ultimate goal is to confirm the aforementioned conjecture for $n=-1$. This is a joint work with Nicolae Ciprian Bonciocat (Bucharest, Romania) and Maurice Mignotte (Strasbourg, France).

On $D(n)$-quadruples in $\mathbb{Q}(\sqrt{2},\sqrt{3})$

Zrinka Franušić, University of Zagreb

Let $\mathcal{O}$ be the ring of integers of the number field $\mathbb{Q}(\sqrt{2},\sqrt{3})$. A Diophantine quadruple with the property $D(n)$ or $D(n)$-quadruple in the ring $\mathcal{O}$ is a set of four distinct non-zero elements such that the product of each two distinct elements increased by n is a perfect square in $\mathcal{O}$. We show that the set of all $n\in\mathcal{O}$ such that a $D(n)$-quadruple in $\mathcal{O}$ exists coincides with the set of all integers in $\mathbb{Q}(\sqrt{2},\sqrt{3})$ that can be represented as a difference of two squares in $\mathcal{O}$. $D(n)$-quadruples are effectively constructed via some polynomial formulas.

This is a joint work with Borka Jadrijević.

Composite values in polynomial power sums

Clemens Fuchs, University of Salzburg

Let $(G_n(x))_{n=0}^{\infty}$ be a sequence of complex polynomials satisfying a linear recurrence having simple characteristic roots which are polynomials over $\mathbb{C}$, i.e. each $G_n(x)$ may be expressed as a polynomial power sum of the form $a_1\alpha_1^n+\cdots+a_t\alpha_t^n$ with $a_1,\ldots,a_t\in\mathbb{C},\alpha_1,\ldots,\alpha_t\in\mathbb{C}[x]$. We ask for $n\in\mathbb{N}$ such that the equation $G_n(x)=g\circ h$ is satisfied for polynomials $g,h\in\mathbb{C}[x]$ with $\deg g,\deg h>1$. This question is closely related to studying the underlying permutation representation given by representing the Galois group of the Galois closure of the field extension $\mathbb{C}(x)\supseteq\mathbb{C}(z)$ given by $G_n(x)-z=0$ for $n\in\mathbb{N}$.

In this talk I shall report on recent progress that was made jointly with Christina Karolus (Salzburg) and partly also with Dijana Kreso (Graz) on this question. We proved: Under certain assumptions (including the massive restriction that $t=2$), and provided that h is not of particular type, $\deg g$ may be bounded by a constant independent of n depending only on the sequence. Moreover (now for general t but fixed degree for g), for all but finitely many n the decompositions can be described in "finite terms" coming from a generic decomposition parameterized by an algebraic variety, where all data in this description is effectively computable.

The regularity of extensions of Diophantine triples or pairs

Yasutsugu Fujita, Nihon University

A set of m positive integers $\{a_1, \ldots, a_m\}$ is called *a Diophantine m-tuple* if a_ia_j+1 is a perfect square for all i, j with $1 \le i < j \le m$. Although the folklore conjecture, stating that there does not exist a Diophantine quintuple, has been recently settled by He, Togbé and Ziegler, the stronger conjecture, asserting that all Diophantine quadruples are regular, remains open, where a Diophantine quadruple $\{a, b, c, d\}$ with $a < b < c < d$ is called *regular* if

$$d = d_+ := a + b + c + 2abc + 2rst$$

with $r = \sqrt{ab+1},\ s = \sqrt{ac+1},\ t = \sqrt{bc+1}$. Even the finiteness of irregular Diophantine quadruples has not been shown yet.

In 2017, such finiteness was shown for a fixed Diophantine triple $\{a, b, c\}$ $(a < b < c)$ in a joint paper with Miyazaki. More precisely, it was proved that the number of d's for which $\{a, b, c, d\}$ is a Diophantine quadruple with $c < d$ is at most 11. This upper bound was then improved to 8 in a joint paper with Cipu and Miyazaki (so, the number of such d's with $d > d_+$ is at most 7).

In this talk, we will give key ideas to prove two results above. The rest of the talk will be devoted to showing the progress on "the extendibility problem", in other words, whether a fixed Diophantine triple or pair having certain properties (e.g., expressed with one or two parameters) can only be extended to a regular Diophantine quadruple by joining larger elements.

Multiplicative decompositions of polynomial sequences

Lajos Hajdu, University of Debrecen

Let $\mathcal{A}, \mathcal{B}, \mathcal{C}$ be subsets of $\mathbb{N} \cup \{0\}$ with $|\mathcal{B}| \ge 2$ and $|\mathcal{C}| \ge 2$. Then

$$\mathcal{A} = \mathcal{B} + \mathcal{C}$$

is called an *additive decomposition*, or shortly *a-decomposition* of $\mathcal{A}$. The set $\mathcal{A}$ is *a-reducible* if it has an a-decomposition, otherwise, it is said to be *a-primitive*. finally, $\mathcal{A}$ is said to be *totally a-primitive* if every $\mathcal{A}'$ which is asymptotically equal to $\mathcal{A}$ is a-primitive. If $\mathcal{A} = \mathcal{B} + \mathcal{C}$ is replaced by $\mathcal{A} = \mathcal{B} \cdot \mathcal{C}$, then we get the multiplicative versions of these notions. These definitions were introduced by Ostmann in 1948, who also formulated the following beautiful conjecture:

Conjecture 1. The set $\mathcal{P}$ of primes is totally a-primitive.

Hornfeck, Hofmann and Wolke, Elsholtz and Puchta proved partial results toward this conjecture, however, it is still open. Another related conjecture was proposed by Erdős:

Conjecture 2. If we change $o(n^{1/2})$ elements of the set of squares up to n, then the new set is always totally a-primitive.

This conjecture in a slightly weaker form was proved by Sárközy and Szemerédi. For results concerning similar problems in finite fields, see papers of Gyarmati, Sárközy, Shkredov, Shparlinski and others.

In the talk we present various new results concerning the asymptotic m-primitivity of sets of values of integer polynomials. Concerning arbitrary polynomials of degree $k \ge 3$, first we show that any infinite subset of the set of shifted k-th powers $\mathcal{M}'_k = \{1, 2, 2^k+1, 3^k+1, \ldots, x^k+1, \ldots\}$ is totally m-primitive. Then we give a complete description of such polynomials whose value set in $\mathbb{N}$ is totally m-primitive. In the quadratic case we can give much more precise statements. first we provide a sharp theorem saying that any subset of the shifted squares $\mathcal{M}'_2$ which is "large enough" is totally m-primitive. Then we give a multiplicative analogue of the above mentioned result of Sárközy and Szemerédi concerning $\mathcal{M}'_2$, which is nearly sharp.

In our proofs we combine several tools from Diophantine number theory (including Pell equations, continued fractions, Baker's theory of Thue equations, the Bilu-Tichy method), a classical theorem of Wiegert on the number of divisors of positive integers and a theorem of Bollobás on the Zarankiewicz function related to an extremal problem for bipartite graphs. We conclude the talk with proposing some open problems.

The presented new results are joint with A. Sárközy.

Simplest quartic and simplest sextic Thue equations over imaginary quadratic fields

Borka Jadrijević, University of Split

The families of simplest cubic, simplest quartic and simplest sextic fields and the related Thue equations are well known. The family of simplest cubic Thue equations has already been studied in the relative case, over imaginary quadratic fields. We observe a similar extension of simplest quartic and simplest sextic Thue equations over imaginary quadratic fields. We explicitly give the solutions of these infinite parametric families of Thue equations over arbitrary imaginary quadratic fields. Our result is obtained by an efficient method which allows us to reduce the resolution of relative Thue inequalities $|F(x,y)| < K$ to the resolution of absolute Thue inequalities in the case when the corresponding polynomial $f(x) = F(x,1)$ has real roots.

Diophantine quadruples in $\mathbb{Z}[i][X]$

Ana Jurasić, University of Rijeka

A set consisting of m positive integers such that the product of any two of its distinct elements increased by 1 is a perfect square is called a Diophantine m-tuple. Diophantus of Alexandria found the first such set of rational numbers $\{\frac{1}{16}, \frac{33}{16}, \frac{17}{4}, \frac{105}{16}\}$. There is long history of finding such sets and many generalizations of this problem were also considered.

We prove that every Diophantine quadruple in $\mathbb{Z}[i][X]$ is regular. More precisely, we prove that if $\{a,b,c,d\}$ is a set of four non-zero polynomials from $\mathbb{Z}[i][X]$, not all constant, such that the product of any two of its distinct elements increased by 1 is a square of a polynomial from $\mathbb{Z}[i][X]$, then $(a+b-c-d)^2 = 4(ab+1)(cd+1)$. The consequence of this result is that every polynomial $D(-1)$-triple in $\mathbb{Z}[X]$ can be uniquely extended to $D(-1;1)$-quadruple in $\mathbb{Z}[X]$.

This is a joint work with Alan filipin.

Congruences for sporadic sequences and modular forms for non-congruence subgroups

Matija Kazalicki, University of Zagreb

In 1979, in the course of the proof of the irrationality of $\zeta(2)$ Robert Apéry introduced numbers $b_n = \sum_{k=0}^{n} \binom{n}{k}^2 \binom{n+k}{k}$ that are, surprisingly, integral solutions of recursive relations

$$(n+1)^2 u_{n+1} - (11n^2 + 11n + 3)u_n - n^2 u_{n-1} = 0.$$

Zagier performed a computer search on first 100 million triples $(A,B,C) \in \mathbb{Z}^3$ and found that the recursive relation generalizing b_n

$$(n+1)u_{n+1} - (An^2 + An + B)u_n + Cn^2 u_{n-1} = 0,$$

with the initial conditions $u_{-1} = 0$ and $u_0 = 1$ has (non-degenerate i.e. $C(A^2 - 4C) \neq 0$) integral solution for only six more triples (whose solutions are so called sporadic sequences) .

Stienstra and Beukers showed that for the prime $p \geq 5$

$$b_{(p-1)/2} \equiv \begin{cases} 4a^2 - 2p \pmod{p} \text{ if } p = a^2 + b^2,\ a \text{ odd} \\ 0 \pmod{p} \text{ if } p \equiv 3 \pmod{4}. \end{cases}$$

Recently, Osburn and Straub proved similar congruences for all but one of the six Zagier's sporadic sequences (three cases were already known to be true by the work of Stienstra and Beukers) and conjectured the congruence for the sixth sequence (which is a solution of recursion determined by triple $(17, 6, 72)$).

In this talk we prove that remaining congruence by studying Atkin and Swinnerton-Dyer congruences between Fourier coefficients of certain cusp form for non-congurence subgroup.

Understanding the Gross-Kohnen-Zagier theorem (for non-split Cartan curves)

Daniel Kohen, University of Duisburg-Essen

Let $E/\mathbb{Q}$ be an elliptic curve of conductor p^2 and odd analytic rank. The famous Gross-Kohnen-Zagier theorem states that, as we vary throughout the imaginary quadratic fields in which p is split, the collection of Heegner points generate an at most 1 dimensional space and that their relative position on the Mordell-Weil group of E is encoded in the Fourier coefficients of a certain Jacobi form of weight 2 and index p^2. For imaginary quadratic fields in which p is inert we can construct special points on E via a modular parametrization from a non-split Cartan modular curve, generalizing the classical construction of Heegner points.

In this talk we prove that the position on E of the special points arising from non-split Cartan curves is reflected in the Fourier coefficients of a Jacobi forms of weight 6 and a certain lattice index of rank 9. In order to prove this, we construct an explicit even lattice L of signature $(2, 1)$ obtained by studying the properties of the special points on non-split Cartan curves and we apply Borcherd's striking generalization of the G-K-Z theorem to show that our special points are the coefficients of a vector valued modular form of weight $3/2$. Using Nikulin's theory of discriminant forms and lattices we show the connection with the desired Jacobi form. finally, we provide an explicit example of this construction.

This is joint work with Nicolás Sirolli (Universidad de Buenos Aires).

Torsion groups of elliptic curves over $\mathbb{Z}_p$-extensions of $\mathbb{Q}$

Ivan Krijan, University of Zagreb

For a prime number p, denote by $\mathbb{Q}_{\infty,p}$ the unique $\mathbb{Z}_p$-extension of $\mathbb{Q}$, i.e. the unique Galois extension $\mathbb{Q}[p]$ of $\mathbb{Q}$ such that $\mathrm{Gal}(\mathbb{Q}_{\infty,p}/\mathbb{Q}) \simeq \mathbb{Z}_p$, where $\mathbb{Z}_p$ is the additive group of the p-adic integers We determine, for an elliptic curve E over $\mathbb{Q}$ and for all prime numbers p, all the possible torsion groups $E(\mathbb{Q}_{\infty,p})_{\text{tors}}$.

These results, interesting in their own right, might also find applications in other problems in Iwasawa theory for elliptic curves and in general. For example, results of this type were used to show that elliptic curves over $\mathbb{Q}_{\infty,p}$ are modular for all prime numbers p.

A geometric construction of Witt rings

Ivan Mirković, University of Masschusetts, Amherst

I am interested in the construction that attaches to a commutative ring A a commutative ring scheme $W(A)$ of so called big Witt vectors. This ring has various uses in Number Theory, for instance it is related to the local symbol pairing in the geometric case of Class field Theory. Also the additive structure of W is the congruence subgroup for the multiplicative group. The ring of functions Λ on the scheme W is the ring in infinitely many symmetric functions, so W is the geometric incarnation of the combinatorics that takes place in Λ. The talk will present a purely geometric construction of W as a certain homology of an affine line.

Existence of cuspidal automorphic forms for reductive groups over number fields

Goran Muić, University of Zagreb

In this talk we discuss existence of cuspidal automorphic forms for reducitive groups in adelic settings with special regard on local p–adic components. We explain the generalization of the works of Shahidi, Henniart, and Vigneras on existence of generic cuspidal automorphic forms with one cuspidal component. If time permits, then we will show some applications of the theory on the questions of existence of cuspidal automorphic forms with prescribed level for congruence subgroups of semisimple Lie groups.

This is a joint work with Allen Moy.

Modularity of elliptic curves over totally real cubic fields

filip Najman, University of Zagreb

We will prove that all elliptic curves over totally real cubic fields are modular and explain the ingredients that go into this proof.

This is joint work with Maarten Derickx and Samir Siksek.

Hypergeometric differential equations and hypergeometric motives

Bartosz Naskrecki, Adam Mickiewicz University, Poznań

In this talk we will discuss what are the so-called hypergeometric motives and how one can approach the problem of their explicit construction as Chow motives in explicitely given algebraic varieties. The class of hypergeometric motives corresponds to Picard-Fuchs equations of hypergeometric type and forms a rich family of pure motives with nice L-functions. Following recent work of Beukers-Cohen-Mellit we will show how to realise certain hypergeometric motives of weights 0 and 2 as submotives in elliptic and hyperelliptic surfaces. An application of this work is the computation of minimal polynomials of hypergeometric series with finite monodromy groups and proof of identities between certain hypergeometric finite sums, which mimics well-known identities for classical hypergeometric series. This is a part of the larger program conducted by Villegas et al. to study the hypergeometric differential equations (special cases of differential equations "coming from algebraic geometry") from the algebraic perspective.

Results and problems on diophantine properties of radix representations

Attila Pethő, University of Debrecen

My talk is based partially on joint works with Jan-Hendrik Evertse, Kálmán Győry and Jörg Thuswaldner.

Characterization of integers including special pattern in their g-ary representations lead to interesting and hard diophantine problems. I mention here only the repunits and integers having bounded number of non-zero digits in two different bases.

Thanks to intensive work, we have now an appropriate overview on radix representations in and over algebraic number fields. Let $\{\gamma, D\}$ be a GNS, i.e. γ the bases and D the digit set of a radix representation in an algebraic number field $\mathbb{K}$. For $\alpha \in \mathbb{K}$ denote by $(\alpha)_\gamma$ the word of the digits of the representation of α. We discuss in our talk following topics:

(1) Representations of rational integers. We show under mild condition that there are only finitely many rational integer m with bounded number of non-zero characters in $(m)_\gamma$.

(2) We have analogous statement for the representations of units. The results are effective. An interesting problem is to establish all units in cubic and/or quartic number fields with three,four, five non-zero digits. To do the same for rational integers seems more challenging.

(3) Let $w = (1)_\alpha(\alpha)_\gamma(\alpha^2)_\gamma \ldots$. By generalizing a result of K. Mahler we proved that w is not periodic. (In fact we proved much more.) Write $w = s_1 s_2 \ldots,\ s_j \in D$ and $A = \sum_{j=1}^{\infty} s_j \gamma^j$. It is natural to expect $A \notin \mathbb{K}$, which holds for $\mathbb{K} = \mathbb{Q}$. What about if $\mathbb{K} \neq \mathbb{Q}$?

(4) Consider the set F of the first coordinates of the integer solutions of a norm form equation $N_{\mathbb{K}/\mathbb{Q}}(\underline{\mathrm{x}}) = m$. (In the quadratic case the norm form equation is a Pell equation, thus the elements of F form a linear recursive sequence.) We show that there are only finitely many repunits with respect to any base $g \geq 2$, in F. Give an algorithm for the computation of all repunits in the set F.

(5) With the solutions of relative index form equations one can establish the bases of - up to equivalence - all power integer bases in a relative extension of a number field. We proved that the bases of the radix representations are special translates of bases of power integral bases. All these results are effective, but nobody performed yet the necessary computations in a given case.

(6) For given $D \subset \mathbb{Z}$ there is only finitely many $\gamma \in \mathbb{K}$ such that $\{\gamma, D\}$ is a GNS. This is trivial for $\mathbb{K} = \mathbb{Q}$, but quite involved in general. For some low degree (2,3,4) number fields establish all binary and decimal GNS.

Rational Diophantine sextuples

Vinko Petričević, University of Zagreb

A set of m distinct nonzero rationals $\{a_1, a_2, \ldots, a_m\}$ such that $a_i a_j + 1$ is a perfect square for all $1 \leq i < j \leq m$, is called a rational Diophantine m-tuple. The first example of a rational Diophantine quadruple was the set $\left\{\frac{1}{16}, \frac{33}{16}, \frac{17}{4}, \frac{105}{16}\right\}$ found by Diophantus. Euler proved that the exist infinitely many rational Diophantine quintuples. In 1999, Gibbs found the first example of rational Diophantine sextuple $\left\{\frac{11}{192}, \frac{35}{192}, \frac{155}{27}, \frac{512}{27}, \frac{1235}{48}, \frac{180873}{16}\right\}$. In 2017 Dujella, Kazalicki, Mikić and Szikszai proved that there are infinitely many rational Diophantine sextuples, while Dujella and Kazalicki (inspired by the work of Piezas) described another construction of parametric families of rational Diophantine sextuples. No example of a rational Diophantine septuple is known.

In 2016 Gibbs collected over 1000 examples of positive rational Diophantine sextuples with relatively small numerators and denominators, and found 3 almost septuples (with only one condition missing).

Recently we (joint work with Dujella and Kazalicki) have extended the search for Diophantine sets with small height and included also examples with mixed signs. We have found more than 40 almost septuples, and two new infinite families of sextuples, one such that denominators of all the elements are perfect squares, and other containing subquadruples and subquintuples of special type.

A Pellian equation with primes and its applications

Ivan Soldo, University of Osijek

We consider the equation $x^2 - (p^{2k+2}+1)y^2 = -p^{2l+1}$, $l \in \{0,1,\dots,k\}, k \geq 0$, where p is an odd prime and prove that it is not solvable in positive integers x and y. By combining that result with other known results on the existence of Diophantine quadruples, we are able to prove results on the extensibility of some parametric families of $D(-1)$-pairs to quadruples in the ring $\mathbb{Z}[\sqrt{-t}], t > 0$.

On problems showing up in classifying irreducible unitary representations of classical p-adic groups

Marko Tadić, University of Zagreb

The set of equivalence classes of irreducible unitary representations of a locally compact group G is called unitary dual of G, and it is a basis of harmonic analysis on that group. In our talk we shall outline a possible strategy of approaching the problem of classification of unitary duals of classical p-adic groups (like symplectic or orthogonal groups). This very general strategy has been checked to work in a very special cases, in particular in the generalised rank (up to) three. We shall describe some of these results, and discuss some possible further steps.

Equidistribution, van der Corput sets and exponential sums

Robert Tichy, Technische Universität Graz

A set $H \subset \mathbb{Z}$ is called a van der Corput set if any sequence $(x_n)_{n\in\mathbb{N}}$ is equidistributed provided that the difference sequences $(x_{n+h}-x_n)_{n\in\mathbb{N}}$ are equidistributed for all $h \in H$. By van der Corput's difference theorem, $H = \mathbb{N}$ is a van der Corput set. This concept is related to sets of recurrence and difference sets and other concepts from additive combinatorics. We establish new results on sets of recurrence and van der Corput sets in $\mathbb{Z}^k$ (i.e. for $\mathbb{Z}^k$-actions) which refine and unify some of the previous results obtained by Sarkőzy, Furstenberg, Kamae and Mèndes France, and Bergelson and Lesigne. Furthermore, we construct some new examples of such sets involving prime numbers. This involves new bounds for exponential sums containing generalized polynomials of the form

$$f(x) = \sum_{j=1}^{m} \alpha_j x^{\theta_j}$$

where $0 < \theta_1 < \theta_2 < \ldots < \theta_m$, α_j are non-zero reals and at least one α_j is irrational if all $\theta_j \in \mathbb{N}$. Furthermore, we apply this method to diophantine inequalities involving prime numbers p. As a special result we obtain

$$\min_{1\leq p\leq N} \|\, \xi \lfloor f(p) \rfloor \,\| \ll N^{-\eta},$$

where ξ is a real number, N a sufficiently large positive integer and $\|\cdot\|$ denotes the distance to the nearest integer, $\lfloor \cdot \rfloor$ the floor function and $\eta > 0$ a suitable exponent.

This is recent joint work with Manfred Madritsch.

Torsion subgroups of elliptic curves over number fields of small degree

Antonela Trbović, University of Zagreb

For a number field K and an elliptic curve E defined over K it is known that the set of K-rational points on the elliptic curve is isomorphic to $\mathbb{Z}^r \oplus E(K)_{tors}$, where $E(K)_{tors}$ is the torsion subgroup. For number fields of small degree, we present conditions on the number field under which certain groups of the form $\mathbb{Z}/m\mathbb{Z} \oplus \mathbb{Z}/n\mathbb{Z}$ do (not) occur as a torsion subgroup of any elliptic curve over that number field.

Torsion subgroups of rational elliptic curves over some cyclotomic fields

Borna Vukorepa, University of Zagreb

Let $E/\mathbb{Q}$ be a rational elliptic curve and let $E(\mathbb{Q}(\zeta_n))_{tors}$ be the group of torsion points on E which are defined over some cyclotomic field. Motivated by the work of Michael Chou on torsion of rational elliptic curves over the maximal abelian extension of $\mathbb{Q}$, we will determine all possibilities for $E(\mathbb{Q}(\zeta_n))_{tors}$ for several values of n which have not been considered before.

Non-vanishing of Poincaré series

Sonja Žunar, University of Zagreb

The question when a cusp form given by a Poincaré series vanishes identically was recognized as interesting and non-trivial as early as 1882 by Poincaré himself. Nevertheless, a complete answer is yet to be found even for the classical Poincaré series.

In 2009, Goran Muić proved an integral criterion for the non-vanishing of Poincaré series on locally compact Hausdorff groups. By applying it to certain families of cuspidal automorphic forms on $\mathrm{SL}_2(\mathbb{R})$, he proved results on the non-vanishing of the corresponding cusp forms of integral weight. In this talk, we present a strengthening of Muić's criterion and discuss its applications to cuspidal automorphic forms on the metaplectic cover of $\mathrm{SL}_2(\mathbb{R})$ and to the corresponding cusp forms of half-integral weight.

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Real groups section

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