XV. International Workshop

LIE THEORY AND ITS APPLICATIONS IN PHYSICS

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A B S T R A C T S

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Address for correspondence:
Prof. V.K. Dobrev
Bulgarian Academy of Sciences
Institute for Nuclear Research and Nuclear Energy
72 Tsarigradsko Chaussee
1784 Sofia
Bulgaria
WWW: http://theo.inrne.bas.bg/∼dobrev/LT-15.htm

Raschid Abedin

Geometry of twisted standard Lie bialgebra structures on loop algebras

In the late 80's Drinfeld proposed the construction of new Hopf algebras, called quantum groups, by quantizing Lie bialgebras. One of the most important Lie bialgebra structures is the standard structure on an affine Kac-Moody algebra. This structure induces a Lie bialgebra on the underlying loop algebra. Twisting the induced structure results in the family of so-called twisted standard bialgebra structures. In this talk, we associate this family of Lie bialgebras with sheaves of Lie algebras on nodal irreducible cubic curves. This relation is used to classify these twisted standard structures. The geometric approach presented in this talk is a special instance of a more general algebro-geometric theory of certain infinite-dimensional Lie bialgebra structures.

Darlayne Addabbo

Vertex operators for imaginary $\mathfrak{gl}_2$-subalgebras in the Monster Lie algebra

The Monster Lie algebra $\mathfrak{m}$ is a quotient of the physical space of the vertex algebra $V = V_{1,1} \otimes V^\natural$, where $V_{1,1}$ is the vertex algebra corresponding to the rank 2 even unimodular lattice $\mathrm{II}_{1,1}$ and $V^\natural$ is Frenkel, Lepowsky, and Meurman's Moonshine module. The Monster Lie algebra $\mathfrak{m}$ has subalgebras isomorphic to $\mathfrak{gl}_2$, generated by real and imaginary root vectors and the Monster simple group $\mathbb{M}$ acts trivially on the $\mathfrak{gl}_2$-subalgebra corresponding to the unique real simple root. We will discuss the construction of elements of $V = V_{1,1} \otimes V^\natural$ that project under the quotient map to generators of families of $\mathfrak{gl}_2$-subalgebras corresponding to the imaginary simple roots of $\mathfrak{m}$. We will describe the action of the Monster finite simple group on these families of subalgebras and applications to the construction of a Lie group analog for the Monster Lie algebra, as well as related open questions. (This is joint work with Lisa Carbone, Elizabeth Jurisich, Maryam Khaqan, and Scott H. Murray.)

Naruhiko Aizawa

Towards a superfield formulation of $\mathbb{Z}_2^2$-supersymmetry

Recently, symmetries generated by $\mathbb{Z}_2^n$-graded Lie (super)algebras have attracted a lot of interests ($\mathbb{Z}_2^n := \mathbb{Z}_2 \otimes \cdots \otimes \mathbb{Z}_2,\ n$ times). After a review of such $\mathbb{Z}_2^n$-symmetries, we focus on $\mathbb{Z}_2^2$-worldline supersymmetry. What is interesting about such a theory is the existence of exotic bosons in addition to commuting fermions. However, the exotic bosons are a major obstacle to constructing invariant actions using the $\mathbb{Z}_2^2$-version of superfields, because integration on $\mathbb{Z}_2^2$-superspace has not been established yet due to the coordinates corresponding to the exotic bosons. In this work, we explore possible definitions of integration on the minimal $\mathbb{Z}_2^2$-superspace. It is shown that some definitions restrict the integrable functions and others do not. An interesting observation is that in some cases the exotic bosonic coordinate is turned into an extra spatial coordinate so that one may obtain a theory defined in one-dimensional higher spacetime than the original one.

Cristian Anghel

Ribbon structures derived from homotopy Leibniz algebras and symplectic Lie pairs

Ribbon structures in derived categories of coherent sheaves on hyperkahler manifolds, appeared for the first time in the work of Roberts and Willerton, concerning Lie type structures in Rozansky-Witten theories. After that, part of this approach was extended to symplectic Lie pairs by Voglaire & Xu and by Chen & Stienon & Xu. We intend to review this topic and discuss the existence of ribbon structures in the general context of symplectic Lie pairs. This work is a joint project with Dorin Cheptea.

Lilia Anguelova

Dynamical consistency conditions for rapid turn inflation

We derive consistency conditions for sustained slow roll and rapid turn inflation in two-field cosmological models with oriented scalar field space, which imply that inflationary models with field-space trajectories of this type are non-generic. In particular, we show that third order adiabatic slow roll, together with large and slowly varying turn rate, requires the scalar potential of the model to satisfy a certain nonlinear second order PDE, whose coefficients depend on the scalar field metric. We also derive consistency conditions for slow roll inflationary solutions in the so called "rapid turn attractor" approximation, as well as study the consistency conditions for circular rapid turn trajectories with slow roll in two-field models with rotationally invariant field space metric. Finally, we argue that the rapid turn regime tends to have a natural exit after a limited number of e-folds.

Koichi Arashi

Multiplicity-free representations of nilpotent Lie groups over Siegel domains

We will explain the multiplicity-freeness property of holomorphic multiplier representations of affine transformation groups on a Siegel domain of the second kind. This setting includes every bounded symmetric domain of non-tube type. We deal with nilpotent groups and the first objective is a generalized Heisenberg group. We will explain the multiplicity-freeness of such representations focusing on the notion of the coherent state representation, which is introduced by W. Lisiecki. Next, for a smaller group, we give some necessary and sufficient conditions for the representation defined by the trivial multiplier to be multiplicity-free. We relate the multiplicity-freeness property, which can be characterized in terms of the orbit method, to the coisotropicity and the visibility of the group action, which is introduced by T. Kobayashi, and to the commutativity of the algebra of invariant differential operators.

Paolo Aschieri

Gauge transformations and Atiyah sequences of braided Lie algebras

We review different approaches to the gauge group of noncommutative principal bundles. In the triangular braided geometry context it is a braided Hopf algebra. Infinitesimal gauge transformations close a braided Lie algebra and lead to a corresponding Atiyah sequence. Connections are introduced as splittings of the sequence and their curvature studied. Explicit examples of infinitesimal gauge transformations and of connections on principal bundles on noncommutative spheres are presented. (Based on joint works with G. Landi and C. Pagani).

Vasil Avramov

Holographic complexity of rotating and charged Gauss-Bonnet black holes

We will introduce the notion of holographic complexity in current competing paradigms (complexity = action, complexity = volume, complexity = momentum). We will then connect this to the idea of Lloyd bound and how this idea can be used to limit the complexity growth of any theory. We will then present novel calcualtions of the complexity rates of rotating and charged Gauss-Bonnet black holes. Furthermore, we will discuss some issues which arise when trying to define complexity of black holes with non-null horizons.

David Broadhurst

Symmetric tetrahedra in gauge theories

Lie groups and their algebras are fundamental to the gauge theories of the successful standard model of high energy physics. The gauge symmetries are of two sorts: unbroken and spontaneously broken. In each case, I shall exhibit some of the remarkable number theory that results from evaluating tetrahedral Feynman diagrams. In the unbroken case, multiple polylogarithms suffice. In the broken case, there is elliptic substructure, yet the overall result may be polylogarithmic.

Čestmir Burdík

Nested Bethe ansatz for RTT–algebra of sp(4) type with linearly independent Bethe vectors

In our paper (Burdík Č., Navrátil O.: Nested Bethe ansatz for RTT—algebra of sp(4) type. *Theor. and Math. Phys.* **198** No. 1 (2019) 1–16) we study the highest weight representations of the RTT–algebra of the sp(4) type by the nested algebraic Bethe ansatz. For the constructions we used the RTT–algebra $\tilde{\mathcal{A}}_2$. Now we show that our Bethe vectors of this algebra are linearly dependent and the linearly independent vectors can be constructed using Bethe vectors of the RTT–algebra of $\mathrm{gl}(2)$ type only. We hope that the direct generalization for $\mathrm{sp}(2n)$ and $\mathrm{so}(2n)$ will be possible.
This talk is on joint work with O. Navrátil.

Junpeng Cao

Exact solution of D(2)2 model with generic open boundary fields

Exact solution of the quantum integrable D(2)2 spin chain with generic integrable boundary fields is constructed. It is found that the transfer matrix of this model can be factorized as the product of those of two open staggered anisotropic XXZ spin chains. Based on this identity, the eigenvalues and Bethe ansatz equations of the D(2)2 model are derived via off-diagonal Bethe ansatz.

Sultan Catto

Split-octonionic color algebras in hadron physics

Recently observed correspondences among superstrings, supermembranes in critical dimensions, and M-theory may be classified in terms of the Magic Square. We will introduce octonionic aspects of exceptional algebras, discuss groups and coset spaces of Jordan and related algebras, and explore the number theory of octonions as it pertains to the Magic Square. We will place great emphasis on examining physical applications of split-octonion-based Color Algebra in hadronic physics. One such application is a generalization of the Fano plane, which will be discussed in some detail.

Mirjam Cvetic

Geometric approaches to higher-group and non-invertible symmetries

By studying M-theory on singular non-compact special holonomy spaces X we demonstrate, via a process of cutting and gluing of singularities that extend to the boundary of X, the appearance of higher-form and non-invertible symmetries in the resulting supersymmetric quantum field theory.

Ivan Dimitrijević

Cosmological solutions of a nonlocal de Sitter gravity model

In this talk we present a simple nonlocal de Sitter gravity model and its vacuum cosmological solutions. In the Einstein-Hilbert action with Λ term, we introduce nonlocality by the following way:

$$S = \frac{1}{16\pi G}\int \sqrt{R-2\Lambda}(1+F(\Box))\sqrt{R-2\Lambda}\sqrt{-g}\mathrm{d}^4x$$

where $F(\Box) = 1 + \sum_{n=1}^{+\infty} f_n \Box^n + \sum_{n=1}^{+\infty} f_{-n}\Box^{-n}$ is an analytic function of the d'Alembert-Beltrami operator $\Box$ and its inverse $\Box^{-1}$. By this way, nonlocal operator $F(\Box)$ is dimensionless. The corresponding equations of motion for the metric $g_{\mu\nu}$ are presented.

We presented and discussed several exact cosmological solutions for homogeneous and isotropic universe. One of these solutions have properties similar to ones that are usually assigned to dark matter and dark energy. Some solutions are examples of the nonsingular bounce ones in flat, closed and open universe. There are also singular and cyclic solutions. All these cosmological solutions are a result of nonlocality and do not exist in the local de Sitter case.

This talk is based on joint work with Branko Dragovich, Zoran Rakić and Jelena Stanković.

Alina Dobrogowska
Generalization of the concept of classical r-matrix to Lie algebroids

We present some new constructions of Lie algebroids starting from vector fields on manifold M. The tangent bundle TM possess a natural structure of Lie algebroid, but we use these fields to construct a collection of interesting new algebroid structures. Next, we show that these constructions can be used in a more general situation, starting from an arbitrary Lie algebroid over M. In the final step, we show that after limiting ourselves to Lie algebras these formulas as a special case contain brackets well known in theory of classical r-matrices. We can think of our constructions as extending the concept of classical r-matrices to Lie algebroids. Several examples illustrate the importance of these constructions.

Shao-Ming Fei
Quantum information processing and related physics

We introduce quantum information processing and the related physics, including quantum algorithms, quantum coherence, quantum correlations, quantum uncertainty relations, as well as tensor network compressed sensing and machine learning.

Nichol Furey
Bott periodic particle physics

Bott periodicity induces a natural occurrence of a Fock space. After demonstrating this, we set out to identify the off-shell degrees of freedom of the standard model with the repeating Clifford algebra Cl(0,8).
Respecting some known division algebraic substructure, we find a set of Lie algebras and Jordan algebras that bear a close resemblance to those symmetry algebras seen in particle physics. We then propose for them a simple action on Cl(0,8). Under su(3) (+) su(2) (+) u(1) symmetries, we find a set of Z_2-graded states in Cl(0,8) transforming in agreement with 91% of the standard model's off-shell degrees of freedom. We point to a possibility that the missing 9% may materialize upon the construction of a rudimentary gauge theory.
One of the more pertinent observations for this model is the appearance of a "multiplet mirroring" between three colours and three generations, between two quark helicity states and two $su(2)_L$ isospin states, between two lepton helicity states and two $su(2)_R$ isospin states.
This is joint work together with Beth Romano.

Eduardo Guendelman
From homogeneous and isotropic universes to braneworlds in dynamical tension strings

Cosmological solutions are studied in the context of the modified measure formulation of string theory, then the string tension is a dynamical variable and the string the tension is an additional dynamical degree of freedom and its value is dynamically generated. These tensions are then not universal, rather each string generates its own tension which can have a different value for each of the string world sheets and in an ensemble of strings the values of the tensions can have a certain dispersion. We consider a new background field that can couple to these strings, the "tension scalar" which is capable of changing locally along the world sheet and then the value of the tension of the string changes accordingly. When many types of strings probing the same region of space are considered this tension scalar is constrained by the requirement of quantum conformal invariance. For the case of two types of strings probing the same region of space with different dynamically generated tensions, there are two different metrics, associated to the different strings. Each of these metrics have to satisfy vacuum Einstein's equations and the consistency of these two Einstein's equations determine the tension scalar. The universal metric, common to both strings generically does not satisfy Einstein's equation . The two string dependent metrics considered here are flat space in Minkowski space and Minkowski space after a special conformal transformation. The limit where the two string tensions are the same is studied, it leads to a well defined solution. If the string tension difference between the two types of strings is very small but finite, the approximately homogeneous and isotropic cosmological solution lasts for a long time, inversely proportional to the string tension difference and then the homogeneity and and isotropy of the cosmological disappears and the solution turns into an expanding Braneworld where the strings are confined between two expanding bubbles separated by a very small distance at large times.

Nohra Hage

A super Littlewood–Richardson type rule

The Littlewood–Richardson (LR) rule is a combinatorial description of the coefficients that arise when decomposing a product of two Schur functions as a linear combination of other Schur functions. We introduce a super version of the LR-rule for super Schur functions over signed alphabets. In particular, we give combinatorial descriptions of the super Littlewood–Richardson coefficients using the properties of super Young tableaux. The latter combinatorial objects play a central role in the representations of the general linear Lie superalgebra, which has found rich applications in representation theory, algebraic combinatorics, theoretical and mathematical physics.

Malte Henkel

Generalised time-translation-invariance and ageing in relaxation phenomena

Ageing in non-equilibrium physical systems is a non-stationary phenomenon without time-translation-invariance. Then the naturally realised dynamic scaling alone cannot fix entirely the form of the co-variant two-point response functions of quasi-primary operators. Rather than restricting consideration to a sub-algebra of the dynamical symmetries present at equilibrium, one may alternatively consider new representations which admit a non-trivial transformation of scaling operators und time-translations.

A simple understanding of the origin of the scaling forms of responses or correlators usually admitted in simulational or experimental studies is achieved.

Vincel Hoang Ngoc Minh

On the global renormalization and regularization of several complex variable zeta functions by computer

This talk concerns the resolution of a special case of Knizhnik-Zamolodchikov equations (KZ_3) using our recent results on combinatorial aspects of zeta functions on several variables and software on noncommutative symbolic computations. In particular, we describe the actual solution of (KZ_3) leading to the unique noncommutative series, Φ_{KZ}, so-called Drinfeld associator (or Drinfeld series). Non-trivial expressions for series with rational coefficients, satisfying the same properties with Φ_{KZ}, are also explicitly provided due to the algebraic structure and the singularity analysis of the polylogarithms and harmonic sums.

Jiří Hrivnák

Electron in triangular graphene dots

Two types of honeycomb lattice Fourier–Weyl transforms associated to the irreducible crystallographic root system A_2 are utilized to study electronic properties of triangular graphene quantum dots. The triangular dots with armchair and zigzag edges are represented by two fundamentally different geometric configurations of the honeycomb lattice inside the fundamental domain of the A_2 affine Weyl group. The Schrödinger equations produced by tight-binding models of electron propagation with the nearest and next-to-nearest couplings are exactly solved through armchair and zigzag honeycomb Fourier–Weyl transforms. The inclusion of boundary conditions in the tight-binding Hamiltonians provides four types of electronic stationary states expressed via the honeycomb Weyl orbit functions. The contrasting behavior of the armchair and zigzag electronic probability densities is demonstrated. This is a joint work with Lenka Motlochová.

Fabian Januszewski

Families of D-modules and integral structures on automorphic representations

General Taniyama-Shimura type conjectures relate motives over number fields to certain classes of automorphic representations on reductive groups. While motives are naturally equipped with various arithmetic structures which conjecturally govern the arithmetic behavior of special L-values, it remains unclear which structures on the automorphic side may serve as analogues of abovementioned arithmetic structures on motives. In this talk I report on joint work with Takuma Hayashi on the construction of arithmetic models of Harish-Chandra modules via our general theory of D-modules and their application to the construction of canonical half-integral structures on spaces of automorphic forms. As an application I will sketch a definition of canonical periods attached to certain automorphic representations and links to special values of L-functions and to a conjecture of Venkatesh on the structure of the cohomology of arithmetic groups.

Monica Jinwoo Kang

Emergent N=4 supersymmetry from N=1

I will construct 4d N=1,2 SCFTs with identical central charges a=c (without a large N limit) via the diagonal gauging of collections of non-Lagrangian Argyres–Douglas and conformal matter theories. Utilizing a particular family of theories from this construction, I will present a four-dimensional N=1 supersymmetric field theory that is dual to the N=4 super Yang—Mills theory with gauge group SU(2n+1) for each n. The dual theory is constructed through the diagonal gauging of the SU(2n+1) flavor symmetry of three copies of a particular Argyres–Douglas theory. This theory flows in the infrared to a strongly-coupled N=1 SCFT that lies on the same conformal manifold as N=4 SYM.

Roland Kirschner

Orthogonal and symplectic Yangians : examples of first and second order evaluation

Exteded Yangian algebras of orthogonal and symplectic types are defined by the Yang-Baxter RLL relation involving the fundamental R-matrix with $so(n)$ or $sp(2m)$ symmetry. We study representations of highest weight characterized by weight function ratios. We consider the algebra relations for the linear and the quadratic evaluations and the resulting conditions imposed on the representation weights. We present expressions of L-operators constructed on underlying Clifford and Heisenberg algebras and characterize their representations.

Daniil Kliuev

Invariant positive forms on generalized Weyl algebras

Let A be a generalized Weyl or q-Weyl algebra. We will talk about the classification of positive definite Hermitian forms on A that satisfy certain invariance condition. This theory can be thought of as a generalization of the classification of irreducible unitary representations of Lorentz group. This talk is based on papers:

P. Etingof, D. Klyuev, E. Rains, D. Stryker. Twisted traces and positive forms on quantized Kleinian singularities of type A, SIGMA 17 (2021), 029. D. Klyuev. Twisted traces and positive forms on generalized q-Weyl algebras, SIGMA 18 (2022), 009.

D. Klyuev. Unitarizability of Harish-Chandra bimodules over generalized Weyl and q-Weyl algebras, in preparation.

Toshiyuki Kobayashi

A generating operator for Rankin-Cohen brackets

In analogy to the classical study of generating functions for orthogonal polynomials, we initiate a new line of investigation on "generating operators" for a family of differential operators between two manifolds by highlighting Rankin–Cohen brackets.

Some general background of representation theory of reductive Lie groups, in particular about branching problems for the restriction will be also discussed.

Takeo Kojima

Quadratic relations of the deformed W-algebra $\mathcal{W}_{q,t}(\mathfrak{g})$

In this talk, we will report on the systematic calculation of generators and relations of the deformed W-algebra $\mathcal{W}_{q,t}(\mathfrak{g})$. The deformed W-algebra $\mathcal{W}_{q,t}(\mathfrak{g})$ is a two-parameter deformation of the classical W-algebra $\mathcal{W}(\mathfrak{g})$ and is also a one-parameter deformation of the W-algebra $\mathcal{W}_\beta(\mathfrak{g})$. It is difficult to handle the W-algebra $\mathcal{W}_\beta(\mathfrak{g})$ in a computational way, except in low-rank cases such as the Virasoro algebra and the $\mathcal{W}_3$ algebra. One of the advantages of considering the deformed W-algebra $\mathcal{W}_{q,t}(\mathfrak{g})$ is that we can perform concrete calculations. Here, we concentrate ourself to $\mathcal{W}_{q,t}(\mathfrak{g})$ for $\mathfrak{g} = A(M,N)^{(1)}$ and $A_{2N}^{(2)}$. Using the free field construction of the W-currents associated with $\mathfrak{g}$, we derive a closed set of quadratic relations among them. These quadratic relations allow us to define the deformed W-algebra $\mathcal{W}_{q,t}(\mathfrak{g})$ by generators and relations. This talk is based on the following papers.

[1] T. Kojima, *J. Math. Phys.* **62**, 051702 (2021)
[2] T. Kojima, *J. Phys.***A**: Math. Theor., 335201 (37pp) (2021)
[3] T. Kojima, *SIGMA* **18** 072, 36 pages (2022)

Otto Kong

Lorentz covariant quantum particle dynamics from the proper symmetry theoretical formulation

On the proper symmetry theoretical formulation of the theory of Lorentz covariant, or 'relativistic', quantum particle dynamics, we illustrate the inadequacy of the Poincare symmetry for the purpose and present a fully conceptually consistent formulation from a larger symmetry which also admits a noncommutative geometric interpretation as an exact analog of that of the standard quantum mechanics as its 'nonrelativistic' limit, to be retrieved from a symmetry contraction procedure. Our approach emphasizes how such a formulation gives essentially all aspects of the theory from a full representation picture, including the dynamics from the natural symplectic geometry.

Nikola Kovačević

Irreducibility of variety of commuting elements of Lie algebras of type D_4

Let L be a Lie algebra and n a natural number. Gerstenhaber proved in 1965 that:

$$C_n(L) = \{(x_1, ..., x_n) \in L^n : (\forall 1 \leq i, j \leq n)[x_i, x_j] = 0\}$$

is an algebraic variety. One can ask geometrical questions about this variety: do we have a condition saying when is this reducible? Other question might be: if we know it is reducible, can we know (at least in small rank) components of certain Lie algebra. My research is centered around first question, second question is open completely. After a short introduction to the subject, I will talk what happens with $C_3(D_l)$ for $4 \leq l \leq 10$. Well, we hope to apply techniques developed by Han and Šivic and modify them to D_l. This is completely done for D_4 and I am presenting all the wonderful techniques used there. This is what I will try to cover:

- Han's lemma (case D_l) (just the statement without proof)
- Orbits in D_l
- Reducing to simpler case method

• General method - elements and blocks
• Smooth points
• Inverse method
So I think it will be very interesting.

Hiroshi Kunitomo

Superstring field theory with homotopy Lie algebra structure

A characteristic feature of covariant closed string field theory is that its action is non-polynomial. The gauge invariance of this non-polynomial action requires that the infinitely many interactions have a homotopy algebraic structure, an L-infinity structure. This structure is closely related to the triangulation of the moduli space of Riemann surfaces and ensures that string field theory reproduces the correct scattering amplitudes. In order to extend this to superstring field theory, we adopt the formulation using the picture changing operator (PCO) which appears by performing the super-moduli integral first. In general, however, the position of PCOs on the Riemann surface cannot coincide at the boundaries of all the patches in moduli space, so coming from so called vertical integration must be included, where the L-infinity structure plays an important role. In this talk, we construct a heterotic string field theory as an example of the covariant closed superstring field theory. We put together the infinite number of interactions realizing an L-infinity structure to one nilpotent co-derivation using co-algebra representation. We propose differential equations whose solution gives string products with an L-infinity structure. The action of heterotic string field theory is given by string products obtained by homotopy transfer from the solution.

Viktor Losert

On matrix coefficients of representations of $SL(2, R)$

We talk about the asymptotic behaviour of matrix coefficients of unitary representations of $SL(2, R)$. We review results of earlier authors and describe an approximation based on Whittaker functions which gives rise to new limit relations.

Chen-Te Ma

Modular average and Weyl anomaly in two-dimensional Schwarzian theory

The gauge formulation of Einstein gravity in AdS_3 background leads to a boundary theory that breaks modular symmetry and loses the covariant form. We examine the Weyl anomaly for the cylinder and torus manifolds. The divergent term is the same as the Liouville theory when transforming from the cylinder to the sphere. The general Weyl transformation on the torus also reproduces the Liouville theory. The Weyl transformation introduces an additional boundary term for reproducing the Liouville theory, which allows the use of CFT techniques to analyze the theory. The torus partition function in this boundary theory is one-loop exact, and an analytical solution to disjoint two-interval Rényi-2 mutual information can be obtained. We also discuss a first-order phase transition for the separation length of two intervals, which occurs at the classical level but is smoothed out by non-perturbative effects captured by averaging over a modular group in the boundary theory.

Stepan Maximov

Classification of twists of the standard Lie bialgebra structure on loop algebras

The standard Lie bialgebra structure on an affine Kac–Moody algebra induces a Lie bialgebra structure on the underlying loop algebra. We present a classification of classical twists of the induced structures in terms of Belavin-Drinfeld quadruples using their relation to classical r-matrices and the structure theory of loop algebras.

Arnaud Mayeux

Algebraic Magnetism

In the context of an arbitrary action of a diagonalizable group scheme on an algebraic space, I will introduce and study algebraic attractors and explain why they are interesting.

Ki-Bong Nam

Radical Weyl algebras and their isomorphisms

We define Radical Weyl algebras on the $\mathbb{F}$-algebra $\mathbb{F}[*^{\frac{\pm 1}{2}}, m, n]$ which contains the polynomial ring $\mathbb{F}[x_1, \cdots, x_n]$ and we show that the algebras are simple in this work. If we define a Weyl type algebra A on the generalized $\mathbb{F}$-algebra which contains the polynomial ring, then we need more relations along with the Weyl relation. We show that there are uncountably many non-isomorphic, non-commutative, associative simple-algebras and there are uncountably many non-isomorphic, infinite di-

mensional simple Lie algebras as well. We show that two different radical polynomials induce non-isomorphic radical Weyl algebras and Lie algebras. We define simple radical Weyl algebra-modules in this work.
Not given

Yuta Nasuda

SWKB formalism for the modulation of harmonic oscillator with discontinuity

The supersymmetric quantum mechanics (SUSY QM) has been extensively investigated for decades. In the context of SUSY QM, a WKB-like quantization condition called supersymmetric WKB (SWKB) condition has been proposed. The quantization condition successfully reproduces the exact bound-state spectra for many of the well-known exactly solvable potentials such as the harmonic oscillator, the Coulomb potential, the Morse potential and the Pöschl–Teller potential. The exact-solvability of these potentials is guaranteed by the classical orthogonal polynomials. In this talk, we first reconstruct those potentials by using the SWKB condition. Here, our only assumption is the knowledge of the explicit expressions for their energy spectra. We then discuss the construction method of a novel class of solvable potentials in the context of the SWKB formalism. Their solvability is also discussed.

Anton Nedelin

Elliptic integrable models and their spectra from superconformal indices

In this talk I will present a method of derivation of both previously known and novel integrable finite difference operators using N=1 quantum field theories. I will start with a brief review of the 4d compactifications of various 6d SCFTs leading to the wide class of 4d SCFTs. Then I will show how to derive various elliptic integrable systems using superconformal indices of these 4d theories as well as some intuition coming from the geometry of 6d compactifications. Finally I will briefly discuss novel method of obtaining eigenfunctions of these integrable operators using our field theory constructions.

Petr Novotný

Quantum particle on G_2 dual weight lattice in even Weyl alcove

Model of a free non-relativistic quantum particle propagating on the dual weight lattice inside the scaled fundamental domain is described and solved using Weyl orbit functions. Example concerning G_2 root system is presented.

Mikhail Podoinitsyn

Generalization of the Bargmann-Wigner construction for infinite spin fields

I will talk about the generalization of the Wigner scheme for constructing the relativistic fields corresponding to irreducible representations of the four-dimensional Poincaré group with infinite spin. The fields are parameterized by a momentum vector and an additional commuting vector or spinor variable. The equations of motion for fields of infinite spin are derived in both formulations under consideration.
Not given

Elena Poletaeva

On linked modules over super-Yangians and finite W-algebras

Let $Q(n)$ be the queer Lie superalgebra, W^n be the finite W-algebra for $Q(n)$ associated with the principal even nilpotent coadjoint orbit, and $YQ(n)$ be the super-Yangian of $Q(n)$. We consider the categories of finite-dimensional $YQ(1)$-modules and W^n-modules. After we classified simple modules, the natural problem is to describe blocks in these categories. We determine conditions under which two 1-dimensional modules over $YQ(1)$ and over W^n can be extended nontrivially. We use these results to describe blocks in the category of finite-dimensional W^2-modules. In certain cases we determine conditions under which two simple finite-dimensional $YQ(1)$-modules admitting a nonzero central character can be extended nontrivially and propose a conjecture in the general case.
It is a joint work with V. Serganova.

Todor Popov

Landau level quantization revisited

We revisit the Landau level quantization in a spherical geometry describing a charged particle in the magnetic monopole field. This monopole approach pioneered by Haldane in his studies of the Fractional Quantum Hall system has mainly concentrated in the lower Landau level. However higher Landau levels are also relevant. The monopole system enjoys a hidden dynamical conformal symmetry which we trace back to the conformal invariance of the electrodynamics.

Erich Poppitz

From the femtouniverse toward the "real world", via anomalies and twists

't Hooft anomalies involving generalized symmetries have provided new insights into the structure of gauge theories. I will first describe how the mixed anomaly between 0-form and 1-form symmetries in pure (super) Yang-Mills theory arises in the Hamiltonian formalism and show that it implies exact degeneracies in the Hilbert space at arbitrary spatial volume. Then, I will argue that, combined with semiclassical calculability (which holds in the compact "femtouniverse" and its various generalizations) the anomaly constraints and semiclassics reproduce the vacuum structure expected in the infinite-volume theory. This leads one to hope that further insights await along this road.

Tomas Prochazka

Bethe equations in 2d conformal field theory

I want to discuss the integrable structure of 2d conformal field theory. In particular the application of quantum inverse scattering method to Maulik-Okounkov instanton R-matrix leads to Bethe equations for quantum ILW hierarchy. The special cases of this construction lead to Bazhanov-Lukyanov-Zamolodchikov local Hamiltonians as well as Benjamin-Ono or Yangian Hamiltonians.

Miroslav Radomirov

Thermodynamic stability of AdS black holes

We study the local and the global thermodynamic stability of the AdS black hole solutions. The criteria for such equilibria are well-established in classical thermodynamics, but they have not been fully utilized in the black hole physics. The global thermodynamic analysis is based on the Sylvester criterion for positive definiteness of the Hessian of the energy. The study of local thermodynamic stability is realized through the calculation of the heat capacities and their positiveness.

Radoslav Rashkov

Remarks on the relations between spread complexity and certain integrable structures/models

The features as complexity, entanglement and so called information theory are becoming more and more topical and important in many areas of theoretical and mathematical physics. Characteristics as operator growth for instance, provide invaluable information about behavior of dynamical systems. As an example, in chaotic quantum many-body systems, operators grow in size as time evolves decaying into increasingly nonlocal operators. Thus, complexity growth, operator growth , entanglement and in general, all these concepts at quantum level and their holographic counterparts have far-reaching implications for quantum many-body systems, gravity and high-energy physics as a whole. In this talk I'll consider the so called spread complexity from different points of view. First I'll briefly review the contemporary understanding of spread complexity and (part of) approaches for its computation. Next I will discuss connections with integrable models, Painleve-type equations, etc.

Michel Rausch de Traubenberg

Fermions and bosons realisation of Kac-Moody and Virasoro algebras of the two-torus

In the first part of this talk we recall the main steps to obtain extensions of Kac-Moody algebras for higher dimensional compact manifolds. We then show that for the two-torus and the two-sphere, these extensions, as well as extensions of the Virasoro algebra can be obtained naturally from the usual Kac-Moody and Virasoro algebras. Explicit fermionic and bosonic realisations are proposed. In order to have well defined generators, beyond the usual normal ordering prescription, we introduce a regulator and regularise infinite sums by means of Riemann $\zeta-$function.

Akifumi Sako

Lie algebra and quantization in quantum world

We discuss the inverse problem of determining the classical limit from some Lie algebra. From a Lie algebra, we construct a sequence of quantization spaces, from which we determine a Poisson algebra by a classical limit as a category theory. We present a method to obtain this sequence of the quantizations from the principle of least action by using matrix regularization.

Igor Salom

Rational so(3) Gaudin model - a comprehensive treatment

We analyze the so(3) Gaudin model in the framework of the algebraic Bethe ansatz, while keeping the full generality of the boundary K-matrix parameters (which is made possible by constructing an appropriate vacuum vector). In particular: we conjecture and consequently prove (by mathematical induction) the form of off-shell action of the generating function on the Bethe vectors; we compute explicit forms of Gaudin Hamiltonians with general boundary terms, and find their off-shell action on the Bethe states; we establish the correspondence between the Bethe states and the solutions to the generalized Knizhnik-Zamolodchikov equations; we provide formulas for the on-shell norm of the Bethe states, as well as for their off-shell scalar product.

Avner Segal

New-way integral representations

Automorphic L-functions are objects of great importance in the fields of number theory, algebraic geometry and physics. The analytic behaviour of such functions can supply us with information on the spectrum of groups and its functorial lifts as well as on quantum chaos and black holes.The key tool for understanding this analytic behaviour is by writing an integral representation of these L-functions. While most such integral representations make use of a unique model for cuspidal representations. However, certain families of integral representations involve non-unique models, such integral representation are called new-way integral. The non-uniqueness of the model involved makes them more difficult to establish and this difficulty ditter people from working with them. This difficulty, however, can be overcome via a method suggested by I. Piatetski-Shapiro and S. Rallis. In this talk, I will present the ideas of an automorphic L-function, integral representations, unique vs. non-unique models and the PS-R's new-way by demonstrating it on a simple group.

Gizem Sengor

Searching for discrete series representations at the late-time boundary of de Sitter

The group SO(d+1,1) makes an appearance both as the conformal group of Euclidean space in d dimensions and as the isometry group of de Sitter spacetime in d+1 dimensions. While this common feature can be taken as a hint towards holography on de Sitter space, understanding the representation theory has importance for cosmological applications where de Sitter spacetime is relevant. Among the categories of SO(d+1,1) unitary irreducible representations, discrete series is important in physical applications because they are expected to capture gauge fields. However, they are also the most difficult ones to recognize in field theoretical examples compared to representations from the other categories. Here we point towards some examples where we are able to recognize discrete series representations from fields on de Sitter and highlight some of the properties of these representations.

Andrei Smilga

Monopole harmonics on CP^{n-1}

We find the spectra and eigenfunctions of both ordinary and supersymmetric quantum-mechanical models describing the motion of a charged particle over the $\mathbb{CP}^{n-1}$ manifold in the presence of a background monopole-like gauge field. The states form degenerate SU(n) multiplets and their wave functions acquire a very simple form being expressed via homogeneous coordinates. Their relationship to multidimensional orthogonal polynomials of a special kind is discussed. By the well-known isomorphism between the twisted Dolbeault and Dirac complexes, our construction also gives the eigenfunctions and eigenvalues of the Dirac operator on complex projective spaces in a monopole background.

Peter Spacek

Towards type-independent canonical mirror constructions for cominuscule homogeneous spaces

We will discuss a version of mirror symmetry where the (small) quantum cohomology ring of a homogeneous space is isomorphic to the coordinate ring of a mirror variety modulo relations generated by the derivatives of a (super)potential (also known as the Jacobi ring of the LG-model). We will describe how the structure of minuscule representations give rise to natural projective coordinates on minuscule homogeneous spaces, called (generalized) Plücker coordinates. We will then give an indication of the general construction (still ongoing work) of a potential on this minuscule homogeneous space creating a Landau-Ginzburg model forming the mirror to the cominuscule homogeneous space that is Langlands dual to the minuscule one. The type-independent constructions will return the known canonical mirror models for Grassmannians, Lagrangian Grassmannians and quadrics of Marsh-Pech-Rietsch-Williams, as well as those for the exceptional cominuscule family by S.-Wang.

Denitsa Staicova

Effect of the cosmological model on LIV constraints from GRB Time-Delays datasets

Putting constraints on a possible Lorentz Invariance Violation (LIV) from astrophysical sources such as gamma-ray bursts (GRBs) is an essential tool for finding evidences of new theories of quantum gravity (QG) that predict energy-dependent speed of light. Such a search has its own difficulties, so usually, the effect of the cosmological model is understudied and the default model is a fixed-parameters ΛCDM. In this work, we use different astrophysical datasets to study the effect of a number of dark energy models on the LIV constrains. To this end, we combine two public time-delay GRB datasets with the supernovae Pantheon dataset, a number of angular baryonic acoustic oscillations (BAO), the cosmic microwave background (CMB) distance prior and a GRB or quasars dataset. We find for α the expected average value of 4×10^{-4}, corresponding to EQG $\geq$ 1017 GeV for both time-delay (TD) datasets, with the second one being more sensitive to the cosmological model. We find that the cosmology amounts to at least 20% deviation in our constraints on the energy. Also interestingly, adding the TD points makes the DE models less-preferable statistically and shifts the value of the parameter c/(H0rd) down, making it smaller than the expected value. We see that possible LIV measurements depend critically on the transparency of the assumptions behind the published data with respect to cosmology and that taking it into account may be important contribution in the case of possible detection

Rafael Stekolshchik

Factorization of the longest element in the Weyl group with factors corresponding to highest roots

The longest element of the Weyl group (W, S) is factorized into a product of several (less than $|S| + 1$) reflections corresponding to mutually orthogonal (not necessarily simple) roots, each of which is either the highest root for a certain root subsystem J in S or is a simple root. The elements of factorization are presented for each type of the root system. The relationship between the longest elements of different types is found out. The uniqueness of the considered factorization and the connection with other known factorizations are discussed.

Stoimen Stoimenov

Symmetry analysis of the non-equilibrium dynamics of the biased spherical model

We consider an application of meta-conformal and meta-Schrödinger invariance to ferromagnetic spherical model, with a biased dynamics and spatially long-ranged initial correlations. Our hypotheses is that a dynamical scaling regime with dynamical exponent $z = 1$ can be identified. In order to justify this hypotheses, we compare the two-point response and correlation functions of the model, obtained by direct calculations with a two-point quantities covariant under ageing representations of meta-conformal and meta-Schrödinger algebras.

Hiroyasu Tajima

Universal trade-off relation between symmetry, irreversibility and quantum coherence

Symmetry, irreversibility, and quantum coherence are foundational concepts in physics. Here, we present a universal tradeoff relation between these three concepts. This particularly reveals that (1) under a global symmetry, any attempt to change the local conserved charge corresponding to the symmetry causes inevitable irreversibility, and (2) such irreversibility can be mitigated by quantum coherence. Our result follows only from the unitarity and global symmetry of the total dynamics and restricts various irreversibility, from thermodynamic irreversibility to the recovery error of error-correcting codes. Therefore, this result has many applications. For non-equilibrium physics, our result relates the coherence cost and the entropy production in arbitrary quantum processes. For quantum information theory, our tradeoff unifies and extends symmetry-induced restrictions on various information processing from measurements to error-correcting codes. For black hole physics, our tradeoff provides a universal lower bound on how many bits of classical information thrown into a black hole become unreadable under energy conservation. When the black hole is large, under suitable encoding, about $m/4$

bits in the thrown m bits will be irrecoverable until the black hole almost evaporates. Our main relation is based on quantum uncertainty relation, showcasing intimate relations between fundamental physical principles and ultimate operational capability.
Given by zoom

Ivan Todorov

The 2022 Nobel Prize in Physics

A handful of outcasts: the allegedly "senile" Einstein [EPR], the persecuted David Bohm [F15, F19], the "wasting his talent" John Bell [W16], the rejected for an academic job John Clauser [C02], ... rebelled against the sanctity of the Copenhagen interpretation of quantum mechanics and recognized a new phenomenon: the quantum entanglement [G08]. Its study and well advertised attempts to apply it now flourish. The Nobel Prize came 32 years after the death of John Bell [B], the theorist who triggered the "new quantum revolution" [A13], and 50 years after Clauser, the youngest among the above listed rebels, made his crucial experiment (at age 30). Even at this late date the Nobel committee displayed a misunderstanding of what has been achieved [M22].

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Valdemar Tsanov

On the nonconvexity of momentum map images

A classical theorem of Atiyah asserts that the image of a momentum map for a Hamiltonian action of a connected compact Lie group on a compact Kaehler manifold is a convex polytope, whenever the group is abelian. For a nonabelian group, a convex polytope is obtained by intersecting the image with a Weyl chamber, but the entire image may or may not be convex. In this talk, I will discuss some phenomena cause nonconvexity, and derive sufficient conditions for convexity of the entire image.

Joris Van der Jeugt

On classical $\mathbb{Z}_2 \times \mathbb{Z}_2$ graded Lie algebras

A $\mathbb{Z}_2 \times \mathbb{Z}_2$-graded Lie algebra $\mathfrak{g}$ is a $\mathbb{Z}_2 \times \mathbb{Z}_2$-graded algebra $\mathfrak{g}$ with a bracket $[\![\cdot,\cdot]\!]$ that satisfies certain graded versions of the symmetry and Jacobi identity. In particular, despite the common terminology, $\mathfrak{g}$ is not a Lie algebra. We construct classes of $\mathbb{Z}_2 \times \mathbb{Z}_2$-graded Lie algebras corresponding to the classical Lie algebras, in terms of their defining matrices. For the $\mathbb{Z}_2 \times \mathbb{Z}_2$-graded Lie algebra of type A, the construction coincides with the previously known class. For the $\mathbb{Z}_2 \times \mathbb{Z}_2$-graded Lie algebra of type B, C and D our construction is new and gives rise to interesting defining matrices closely related to the classical ones but undoubtedly different. We also give some examples and possible applications to parastatistics.

Olena Vaneeva

Extended symmetry analysis of two-dimensional degenerate Burgers equation

We discuss the results of the extended symmetry analysis of a two-dimensional degenerate Burgers equation. Its complete point-symmetry group is found using the algebraic method, and all its generalized symmetries are proved to be equivalent to its Lie symmetries. We also prove that the space of conservation laws of this equation is infinite-dimensional and is naturally isomorphic to the solution space of the (1+1)-dimensional backward linear heat equation. Lie reductions of the two-dimensional degenerate Burgers equation are comprehensively studied and new Lie invariant solutions are constructed. We additionally consider solutions that also satisfy an analogous nondegenerate Burgers equation. In total, we construct four families of solutions of two-dimensional degenerate Burgers equation that are expressed in terms of arbitrary (nonzero) solutions of the (1+1)-dimensional linear heat equation.

Tsvetan Vetsov

Thermodynamic length and holographic models

We are going to consider the concept of thermodynamic length between macrostates and its implications for holographic models.

Yihong Wang

Progress on the Shapovalov construction of scattering amplitudes

In this talk, I will talk about the progress we have since LT-14 on the Lie-algebraic construction of scattering amplitudes, including how to extending the Shapovalov form construction of momentum kernel to numerators and amplitudes and its relation to string vertex algebra.

Bruce Westbury

Series of representations

The idea of a series of representations was inspired by Vogels approach to adjoint representations using the universal Lie algebra. A continuation of this idea is to regard the preferred representations in each row of the Freudenthal magic square as a series of representations. In this talk I will consider representations, V, with the properties:

- V is self-dual

• $V \times V$ is multiplicity free
• $V \times V$ has at most five composition factors
I will explain how these representations are organised into lines using the quadratic Casimir. This leads to a description of a commutative algebra which interpolates the algebras $End(V \times V)$ using the classification of representations of the three string braid group.

Milen Yakimov

Poisson geometry and representation theory of cluster algebras

In the area of cluster algebras, there are two general constructions: the Gekhtman-Shapiro-Vainshtein Poisson structures on cluster algebras and the associated root of unity quantum cluster algebras. We will prove that the spectrum of each of the former algebras has an explicit Zariski open torus orbit of symplectic leaves, which is a far reaching generalization of the complement of the Richardson divisor of Schubert cells in Lie theory. We will then show that the algebras in the latter class have canonical Cayley-Hamilton structures in the sense of Procesi. Based on these two methods, we will describe explicitly the fully Azumaya loci of all root of unity quantum cluster algebras. This classifies their irreducible representations of maximal dimension.
This is joint work with Shengnan Huang, Thang Le, Greg Muller, Bach Nguyen and Kurt Trampel.

George Zoupanos

Unification based on a N=1, 10D, E(8) theory, leading to a split-like supersymmetric model after dimensional reduction over a modified flag manifold

We examine a supersymmetric extension of the Standard Model which results from a 10D, N=1, E(8) gauge theory. The initial unified theory is dimensionally reduced over the $SU(3)/U(1) \times U(1) \times Z(3)$ space and, after using the Wilson flux breaking, the resulting 4D theory is an N=1, $SU(3)^3 \times U(1)^2$ Grand Unified Theory. Below the unification scale we are left with a split-like supersymmetric version of the Standard Model with two global U(1) symmetries. The model is proton-decay safe and the lightest new particles acquire masses of a few TeV. The above is based on one-loop analysis, while the two-loop is in progress.

Late Abstracts received after Booklet was ordered

Hamed Pejhan

The Relativistic Meaning of the 1 + 3-Dimensional de Sitter Relativity Group

This presentation delves into the relativistic meaning of the (1+3)-dimensional de Sitter (dS_4) relativity group and its associated Lie algebra. Our exploration focuses on the physical analysis of dS_4 relativity, specifically in relation to its flat contraction limit, where the radius of curvature tends towards infinity.

Elchin Jafarov

The semiconfined harmonic oscillator with a position-dependent effective mass: exact solution, dynamical symmetry algebra and quasi-probability distribution functions

We present details of the new model of the quantum harmonic oscillator [1]. This model is semiconfined due to a specific change of its mass by position. We succeeded to solve exactly the Schroedinger equation corresponding to this model in the framework of the non-relativistic canonical quantum mechanics. Surprisingly, its energy spectrum completely overlaps with the energy spectrum of the known so-called Hermite oscillator, but the wavefunctions of the stationary states are expressed through the generalized Laguerre polynomials. We also extended this exact solution to the case, when the oscillator model suddenly becomes exposed to the action of the external homogeneous field [2]. Moreover, we found that the dynamical symmetry algebra for this semiconfined harmonic oscillator model is su(1,1) Heisenberg-Lie algebra [3]. Further, we constructed the phase space of this oscillator model and could compute analytically its Husimi function in terms of the parabolic cylinder function [4] and Wigner function in terms of the product of the Bessel function of the first kind and Laguerre polynomials [5]. A lot of other useful properties of this model are also studied and a number of analytical expressions extending known expressions of the Hermite oscillator are obtained, too. This is the joint work with A.M. Jafarova, S.M. Nagiyev (Institute of Physics, Baku), and J. Van der Jeugt (Ghent University). This work was supported by the Azerbaijan Science Foundation – Grant Nr AEF-MCG-2022-1(42)-12/01/1-M-01.

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Yacine Barhoumi

Independence structures in random matrix theory and integrable probability

We write the largest eigenvalue of a random matrix and the largest part of a random partition distributed according to the Schur measure as a maximum of independent random variables. This implies algebraic identities between Painlevé functions or Verblunski coefficients of Orthogonal polynomials on the unit circle.
Poster session

Shu Chen

Exact solution of 1D Bose-Hubbard model with unidirectional hopping

The 1D Bose-Hubbard is generally not exactly solvable. We show that the 1D Bose-Hubbard model with unidirectional hopping is an integrable model, which is guaranteed by Yang-Baxter equation. We exactly solve the model and demonstrate the existence of superfluid-Mott transition for integer filling. We also show the existence of non-Hermitian skin effect even in the presence of interaction.
Poster session

Kalin Marinov

Modeling of non-rotating neutron stars in minimal dilatonic gravity

The model of minimal dilatonic gravity (MDG) is an alternative model

of gravitation, which uses one Branse-Dicke gravitation-dilaton field Φ and offers a simultaneous explanation of the effects of dark energy (DE) and dark matter (DM). We present an extensive research of nonrotating neutron star models in MDG with four different realistic equations of state (EOS), which are in agreement with the latest observational data. The equations describing static spherically symmetric stars in MDG are solved numerically. The effects corresponding to DE and DM are clearly seen and discussed.
Poster session