THE XXVI. INTERNATIONAL CONFERENCE ON INTEGRABLE SYSTEMS AND QUANTUM SYMMETRIES

A B S T R A C T S

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PLENARY SPEAKERS

Global analysis and global pseudo-differential operators on quantum groups

Cardona, Alexander

Universidad de los Andes, Bogotá, Colombia

M. Ruzhansky and V. Turunen introduced the notion of global pseudo-differential operators on Lie groups and homogeneous spaces a few years ago, using the machinery of Fourier analysis on groups to define matrix-valued symbols, which naturally "quantize" the local notion used in global analysis on manifolds. This notion can be used to define pseudo-differential operators on compact quantum groups in terms of their distribution theory and the corresponding Fourier analysis, which follows the lines of the already accomplished theory for compact Lie groups and give a different perspective to approach the global analysis on such objects. In this talk we will present the building blocks of the theory and some applications, in particular in the case of the quantum group $\mathrm{SU}_q(2)$.

Different uses of supersymmetry in particle physics

Catto, Sultan

CUNY Graduate School and The Rockefeller University, New York, USA

In this talk we shall first give a partial summary of the different applications of supersymmetry (SUSY) in particle physics and then primarily concentrate on obtaining phenomenological SUSY from QCD. We will discuss the formation of diquarks, effective Hamiltonians for two- and three-quark systems leading to an approximate supersymmetry in a baryon-meson system based on an extended $SU(6)$ formalism, derivation of the split octonionic color algebra, new linear and quadratic mass formulae for vector mesons, extending into multiquark systems, such as pentaquarks, with emphasis on mass splittings, and lastly, we will provide further remarks on the symmetries of a baryonic system.

Quantum projection evolution in spacetime versus evolution in time – problem of symmetries

Góźdź, Andrzej

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Joint work with: Marek Góźdź, Aleksandra Pędrak

There are experiments showing unexpected quantum phenomena. Good example of such phenomenon is time interference. The other experiments based on the EPR correlations suggest that the notion of causality should be also revisited. In addition, a part of known quantum paradoxes like delayed choice, quantum eraser and many others try to be explained in an inconsistent way. Relativity also requires treatment of all spacetime coordinates on the same footing.

All these problems seem to be solved assuming that physical time is the quantum observable like other position operators. The idea of projection evolution fulfil this requirement. The projection evolution is a kind of stochastic quantum process driven by changes of the Universe enumerated by linearly ordered set, not the time.
During the seminar the main idea and some examples will be presented. This approach opens a series of important physical and also mathematical problems. The second part of this seminar devoted to symmetries and conservation laws will be given by A. Pędrak.

Supersymmetric Calogero and Calogero-Sutherland models from gauging

Ivanov, Evgeny

BLTP JINR, Dubna, Russian Federation

We derive new kind of $N = 2$ and $N = 4$ supersymmetric extensions of the rational and hyperbolic Calogero models by gauging $U(n)$ symmetry of the appropriate superfield matrix models. These systems feature non-standard numbers Nn^2 of physical fermionic variables as compared with Nn in the standard case. An essential ingredient of $N = 4$ models is the necessary presence of semi-dynamical spin variables described by $d = 1$ Wess-Zumino terms. The bosonic cores of $N = 4$ models are $U(2)$ spin Calogero and Calogero-Suitherland models. In the hyperbolic case two non-equivalent $N = 4$ extensions exist, with and without the interacting center-of-mass coordinate in the bosonic sector. The talk is based on joint works with Serfey Fedoruk and Olaf Lechtenfeld.

Large Extended supersymmetric Calogero models

Krivonos, Sergey

BLTP JINR, Dubna, Russian Federation

We present the supercharges of the N N -extended supersymmetric A_n Calogero models in the standard form, maximally cubic in the fermions. The complexity of the model is encoded in a non-canonical and nonlinear conjugation property of the fermions. Employing the new cubic supercharges, we apply a supersymmetric generalization of a "folding" procedure for $A_{2n-1} \oplus A_1$ to explicitly construct the supercharges and Hamiltonian for arbitrary even- N supersymmetric extensions of the B_n, C_n and D_n rational Calogero models. We demonstrate that all considered models possess a dynamical $osp(\mathcal{N}|2)$ superconformal symmetry. We also construct N = 4 supersymmetric trigonometric/hyperbolic Calogero models associated with A_n, B_n, C_n and D_n algebras.

New approach to colour symmetries: Z-3-graded Dirac equations for quarks and confinement

Lukierski, Jerzy

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We describe a modification of standard QCD description of quark fields endowed with colour degrees of freedom by introducing a 12-component colour generalization of Dirac spinor, with built-in Z_3 grading playing an important role in generating quarks confinement. In colour Dirac equations the $SU(3)$ colour symmetry is entangled with the Z_3-graded generalization of Lorentz symmetry, which contains three 6-parameter sectors related by Z_3 maps. The generalized Lorentz covariance requires simultaneous presence of 12 colour Dirac multiplets, which lead to the description of all internal symmetries of quarks: $SU(3) \times SU(2) \times U(1)$,Xiv: the flavour symmetries and three quark families. The paper is based on my recent publication in Physics Letters B, co-authored with Richard Kerner (arXiv 1901.10936 [hep-th])

Boundary matrices for the higher spin six vertex model

Mangazeev, Vladimir

The Australian National University, Canberra, Australia

In this talk we consider solutions to the reflection equation related to the higher spin stochastic six vertex model. The explicit formulas for boundary K-matrices for spins s= 1/2,1 are well known. We derive difference equations for the generating function of matrix elements of the K-matrix for any spin s and solve them in terms of hypergeometric functions. As a result we derive the explicit formula for matrix elements of the K-matrix for arbitrary spin. In the lower- and upper- triangular cases, the K-matrix simplifies and reduces to simple products of q-Pochhammer symbols.

Sugawara operators for centralizers

Molev, Alexander

University of Sydney, Sydney, Australia

By a celebrated theorem of Feigin and Frenkel (1992), the center of the affine vertex algebra at the critical level, associated with a simple Lie algebra $\mathfrak{g}$, is an algebra of polynomials in infinitely many variables. This theorem was extended in a recent work by Arakawa and Premet (2017) to the case where $\mathfrak{g}$ is replaced by the centralizer $\mathfrak{g}^e$ of a nilpotent element $e \in \mathfrak{g}$. We construct a family of free generators of the center for $\mathfrak{g} = \mathfrak{gl}_N$ and an arbitrary nilpotent element e. As a corollary, we recover the Casimir elements for the centralizer produced earlier by Brown and Brundan (2009).

Manifestation of symmetries in two-electron quantum dots in a magnetic field

Nazmitdinov, Rashid

Joint Institute for Nuclear Research, Dubna, Russia

We use entanglement to study the electron density distribution (shape) in two-electron axially-symmetric parabolic quantum dots under a perpendicular magnetic field. At a specific value of the magnetic field the density distribution attains a spherical symmetry. The shape transition from the axial to the spherical symmetry manifests itself as a drastic change of the entanglement of the lowest state with zero angular momentum projection. While the electrons in such a state are always localized in the plane (x-y) before the transition point, after this point they become localized in the vertical direction.

$\mathbf{CP}^N$-generalizations of oscillator and Rosochatius systems and their supersymmetrization

Nersessian, Armen

Yerevan Physics Institute, Yerevan, Armenia & JINR, Dubna, Russia

Joint work with: Evgeny Ivanov, Hovhannes Shmavonyan

We propose superintegrable mechanical system on the complex projective space CPN involving a potential term together with coupling to a constant magnetic fields. This system can be viewed as a $\mathbf{CP}^N$-analog of both the flat singular oscillator and its spherical analog known as "Rosochatius system". We find that this system belongs to the class of "Kähler oscillators" admitting $SU(2|1)$ supersymmetric extension. We show that, in the absence of magnetic field and with the special choice of the characteristic parameters, the system admits $\mathcal{N} = 4, d = 1$ Poinacaré supersymmetric extension.

The octagon as a determinant

Petkova, Valentina

Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria

Recently it has been shown, using integrability inspired technique, that the computation of a certain class of four-point functions of heavily charged BPS operators in the $\mathcal{N} = 4$ supersymmetric Yang-Mills theory boils down to the computation of a special form factor - the octagon. We obtain a closed analytic expression for the octagon (or for its square) at any coupling as a Fredholm pfaffian (respectively Fredholm determinant). Furthermore the octagon is represented as a determinant of a semi-infinite matrix. At weak coupling the entries of this matrix are linear combinations with simple rational coefficients of the functions expressed by polylogarithms which evaluate ladder Feynman graphs. The octagon also admits an operator representation in terms of massless free bosons or fermions living in the rapidity plane. This is joint work with Ivan Kostov and Didina Serban.

Integrable systems of Calogero-Moser type on moduli spaces of flat connections.

Reshetikhin, Nicolai

University of Califronia, Berkeley, USA

In this talk we describe a family of superintegrable Hamiltonian systems on moduli spaces of flat connections on a surface. For a torus with one puncture these systems are known as relativistic spin Calogero-Moser systems and relativistic spin Rujsenaars-Shneider systems. The connection with other recent results on Calogero-Moser type systems will be discussed. This is a joint work with S. Artamonov.

Generalisation of the Poincare Group and of the Yang-Mills theory

Savvidy, George

Demokritos National Research Centre, Athens, Greece

We suggested an extension of the Poincaré algebra adding infinitely many generators carrying internal and space-time indices. The representations of this algebra are divided into two subsets, longitudinal and transversal. The transversal representations involve an infinite series of integer helicities. In the proposed generalisation of Yang-Mills theory the non-Abelian tensor gauge fields take value in the extended Poincaré algebra. The invariant Lagrangian has quadratic kinetic terms, as well as cubic and quartic terms describing non-linear interaction of tensor gauge fields with the dimensionless coupling constant. We demonstrate that extended gauge symmetry allows to fix the unitary gauge and derive scattering amplitudes. We calculated the Callan-Symanzik beta function, the contribution is negative and corresponds to the asymptotically free theory.

All basic quantizations of orthosymplectic Lie superalgebra $\mathfrak{osp}(1|2;\mathbb{C})$ and its real forms

Tolstoy, Valeriy

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Using a simple algebraic technique we obtain the complete classification of all basic (non-isomorphic) quantum deformations for the orthosymplectic Lie superalgebra $\mathfrak{osp}(1|2;\mathbb{C})$ and its real forms in terms of the classical r-matrices. In particular, we prove that the $D = 3$, $N = 1$ Lorentz supersymmetry, which is the non-compact real form of $\mathfrak{osp}(1|2;\mathbb{C})$, has four different Hopf-algebraic quantum deformations: two standard q-analogs, and two Jordanian and super-Jordanian twist deformations. All basic Hopf-algebraic quantum deformations are presented in the explicit form.

Exact solution of the $sp(4)$ integrable spin chain with generic boundaries

Yang, Wen-Li

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The off-diagonal Bethe ansatz method is generalized to the integrable model associated with the $sp(4)$ Lie algebra. By using the fusion technique, we obtain the complete operator product identities among the fused transfer matrices. These relations, together with some asymptotic behaviors and values of the transfer matrices at certain points, enable us to determine the eigenvalues of the transfer matrices completely. For the periodic boundary condition case, we recover the same $T-Q$ relations obtained via conventional Bethe ansatz methods previously, while for the off-diagonal boundary condition case, the eigenvalues are given in terms of inhomogeneous $T-Q$ relations, which could not be obtained by the conventional Bethe ansatz methods.

ABSTRACTS OF PARTICIPANTS

Negativity of Wigner function as an indicator of the total nonclassicality of the state space of N-level quantum system

Vahagn Abgaryan[1,2] *and Arsen Khvedelidze*[1]

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Modern views on quantum theory on the phase space indicate that the "nonclassicality" of the state is reflected by the negativity of its Wigner function. Moreover, due to the vagueness of the notion of "nonclassicality" it is often identified as the negativity itself. We start from the construction of the Wigner function for an N-level system in a way that the mapping kernel fulfills Stratanovich-Weyl restrictions. Then the relative volume of part of the support where Wigner function is negative is introduced as a measure of "nonclassicality". Based on this we calculate the total neoclassicality contained in the Hilbert space of N-level quantum system with respect to the Hilbert-Schmidt measure. This quantity does not depend on the choice of Stratonovich-Weyl kernel in the limit of infinite dimensional system.

Bound State Solution of the Klein-Fock-Gordon equation for the sum of Manning-Rosen and Yukawa potential within SUSY quantum mechanics

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Joint work with: M. Demirci, S. M. Aslanova

In this paper, the bound state solution of the modified Klein-Fock-Gordon equation is obtained for the sum of Manning-Rosen and Yukawa potential by using the developed scheme to overcome the centrifugal part. The energy eigenvalues and corresponding radial wave functions are defined for any $l \neq 0$ angular momentum case on the conditions that scalar potential is whether equal and nonequal to vector potential, the bound state solutions of the Klein-Fock-Gordon equation for the sum of Manning-Rosen and Yukawa potential are obtained by Nikiforov-Uvarov (NU) and supersymmetric quantum mechanics (SUSYQM) methods. The equivalent expressions are obtained for the energy eigenvalues, and the expression of radial wave functions transformations to each other is revealed owing to both methods. The energy levels and the corresponding normalized eigenfunctions are represented in terms of the Jacobi polynomials for arbitrary l states. A closed form of the normalization constant of the wave functions is also found. It is shown that the energy eigenvalues and eigenfunctions are sensitive to n_r radial and l orbital quantum numbers.

On dual description of the deformed $OSp(Nj2m)$ sigma models

Alfimov, Mikhail

HSE University and P.N. Lebedev Physical Institute of the RAS, Moscow, Russia

Joint work with: Boris Feigin, Ben Hoare and Alexey Litvinov

We study dual strong coupling description of an integrable deformation of the $OSp(Nj2m)$ sigma model. This description is based on the set of screening charges, which we present and which describes the integrable structure of this theory. We find one-parametric Yang-Baxter deformation of the $OSp(Nj2m)$ sigma model and study its one-loop renormalization group ow. This action is conjectured to appear from the mentioned system of the screening charges.

Analytical integrability in some gravitational and electromagnetic backgrounds

Andrzejewski, Krzysztof

University of Lodz, Lodz, Poland

During the talk I will discuss the existence of analytical solutions to the equations of motion for a particle in some gravitational and electromagnetic backgrounds. Considered backgrounds are related to the conformal symmetry and can be used to model some physical phenomena; in consequence, some deeper insight into the interaction between particles and fields can be obtained.

Stochastic products of quantum states

Aniello, Paolo

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A notion of stochastic product, defined as a binary operation on the convex set of quantum states preserving the convex structure, is introduced. We will describe, in particular, an interesting class of group-covariant, associative stochastic products, the so-called twirled products. Each binary operation in this class is obtained by means of a square integrable projective representation of a locally compact topological group, by a probability measure on this group and by a fiducial density operator in the Hilbert space of the representation. It turns out that, by suitably extending this binary operation from the density operators to the full Banach space of trace class operators, one gets a Banach algebra. This algebra is commutative in the case where the relevant group is abelian. Finally, the physical interpretation of the twirled stochastic products and various intriguing connections with the literature will be discussed.

The Boundary Conformal Field Theories of the Potts model Critical Points

Balaska, Smain

University of Oran

We identify the Boundary Conformal Field Theories (BCFTs) describing the critical points of the 3-states Potts model on the strip. It consists in measuring the low-lying excitation energies spectra of its quantum spin chain for different boundary conditions and then to compare them with those of the different boundary conformal field theories of the (A4,D4) minimal model.

Darboux transformation and soliton solution for generalized Konno-Oono equation

Bekova, Guldana

L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan

Joint work with: Shaikhova Gaukhar, Ratbay Myrzakulov

In this paper, the generalized Konno-Oono equation is investigated. Using the Lax pair, we obtain a new Darboux transformation for the dispersionless equation. A soliton solution of the generalized Konno-Oono equation is obtained on the basis of the Darboux transformation. Corresponding graphs are also built.

BPS Cho–Maison magnetic monopole

Beneš, Petr

IEAP CTU in Prague, Czech Republic

Joint work with: Filip Blaschke

We present exact solutions to the Cho–Maison magnetic monopole in a family of effective electroweak models that have a Bogomol'nyi–Prasad–Sommerfield limit. We find that the lower bound to the mass of the magnetic monopole is $M \geq 2\pi v/g \approx 2.37$ TeV. We argue that this bound holds universally, not just in theories with a BPS limit.

Polymer Quantum Mechanics as a Deformation Quantization

Berra-Montiel, Jasel

Universidad Autonoma de San Luis Potosi, San Luis Potosi, Mexico

We analyze the polymer representation of quantum mechanics within the deformation quantization formalism. In particular, we construct the Wigner function and the star-product for the polymer representation as a distributional limit of the Schrödinger representation for the Weyl algebra in a Gaussian weighted measure, and we observe that the quasi-probability distribution limit of this Schrödinger representation agrees with the Wigner function for Loop Quantum Cosmology. Further, the introduced polymer star-product fulfills Bohr's correspondence principle even though not all the operators are well defined in the polymer representation. Finally, within our framework, we also derive a generalized uncertainty principle which resembles the one appearing in different scenarios, including theories with a minimal length.

On rotationally invariant (super)integrability with magnetic fields in 3D

Bertrand, Sébastien

Czech Technical University in Prague, Prague, Czech Republic

Joint work with: Libor Šnobl

Superintegrable Hamiltonian systems possess remarkable properties from a physical and mathematical point of view. To obtain these systems, one can start from integrable systems and look for additional integrals of motion. We will consider 3D Hamiltonian systems admitting a nonzero magnetic field, and more precisely, we will focus on such systems that possess two quadratic integrals of motion of nonsubgroup type, where one of them has its leading order term in angular momentum. If the magnetic field is set to zero, it leads to the three cases that allow separation of the Hamilton-Jacobi or Schrödinger equations in the circular parabolic, prolate and oblate spheroidal coordinates. In addition, we will provide some superintegrable systems, mainly for the circular parabolic case.

Finite Electroweak Monopole from Braneworld

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and iTHEMS, RIKEN, 2-1 Hirasawa, Wako, Saitama 351-0198, Japan

We propose a minimal and self-contained model in non-compact flat five dimensions which localizes the Standard Model (SM) on a domain wall. Localization of gauge fields is achieved by the condensation of Higgs field via a Higgs dependent gauge kinetic term in five-dimensional Lagrangian. The domain wall connecting vacua with unbroken gauge symmetry drives the Higgs condensation which provides both electroweak symmetry breaking and gauge field localization at the same time. Our model predicts higher-dimensional interactions $|H|^{2n}(F_{\mu\nu})^2$ in the low-energy effective theory. This leads to two expectations: The one is a new tree-level contribution to $H \to \gamma\gamma$ ($H \to gg$) decay whose signature is testable in future LHC experiment. The other is a finite electroweak monopole which may be accessible to the MoEDAL experiment. Interactions of translational Nambu-Goldstone boson is shown to satisfy a low-energy theorem.

Poisson-Lie groups, integrable deformations of the Rikitake system and bihamiltonian structures

Blasco, Alfonso and Ballesteros, Angel

Universidad de Burgos, (Burgos), Spain

A very well-known model of the (aperiodic) Earth's geomagnetic field reversals is the so-called Rikitake model which is based on the dynamics of two connected identical frictionless disk dynamos, that is non-integrable for most values of the system parameters. Integrable deformations of the following Rikitake-type dynamical system

$$\dot{x} = -\mu x + y(z + \beta_1), \qquad \dot{y} = -\mu y + x(z - \beta_2), \qquad \dot{z} = \alpha - xy,$$

are constructed by deforming their underlying Lie-Poisson Hamiltonian structures. Such deformations are obtained by considering the corresponding Lie-Poisson algebras as a linearization of a certain Poisson–Lie structure on a given dual Lie group. In this way, a deformed Poisson-Hopf algebra can be obtained for each Rikitake model, which enables the construction of integrable deformations of coupled sets of Rikitake systems, whose integrals of the motion can be explicitly obtained. The same procedure can be also applied to a very particular case of Rikitake system, which is bihamiltonian with respect to two different Lie-Poisson algebras. In order to keep the bihamiltonian structure under

deformation, a common dual Poisson-Lie group for the two Lie-Poisson structures have to be found. Coupled systems for this bihamiltonian deformation are also presented. In all coupled systems the use of 'cluster variables' turns out to be convenient in order to analyse the dynamics.

On the status of pointlike fields in integrable QFTs

Bostelmann, Henning

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In integrable models of quantum field theory, local fields are normally constructed by means of the bootstrap-formfactor program. However, the convergence of their n-point functions is unclear in this setting. An alternative approach uses fully convergent expressions for fields with weaker localization properties in spacelike wedges, and deduces existence of observables in bounded regions from there, but yields little information about their explicit form. We propose a new, hybrid construction: We aim to describe pointlike local quantum fields; but rather than exhibiting their n-point functions and verifying the Wightman axioms, we establish them as closed operators affiliated with a net of local von Neumann algebras that is known from the wedge-local approach. This is shown to work at least in the Ising model.

Discrete Transforms and Orthogonal Polynomials of (Anti)symmetric Multivariate Sine Functions

Brus, Adam

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The multivariate antisymmetric and symmetric trigonometric functions allow to generalize the classical Chebyshev polynomials to multivariate settings. The four classes of the multivariate polynomials, related to the symmetrized sine functions, are studied. For each of these polynomials, the weighted continuous and discrete orthogonality relations are shown. The related cubature formulas for numerical integration together with further model examples and properties of selected special cases are discussed.

Conjugacy Classes and Centralizers for Pivotal Fusion Categories

Burciu, Sebastian

Institute of Mathematics of Romanian Academy, Bucharest, Romania

A criterion for Müger centralizer of a fusion subcategory of a braided non-degenerate fusion category is given. Along the way we extend some identities on the space of class functions of a pivotal fusion category introduced recently by Shimizu. We also show that in a modular tensor category the product of two conjugacy class sums is a linear combination of conjugacy class sums with rational coefficients. The talk is based on the preprint arXiv:1904.02226.

On indicator of quantumness from negativity of Wigner functions of Bures and Hilbert-Schmidt ensembles of qubit and qutrit

Bures, Martin

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Joint Institute for Nuclear Research, Dubna, Russia

Joint work with: Vahagn Abgaryan, Arsen Khvedelidze, Iliya Rogojin, Astghik Torosyan

The global indicator quantifying nonclassicality of an N-dimensional system via negativity of the Wigner function is discussed. The indicator is defined via relative volume of the subspace of unitary orbit space of a quantum system where the Wigner distribution is positive. The numerical and analytical results of evaluation of the global indicator for the Hilbert-Schmidt and the Bures ensembles of qubit and qutrit systems are given.

Operator-algebraic construction of quantum integrable models with bound states

Cadamuro, Daniela

University of Leipzig, Institute for Theoretical Physics, Leipzig, Germany

We consider the construction of integrable quantum field theories in the operator-algebraic approach, which is based on quantum fields localized in infinitely extended wedge regions. The existence of strictly localized observables can then be obtained by abstract C^*-algebraic arguments. This avoids dealing with the functional analytic properties of pointlike interacting fields, which are difficult to control due to the convergence problem of the infinite series of their form factors. This approach has been successful for the construction of a class of models with scalar S-matrices and without bound states. In extension of these results, we consider S-matrices with poles in the physical strip ("bound states"). We exhibit wedge-local fields in these models, which arise as a deformation of those in the non-boundstate models by an additive term, the so called "bound state operator". This technique applies to a variety of theories, e.g., the Bullough-Dodd model, the $Z(N)$-Ising model, the affine Toda field theories and the Sine-Gordon model.

Exact solution of an integrable anisotropic $J_1 - J_2$ spin chain model

Cao, Junpeng

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An integrable anisotropic Heisenberg spin chain with nearest-neighbour couplings, next-nearest-neighbour couplings and scalar chirality terms is constructed. After proving the integrability, we obtain the exact solution of the system. The ground state and the elementary excitations are also studied. It is shown that the spinon excitation of the present model possesses a novel triple arched structure. The elementary excitation is gapless if the anisotropic parameter η is real while the elementary excitation has an enhanced gap by the next-nearest-neighbour and chiral three-spin interactions if the anisotropic parameter η is imaginary. The method of this paper provides a general way to construct new integrable models with next-nearest-neighbour interactions.

Gauge-Theory Lagrangians and Projective Geometry

Dahm, Rolf

beratung für IS, Mainz, Germany

We discuss the Lagrangian structure of gauge theory from both sides: Given a typical gauge theory with fermion and boson fields, we re-identify well-known constituents and relate them to representations known from classical projective geometry. Vice versa, starting from second order surfaces like the energy representation $E^2 - \vec{p}^2 = p_\mu p^\mu$, we discuss related line and plane representations of projective geometry in 3-space and their line generators. Following the construction by three linear Complexe yields a boson part, and using Complexe and null systems, we discuss on how to obtain Cartan and Dirac spinor reps. In both cases, the Lie algebra $\mathrm{su}(2) \oplus i\mathrm{su}(2)$ of the Lorentz group (i.e. special relativity) is intrinsically related to line and linear Complex reps, and it originates from infinitesimal motions of rotations and null systems. Last not least, we discuss Lie operator representations and invariants, and we close with a brief outlook on how to generalize aspect of this representation theory by means of projective geometry and P^5.

Lie-algebraically twist-deformed Sprott systems and their synchronization by active control

Daszkiewicz, Marcin

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We provide the Lie-algebraically twist-deformed Sprott models defined on quantum space-time with two spatial directions commuting to space. Further, we demonstrate, that effectively, each of them is described by system of three complex, ordinary and nonlinear differential equations. Apart of that, we find for such modified models the corresponding jerk dynamics as well as we synchronize them with use of so-called active control method. Besides, we illustrate our results by numerical calculations performed for the twist-deformed identical Sprott-A system.

On calculation of the quadrupole operator in the orthogonal Bargmann-Moshinsky basis of SU(3) group

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Quadrupole operators are calculated in orthonormal SU(3) $\supset$ SO(3) non-canonical Bargman-Moshinsky (BM) basis with the highest weight vectors $(L, M = L)$ of SO(3) irreducible representations (λ, μ). A new symbolic-numerical non-standard recursive and fast orthonormalization procedure based on the Gram-Schmidt orthonormalization algorithm is developed. The presented procedure uses the analytical formulas of the overlap integrals of the BM basis and does not involve any square root operation on the expressions coming from the previous recursive computation steps. The computation of the components of the quadrupole operator in the orthonormalized BM basis is implemented in the Wolfram Mathematica 10.1. The tests of performance and efficiency of the developed procedure for the quadrupole operators calculation are presented.

Stringy Kahler moduli, mutation and monodromy

Donovan, Will

Tsinghua University, Beijing, China

Joint work with: Yau MSC

The derived symmetries associated to a 3-fold admitting an Atiyah flop may be organised into an action of the fundamental group of a sphere with three punctures, thought of as a stringy Kahler moduli space. I extend this to general flops of irreducible curves on 3-folds in joint work with M. Wemyss. This uses a novel helix of sheaves supported on the flopping curve, and leads to a conjectural description of the associated derived symmetry group.

Discrete Painlevé Equations in Tiling Problems

Dzhamay, Anton

The University of Northern Colorado, Greeley, CO, USA

Joint work with: Alisa Knizel, Columbia University, New York, NY, USA

The notion of a gap probability is one of the main characteristics of a probabilistic model. A. Borodin showed that for some discrete probabilistic models of Random Matrix Type discrete gap probabilities can be expressed through solutions of discrete Painlevé equations, which provides an effective way to compute them. We discuss this correspondence for a particular class of models of lozenge tilings of a hexagon. For uniform probability distribution, this is one of the most studied models of random surfaces. Borodin,

Gorin, and Rains showed that it is possible to assign a very general elliptic weight to the distribution and degenerations of this weight correspond to the degeneration cascade of discrete polynomial ensembles, such as Racah and Hahn ensembles and their q-analogues. This also correspond to the degeneration scheme of discrete Painlevé equations, due to the work of Sakai. Following the approach of A. Knizel, we consider the q-Hahn and q-Racah ensembles and corresponding discrete Painlevé equations of types $q\text{-P}\left(A_1^{(1)}\right)$ and $q\text{-P}\left(A_2^{(1)}\right)$. We show how to use the algebro-geometric techniques of Sakai's theory to pass from the isomonodromic coordinates of the model to the discrete Painlevé coordinates that is compatible with the degeneration.

Integrable reductions of the dressing chain

Evripidou, Charalampos

University of Hradec Kralove, Hradec Kralove, Czech Republic

In this talk I will show how we construct a family of integrable systems as reductions of the dressing chain, described in its Lotka-Volterra form. For any two non-negative integers k, n satisfying $n \geq 2k+1$ we obtain a Lotka-Volterra system which on the one hand is a reduction of the dressing chain of $2m+1$ variables and on the other hand is a deformation of an integrable reduction of the $2m+1$-dimensional Bogoyavlenskij-Itoh system, where $m = n-k-1$. We show that the systems obtained are both Liouville and non-commutative integrable. For the particular case $k=0$ we also construct a family of discretizations of the obtained integrable systems, including their Kahan discretization, and we show that these discretizzations are also Liouville and superintegrable.

The complete solution of the two-qubit trace-norm geometric discord.

Frydryszak, Andrzej

Institute of Theoretical Physics, University of Wroclaw, Poland

Joint work with: Jakobczyk L., Lugiewicz P.

I will give brief account of the complete solution of the problem of determination of trace-norm geometric discord for arbitrary two-qubit state. Final answer is achieved thanks to the effective reduction of the problem to study critical points of certain mapping depending on projectors.

On T-duality and holographic entanglement entropy for NS5-branes

Golubtsova, Anastasia

The Joint Institute for Nuclear Reaserch, Dubna, Russia

Joint work with: Musaev, Edward

In this talk we discuss T-duality aspects of entanglement entropy for field theories living on NS five branes, including the exotic brane 5_2^r, with $r = 0, 1, 2, 3, 4$. We consider the invariant action of holographic entanglement entropy and propose an algorithm to calculate entanglement entropy for theories living on branes with non-trivial dynamics in doubled space. In the framework of Double Field Theory we propose a generalization of the Ryu-Takayanagi formula which takes into account dependence of localized backgrounds for the branes on winding modes of strings.

On classification of rational K-matrices

Gombor, Tamas

Wigner RCP, Budapest, Hungary

In this talk I present a derivation of the possible residual symmetries of rational K-matrices which are invertible in the "classical limit" (the spectral parameter goes to infinity). This derivation uses only the boundary Yang-Baxter equation and the asymptotic expansions of the R-matrices. The result proves the previous assumption: if the original and the residual symmetry algebras are $\mathfrak{g}$ and $\mathfrak{h}$ then there exists a Lie-algebra involution of $\mathfrak{g}$ for which the invariant sub-algebra is $\mathfrak{h}$.

Thermodynamics of the XXZ spin-$1/2$ chain

Goomanee, Salvish

Ecole Normale Supérieure de Lyon, Lyon, France

In this talk I will present the novel developments pertaining the the thermodynamics of the XXZ spin-1/2. I will decribe the analysis allowing one to prove several features related to the behaviour of the Heisenberg-Ising (or XXZ) spin-1/2 chain at finite temperature. It has been argued in the literature that the *per*-site free energy or the correlation length admit integral representations whose integrands are expressed in terms of solutions of non-linear integral equations. The derivations of such representations rested on various unproven conjectures such as the existence of a real, non-degenerate, maximal in modulus Eigenvalue of the quantum transfer matrix, the existence and uniqueness of the solutions to the auxiliary non-linear integral equations in the infinite Trotter limit. I will show how these conjectures can be proven in a rigorous setting for temperatures high enough. The result of these analyses allowed one to observe that a subset of sub-dominant Eigenvalues of the quantum transfer matrix admits a large temperature asymptotic expansion.

Slightly generalized Maxwell system and longitudinal components of solution

Gordievich, Igor

MIRTEK Ltd, Stavropol, Russia

Joint work with: Simulik, Volodimir

We consider slightly generalized Maxwell equations with electric and magnetic currents and charges densities of the gradient type. Among other versions of the Maxwell system these equations differ by the extended symmetry properties. Such system of equations is invariant with respect to a 256-dimensional algebra, and this algebra is not yet the maximum of possible symmetry. The longitudinal components of both vectors of electric and magnetic field strengths, together with two corresponded scalar waves, are found as the exact solution of such generalized Maxwell equations. The longitudinal wave component of the electric field strength vector itself is found as an exact solution of the standard Maxwell equations with fixed current and charge of the gradient type. This wave is corresponded to the scalar wave component, which is propagated in the same direction. The analysis of found solutions demonstrates that longitudinal components are located near the corresponded current and charge densities, which are the sources of such fields. The relationship with modern experiments is considered briefly.

The Volterra type equation related to the non-Debye relaxation

Górska, Katarzyna

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Joint work with: Andrzej Horzela and Giuseppe Dattoli

I will present the solutions of Volterra equations with the fading memory given by the Prabhakar function with negative upper parameter which is relevant to the standard non-Debye models of dielectric relaxation, namely for the Cole-Cole, Cole-Davidson, and Havriliak-Negami models. These integro-differential equations are solved by using the umbral calculus and Laplace transform method whose results are identically for the same fixed values of the used parameters.

Beyond coherent states quantization

Gouba, Laure

Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy

We present an original approach to quantization based on operator-valued measures that generalize the so-called Berezin-Klauder-Toepliz quantization, and more generally coherent states quantization approches.

Construction Of Multivariate Interpolation Hermite Polynomials In Hypercube

Gusev, Alexander

Joint Institute for Nuclear Research, Dubna, Russia

The algorithms for constructing the Hermite interpolation polynomials d variables on the standard d-dimensional hypercube and simplex are proposed. These polynomials are applied for construction the finite element schemes for solving multidimensional boundary value problems. The test examples for Helmholtz equation are given.

Confluent Heun potentials for the stationary Klein-Gordon equation

Hakobyan, Manush

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Institute for Physical Research, NAS of Armenia, Ashtarak, 0203 Armenia

Joint work with: Ishkhanyan, Tigran and Ishkhanyan, Artur

We present in total fifteen potentials for which the stationary Klein-Gordon equation is solvable in terms of the confluent Heun functions. Because of the symmetry of the confluent Heun equation with respect to the transposition of its regular singularities, only nine of the potentials are independent. Four of these independent potentials are five-parametric. One of them possesses a four-parametric ordinary hypergeometric sub-potential, another one possesses a four-parametric confluent hypergeometric sub-potential, and one potential possesses four-parametric sub-potentials of both hypergeometric types. The fourth five-parametric potential has a three-parametric confluent hypergeometric sub-potential, which is, however, only conditionally integrable. The remaining five independent Heun potentials are four-parametric and have solutions only in terms of irreducible confluent Heun functions.

Conformal transformation between Einstein and Jordan frames

Hendi, Seyed Hossein

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We will give a potential problem in Jordan frame in the context of general relativity which is related to the nontrivial solution of nonlinear differential equation. We propose a suitable conformal transformation in which change the Jordan frame into the Einstein frame. Since in the Einstein frame we can solve differential equation, one can obtain the analytical solution of differential equation in the Jordan frame via inverse conformal transformation.

Coherent States for Rational Extensions and Ladder Operators That Have Only Infinite-Dimensional Representations

Hoffmann, Scott

The University of Queensland, Brisbane, Australia

The systems we consider are rational extensions of the harmonic oscillator, the truncated oscillator and the radial oscillator. In all cases it is possible to construct ladder operators that have only infinite-dimensional representations. Thus all levels of the systems are coupled. We construct Barut-Girardello coherent states in all cases, and calculate their properties to look for classical or non-classical behaviour.

What hide the Hermite coherent states

Horzela, Andrzej

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Joint work with: Katarzyna Górska and Franciszek Hugon Szafraniec

The standard, Glauber-Klauder-Sudarshan coherent states are Gaussian. I will present the construction of coherent states for which the polynomial basis $z^n/\sqrt{n!}$ is replaced the Hermite polynomials in one and two complex variables. Hermite polynomials in complex variables enable us to introduce the family of orthonormal Hermite functions. Representatives of this family depend on a real parameter $0 < \alpha < 1$ and are suitable for obtaining one-particle and bipartite coherent states. The latter also appear to be Gaussian and satisfy properties of the standard coherent states including resolution of the identity and existence of the Bargmann transform. For $0 < \alpha < 1$ the single particle states appear to be squeezed while the bipartite states are simultaneously squeezed and nonfactorizable, i.e. entangled. Squeezing and entanglement disappear in the limit $\alpha \to 1$ which brings our scheme to the standard case.

Higher-spin gauge supermultiplets and supercurrents

Hutomo, Jessica

University of Western Australia, Perth, Australia

In four spacetime dimensions, off-shell formulations for massless higher-spin $\mathcal{N} = 1$ supermultiplets were developed in the early 1990s. For every superspin value $\hat{s}$, integer ($\hat{s} = s$) or half-integer ($\hat{s} = s + \frac{1}{2}$), with $s = 1, 2, \cdots$, there exist two dually equivalent off-shell actions in Minkowski superspace. Upon elimination of the auxiliary fields, each of the two superspin-$\hat{s}$ actions reduce to a sum of the massless spin-$\hat{s}$ and ($\hat{s} + \frac{1}{2}$) actions at the component level. These $\mathcal{N} = 1$ higher-spin supermultiplets were also generalised to the case of anti-de Sitter (AdS) supersymmetry. In this talk I will discuss the construction of higher-spin supercurrent multiplets associated with these massless gauge theories in AdS. Explicit realisations of such higher-spin supercurrents in models for massless and massive chiral scalar superfields will also be presented.

Generalized confluent hypergeometric solutions of the Heun confluent equation

Ishkhanyan, Artur

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Institute for Physical Research, NAS of Armenia, Ashtarak, 0203 Armenia

Joint work with: Ishkhanyan, Tigran

We show that the Heun confluent equation admits infinitely many solutions in terms of the confluent generalized hypergeometric functions. For each of these solutions a characteristic exponent of a regular singularity of the Heun confluent equation is a non-zero integer and the accessory parameter obeys a polynomial equation. Each of the solutions can be written as a linear combination with constant coefficients of a finite number of either the Kummer confluent hypergeometric functions or the Bessel functions.

Quantum Fundamental Group

Ivankov, Petr

Lomonosov Moscow State University, Ramenskoye, Russia

The noncommutative generalization of the topological notion of the fundamental group is discussed, i.e. there is a class $\mathfrak{F}$ of C^*-algebras such that for all $A \in \mathfrak{F}$ there is the well defined quantum fundamental group $\pi_1(A)$. Following results are proven:

1. If $\mathcal{X}$ is a connected locally path connected semilocally 1-connected locally compact second-countable Hausdorff space such that the fundamental group $\pi_1(\mathcal{X}, x_0)$ is residually finite, then $C_0(\mathcal{X}) \in \mathfrak{F}$ and there is a group isomorphism $\pi_1(C_0(\mathcal{X})) \cong \pi_1(\mathcal{X}, x_0)$.

2. Let A be a C^*-algebra with continuous trace, and let $\mathcal{X}$ be the spectrum of A. If $\mathcal{X}$ is a connected locally path connected semilocally 1-connected locally compact second-countable Hausdorff space such that the fundamental group $\pi_1(\mathcal{X}, x_0)$ is residually finite, then $A \in \mathfrak{F}$ and there is a group isomorphism $\pi_1(A) \cong \pi_1(\mathcal{X}, x_0)$.

Tropical KP and Young tableaux

Iwao, Shinsuke

Department of Mathematics, Tokai University, Kanagawa, Japan

In this talk we propose a new tropical-theoretic approach to combinatorics on Young tableaux. We show that the "rectification algorithm" for Young tableaux is nicely characterized by using the theory of tropical integrable systems. In fact, the algorithm can be interpreted as an exchange rule of totally positive matrices, which is also viewed as a time evolution rule of the discrete Toda equation or the discrete relativistic Toda equation. As an application of this result, a new proof of fundamental theorems such as uniqueness of rectification and "shape change theorem" is given in a simpler way. Our work is based on two previous works: the theory of tropical tableaux by Kirillov (2001), Noumi-Yamada (2004) and the tropical-theoretic presentation of jeu de taquin by Mikami (2006), Katayama-Kakei (2015).

The application of the Schur-Weyl duality in the one-dimensional Hubbard model.

Jakubczyk, Dorota

Rzeszow University of Technology, Rzeszow, Poland

I will present the application of the Schur-Weyl duality in the one-dimensional Hubbard model in the case of half-filled system of any number of atoms. I replaced the actions of the dual symmetric and unitary groups in the whole 4^N- dimensional Hilbert space by the actions of the dual groups in the spin and pseudo-spin spaces. The calculations significantly reduce the dimension of the eigenproblem of the one-dimensional Hubbard model.

Qualitative spectral analysis of two-dimensional Dirac fermions in magnetic waveguides

Jakubský, Vít

Nuclear Physics Institute of CAS, Řež, Czech Republic

We focus on the confinement of two-dimensional Dirac fermions within the waveguides created by realistic magnetic fields. Understanding of their band structure is of our main concern. We provide easily applicable criteria that can guarantee existence or absence of the energy bands and, this way, provide a valuable insight into the systems where analytical solution is impossible. The general results are employed in specific systems where the waveguide is created by the magnetic field of a set of electric wires or by a magnetized strip.

Quantum White Noise Derivatives and Implementation Problems

Ji, Un Cig

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We start with some basic notions of the quantum white noise theory. Motivated by the Fock expansions of the white noise operators, we introduce the notions of annihilation and creation derivatives as quantum white noise derivatives. We examine some examples and a representation of the white noise derivatives and then we discuss their Wick derivation property. We study the unique existence of the solutions of simple Wick type linear differential equations. As applications, we discuss some implementation problems related to canonical commutation relations and their perturbations by quadratic white noise operators. Finally, motivated by the solutions of implementation problems, we introduce a general transformation including Fourier-Gauss transform, Fourier-Mehler transform, Weyl transform, Bogoliubov transformation and a quantum extension of Girsanov transformation.

Analytical Solution of Dirac Equation for the Hyperbolic-type Potential Field in the case of Pseudospin Symmetry

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Analytical solution of Dirac equation is obtained when the scalar and vector potentials satisfy the condition $V(r) = -S(r)$ for a hyperbolic-type potential by extended Nikiforov-Uvarov method. It is presented that the Dirac equation is reduced to confluent Heun equation. Moreover eigenfunction solution is obtained in terms of confluent Heun polynomials since condition of existence of polynomial solutions of confluent Heun equation is provided simultaneously.

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Orthogonal and symplectic Yangians - representations of the quadratic evaluation

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Joint work with: D. Karakhanyan

Orthogonal or symplectic Yangians are defined by the Yang-Baxter RLL relation involving the fundamental R matrix with $so(n)$ or $sp(2m)$ symmetry. The conditions on the evaluation of first and second order are investigated. The restrictions implied by these conditions on the representation weights are formulated.

Poisson bracket deformations using Kontsevich graphs: open problems

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Joint work with: R. Buring (IM JGU Mainz, Germany)

We formulate several open problems from the theory of universal – by using the Kontsevich calculus of oriented graphs – infinitesimal deformations of Poisson brackets P on finite-dimensional affine manifolds. Apart from the linear scaling $P \mapsto a \cdot P$, there are at least countably many nonlinear flows $\dot{P} = Q(P)$ which are associated by the graph orientation morphism with the Grothendieck–Teichmüller Lie algebra-related cocycles in the unoriented graph complex. An open problem is whether there exist any other deformations which, also encoded by graphs and therefore universal w.r.t. all brackets, neither are Poisson cohomology trivial nor vanish identically if the bracket to deform is Poisson.

The core open problem about universal infinitesimal deformations $\dot{P} = Q(P)$ is that spontaneously, for all the known flows which are built from unoriented graph cocycles, the velocity value is Poisson cohomology trivial, $Q(P) = [\![P, X]\!]$, at every Poisson bracket P tried so far, although it is seen that there are no universal, graph-encoded 1-vector solutions $X(P)$ to the factorization $Q(P) - [\![P, X]\!] = \nabla(P, [\![P, P]\!])$ via consequences of the Jacobi identity. We argue that even if these countably many flows indeed are ∂_P-trivial, their vector fields X still yield nonlinear infinitesimal changes of local coordinates on the affine maniflold at hand, making it look almost like a smooth one! Whether the coordinate reparametrizations along integral trajectories of the vector fields X are in any sense dense is an open problem. The same applies to integrability properties of nonlinear PDE systems $\dot{P} = Q(P)$ and to their physical applications in (bio)chemistry, e.g., in the context of mutations of organic life systems.

Self-organized Critical Dynamics in Coupled Discrete Systems

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Superferromagnetism was invoked to specify structures involving objects with discrete spectra due to quantum confinement, e.g., atomic nuclei and clusters, quantum dots, nanocrystals referred for hereafter as DS. We consider dynamics of DS arrays by employing the randomly jumping interacting moments model including quantum fluctuations, inter-DS coupling and disorder. State equation of such a system is demonstrated to exhibit spinodal regions in disorder, magnetic field-plane and the critical points. In vicinity of such points of self-organized (SO) criticality the system exhibits erratic jumps similar to the well-known Barkhausen effect. Exploring correlations of noise amplitudes represents then convenient analytical tool for quantitative definition, description and study of SO criticality in DS assemblies.

Wreath Products and Multipartite Quantum Systems

Kornyak, Vladimir

JINR, Dubna, Russia

A natural symmetry group of a multicomponent quantum system is a special combination of a symmetry group acting within a single component ("local group") and a group that permutes the components ("spatial symmetry group"). This combination is called the *wreath product*. Unitary representations of wreath products describe quantum evolutions of multipartite systems. It is known that any unitary representation of a finite group is contained in some permutation representation. We describe an algorithm for decomposing permutation representations of wreath products into irreducible components. This decomposition makes it possible to study the quantum behavior (entanglement, non-local correlations, etc.) of multipartite systems in invariant subspaces of the permutation Hilbert space.

$N = 4$, $d = 4$ Born-Infeld theory by dimensional reduction

Kozyrev, Nikolay

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The $N = 4$, $d = 4$ Born-Infeld theory is the theory of the $N = 2$, $d = 4$ vector multiplet with an additional spontaneously broken $N = 2$, $d = 4$ supersymmetry. One of the natural ways to construct the action of this theory is to perform the dimensional reduction of the $N = 2$, $d = 6$ Born-Infeld theory to four dimensions. We explicitly perform the reduction of the component action and provide arguments why both supersymmetries are compatible with this reduction. The resulting action is found to be equivalent up to fourth power in the fields to the perturbatively known superfield action. The issue of self-duality of this action is discussed; it is found that it does not satisfy the standard criterion of self-duality and could be self dual only if highly nontrivial duality transformations of the scalars and the fermions are assumed.

Application of Geometrical Methods to Study the Systems of Differential Equations for Quantum-Mechanical Problems

Krylova, Nina

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Joint work with: Ya.A. Voynova, V. Balan

A geometrical method based on the structural stability theory is used to study systems of differential equations which arise in quantum-mechanical problems. We consider a 1/2-spin particle in external Coulomb field or in the presence of magnetic charge on the background of the de-Sitter space, a free 3/2-spin particle in spherical coordinates of the flat space, or a vector particle in the Coulomb potential. It turns out that the first and the second Kosambi-Cartan-Chern invariants are nontrivial for the systems, while the 3-d, 4-th and 5-th invariants identically vanish. The first invariant determines the vector field on the configuration space of the differential system, and is interpreted as an external field potential. From physical point of view, the second invariant determines how rapidly the different branches of the solution diverge from or converge to the intersection points, which usually are the singular ones. It is shown that the behavior of the eigenvalues of the second Kosambi-Cartan-Chern invariant is the same for the complicated initial system, and for the transformed simplified one. The vanishing of the 3-d, 4-th and 5-th invariants means that, in geometrical terms, there exists a nonlinear connection on the tangent bundle, with zero torsion and curvature.

CDD factors in Smirnov-Zamolodchikov type models

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Joint work with: Pugai, Yaroslav

F. Smirnov and A. Zamolodchikov in the paper published in 2016 showed that a special class of irrelevant perturbations (current-current perturbations) in integrable models of quantum field theory leads to appearance of CDD factors in the scattering matrices, i.e. scalar factors corresponding to non/uniqueness of solution to the Yang-Baxter equation for S matrices. They considered the sine/Gordon model and analogous models that only contain odd-spin integrals of motion. We find CDD factors (in the first order in the perturbation theory) for the current--current perturbations on the example of models that contain even-spin integrals of motion as well, the complex sinh/Gordon model and the scaling $\mathbb{Z}_N$ symmetric Ising model. Thus we generalize the Smirnov-Zamolodchikov formula to the case of several particles with diagonal scattering. We also obtain the CDD factors for Lorentz non/invariant perturbations of this type. Technically we use the representation by free fields for form factors, developed by us earlier.

Superintegrable systems of subgroup-type in a magnetic field

Marchesiello, Antonella

Czech Techinical University in Prague, Czech Republic

Joint work with: J. Snobl

We study the problem of the classification of three dimensional superintegrable systems in a magnetic field in the case they admit integrals polynomial in the momenta, two of them in involution and at most of second order (besides the Hamiltonian). We start by considering second order integrable systems that would separate in subgroup-type coordinates in the limit when the magnetic field vanishes. We look for additional integrals which make these systems minimally or maximally superintegrable.

Fermionic limit of Calogero-Sutherland system

Matushko Maria

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We discuss the limits of quantum Calogero-Sutherland (CS) system for bosonic particles and fermionic particles. The bosonic limit is realized as a projective limit of finite models, it was studied by M.Nazarov and E.Sklyanin and by A.Veselov and A.Sergeev. They presented precise construction of the family of commuting Hamiltonians in the bosonic Fock space. The crucial point of their constructions is the use of equivariant family of Heckman–Dunkl operators as a quantum L-operator for the CS system. The construction of projective type limit for CS system with fermionic particles uses the same ideology — to consider the Heckman–Dunkl operator as a quantum L-operator for the CS system. In this case the explicit formulas for the limits of the Dunkl operators are given by means of vertex operators.

Holographic Stückelberg mechanism and anomalous conductivities

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Joint work with: Manuel Valle

We study the role of quantum anomalies in hydrodynamics of relativistic theories by using holographic methods. In particular, we introduce an Abelian symmetry in the bulk, which allows to switch on an external magnetic field in the dual theory, and therefore study several anomalous transports related to the magnetic response: chiral magnetic and separation effects. This computation is performed with full backreaction on the metric, and this allows to study the chiral vortical effects in the currents and energy-momentum tensor.

Infrared images edge detection using the entropy maximization technique

Meglouli, Hocine

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Image analysis is a domain that allows the extraction of information from the image characteristics. Many application problems require prior image processing in order to detect the image edges. The contours are indeed valuable clues to some interpretations. In this paper, we present a new technique for edge detection by the maximization of entropy, which is based on the concept of uncertainty and information theory as well as on the neighborhood principle. In this paper we present the application of the edge detection technique developed on infrared images that feature people. Indeed, the infrared domain has interesting properties for the detection of people, especially for video surveillance applications or vehicle safety, which should be operational all the time, even at night or in challenging lighting conditions.

The Unruh effect for higher derivative field theory

Molgado, Alberto

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We analyse the emergence of the Unruh effect within the context of a field Lagrangian theory associated with the Pais-Uhlenbeck fourth order oscillator model. To this end, we introduce a transformation that brings the Hamiltonian bounded from below and is consistent with PT-symmetric quantum mechanics. We find that, as far as we consider different frequencies within the Pais-Uhlenbeck model, a particle together with an antiparticle of different masses are created and may be traced back to the Bogoliubov transformation associated with the interaction between the Unruh-DeWitt detector and the higher derivative scalar field. In contrast, whenever we consider the equal frequencies limit, no particle creation is detected as the pair particle/antiparticle annihilate each other. Further, following Moschella and Schaeffer, we construct a Poincaré invariant two-point function for the Pais-Uhlenbeck model, which in turn allows us to perform the thermal analysis for any of the emanant particles.

Vaisman algebroid and doubled structure of gauge symmetry in double field theory

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The Vaisman algebroid is a kind of algebroid structure. It is defined by an extension of the Courant algebroid, and phisically related to the gauge symmetry in Double Field Theory (DFT), which is an effective theory of string theory. DFT has T-duality as a manifest symmetry. In this study, we focus on the doubled structure in the Vaisman algebroid. It is already well known that some kind of Lie algebras are obtained by the Drinfel'd double of Lie bialgebras. The Courant algebroid is obtaind by Drinfel'd double of Lie bialgebroids. We find that the Vaisman algebroid can be obtained by an analogue of the Drinfel'd double of Lie algebroids. We discuss the algebraic origin of the strong constraint in DFT. This talk is the former half of the one by Mr. Shiozawa.

Quantum quaternionic projective spaces and their pseudo-parabolic categories

Mudrov, Andrey

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Joint work with: Gareth Jones

Quaternionic projective space $\mathbb{H}P^n$ is a conjugacy class of the compact form $Sp(n+1)$ of the complex symplectic group $SP(2n+2)$ carrying a Poisson structure compatible with the adjoint action. Its quantization gives rise to a module category $\mathcal{O}\big(\mathbb{H}P^n_q\big)$ over finite-dimensional $U_q(\mathfrak{sp}(2n+2))$-modules, a full subcategory in the quantum category $\mathcal{O}$. We prove that it is semi-simple and equivalent to the category of finite dimensional modules of the isotropy subalgebra $\mathfrak{sp}(2n)\oplus\mathfrak{sp}(2)$. It is also equivalent to the module category of equivariant finitely generated projective $\mathbb{C}_q[\mathbb{H}P^n]$-modules identified with quantum vector bundles on $\mathbb{H}P^n$.

$SU(2|1)$ supersymmetric $\mathbf{CP}^N$-Rosochatius system

Armen Nersessian

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Joint work with: Evgeny Ivanov, Hovhannes Shmavonyan

We propose superintegrable mechanical system on the complex projective space CPN involving a potential term together with coupling to a constant magnetic fields. This system can be viewed as a $\mathbf{CP}^N$-analog of both the flat singular oscillator and its spherical analog known as "Rosochatius system". We find that this system belongs to the class of "Kähler oscillators" admitting $SU(2|1)$ supersymmetric extension. We show that, in the absence of magnetic field and with the special choice of the characteristic parameters, the system admits $\mathcal{N}=4, d=1$ Poinacaré supersymmetric extension.

Further representations of Poincaré group for particle theories

Nisticò, Giuseppe

Università della Calabria, Rende, Italy

Though the irreducible representations of the Poincaré group form the groundwork for the formulation of relativistic quantum theories of a particle, robust classes of such representations are missed in current formulations of these theories. In this work the extended class of irreducible representations is explicitly determined. Consistent particle theories are then developed based on the extended class, through a purely deductive development based on a principle of relativistic invariance. In so doing, not only some well known theories are recovered, but even further consistent theories corresponding to none of the current theories are determined.

Hom-Lie structures on 3-dimensional skew symmetric algebras

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Joint work with: Richter, Johan and Silvestrov, Sergei

We describe the dimension of the space of possible linear endomorphisms that turn skew-symmetric three-dimensional algebras into Hom-Lie algebra. We show that this dimension can be fully described by the matrix of structure constants of the bilinear product of the skew-symmetric algebra. This follows from results showing correspondence between this dimension and the rank of the matrix of such structure constants. Examples from classical complex Lie algebras are given to demonstrate this correspondence.

Spontaneous breakdown of topological supersymmetry: stochastic generalization of dynamical nonintegrability and its applications in computing, astrophysics, and neurodynamics

Ovchinnikov, Igor

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In supersymmetric theory of stochastic dynamics, all stochastic differential equations possess topological supersymmetry that represents preservation of topology of the phase space by continuous-time flows. Its spontaneous breakdown is the stochastic generalization of deterministic chaos also known as non-integrability in the sense of dynamical systems and via the Goldstone theorem this explains ubiquitous long-range dynamical behavior such as 1/f noise that always accompany chaotic dynamics. This talk will focus on the three applications of this theory: astrophysical phenomenon of kinematic dynamo, a novel analogue computing paradigm called digital memcomputing machines, and neurodynamics where the theory predicts that a healthy brain operates in the pre-chaotic (or rather noise-induced chaotic) phase where the topological supersymmetry is broken not by non-integrability of the flow as in conventional chaotic dynamics but by the condensation of neurodynamical (anti-)instantons also known as neuroavalanches.

Scalar particle with intrinsic Darwin-Cox structure: general theory, external Coulomb field, solutions of the radial equation, quantization of energy

Ovsiyuk, Elena

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Joint work with: A.D. Koral'kov, Ya.A. Voynova, A.V. Chichurin, V.M. Red'kov

Generalized Klein-Fock-Gordon equation for a scalar particle with Darwin-Cox structure, which takes into account distribution of electric charge of the particle over the finite spherical region is studied in external Coulomb field. Corresponding radial equation has two irregular singular points, $r = 0$ of the rank 3, $r = \infty$ of the rank 2, and four regular singular points. In the case of minimal angular momentum, $l = 0$, the structure of singularities becomes simpler: the points $r = 0, r = \infty$ are of the rank 2, and four regular points remain the same. There are constructed formally exact Frobenius type solutions of the derived equations, convergence of relevant power series (with 8-term and 7-term recurrent relations respectively) is studied. As analytical quantization rule is taken so-called transcendence conditions, It provides us with 4-th order algebraic equation with respect to energy values, which has four sets of roots. Only one set roots, $0 < E_{l,k} < mc^2$, depending on angular momentum $l = 0, 1, 2, ...$ and main quantum number $n = 0, 1, 2, ...$ may be interpreted as corresponding to some bound states of Darwin-Cox particle in the Coulomb field. In similar manner, we study a generalized nonrelativistic Schrodinger equation for such a particle, the final results are similar.

Methods for recovering the dependence in empirical models of Earth's radiation belts

Pavlov, Andrey

State Research Center Institute of Biomedical Problems RAS (IBMP), Moscow, Russian Federation

Radiation belts of the Earth are characterized by presence of zones with high values of flux density gradient of charged particles. There is given substantiation of rational spatial distribution of the empirical mathematical model's support nodes depending on the specifics of the dependence restoration method. In this case, the required accuracy of the dependency reconstruction may be achieved by an interpolating function with an adaptive adjustable curvature radius based on the comparison of the curvature radius with the first finite and divided differences.

Symmetries in projection evolution model

Pędrak Aleksandra

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Joint work with: Góźdź Andrzej, Góźdź Marek

The idea of projection evolution allows for description of quantum states in full four dimension spacetime, where time and space positions are treated on the same footing. In this model, quantum evolution is a stochastic process driven not by time but by quantum events ordering parameter τ. This evolution is performed by Krasuss-like operators. This approach allows for description of a whole class of new quantum phenomena, among others the time interference. In case of projection evolution model the idea of symmetry has to be revisited. It requires new aproaches to conservation laws in physics. This opens a new field of mathematical and physical investigations.
During the seminar some proposals about symmetries and conservation laws will be presented. This talk is a continuation of seminar of A. Góźdź "Quantum projection evolution in spacetime versus evolution in time – problem of symmetries".

2d CFT and confluent Heun's equations

Marcin Piątek

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BLTP, JINR, Dubna, Russia

Joint work with: Artur R. Pietrykowski

The Heun equation has long been a subject of great interest, because of a big number of applications and its crucial role in the theory of linear ordinary differential equations. It is the simplest generalization of the Gauss hypergeometric equation which corresponds to having 4 regular singularities at $0, x, 1, \infty$ instead of 3. Confluent forms of the Heun differential equation arise when two or more of the regular singularities merge to form an irregular singularity. In two-dimensional conformal field theory (2d CFT) the Heun equation emerges in classical limit from the BPZ null vector decoupling equation for certain 5-point degenerate conformal blocks. In our recent paper [Nucl. Phys. B 938, 543 (2019)] we have derived by means of CFT techniques the so-called path-multiplicative Heun's solutions from the degenerate 5-point Virasoro blocks. Our main motivation for this research line is to use CFT tools in the study of scalar perturbations of certain black hole backgrounds described by the Heun equation. For instance, it is known that the Klein–Gordon equation in the Kerr-AdS$_5$ background can be reduced to the two (angular and radial) Heun equations by a separation of variables. Moreover, the confluent Heun equations determine (at least) scalar perturbations of the Kerr metric in four dimensions (the so-called Teukolsky equations). Hence, an interesting question is how one can get the confluent Heun equations together with its concrete solutions within the formalism of 2d CFT. A discussion of the latter will be the main subject of this talk.

Representations of principal W-algebra for the superalgebra $Q(n)$

Poletaeva, Elena

University of Texas Rio Grande Valley, Edinburg, USA

A finite W-algebra is an associative algebra attached to a complex semisimple Lie algebra $\mathfrak{g}$, or a classical Lie superalgebra, and a nilpotent element $e \in \mathfrak{g}$. We consider the finite W-algebra W for the queer Lie superalgebra $Q(n)$ associated with the principal nilpotent coadjoint orbit. We classified simple W-modules, which are all finite-dimensional, and study blocks in the category of finite-dimensional W-modules.
This is a joint work with V. Serganova.

Conformal geometry and conformal higher-spin gauge theories

Ponds, Michael

University of Western Australia, Perth, Australia

The problem of a consistent coupling of conformal higher-spin (CHS) gauge fields to conformal gravity in diverse dimensions has been a subject of investigation in theoretical physics for decades. In three and four dimensions, gauge-invariant actions for free CHS fields propagating in Minkowski space were proposed over thirty years ago. Since then, many attempts have been made to promote these linearised models to curved backgrounds but the appearance of curvature dependent terms, which break the higher-spin gauge-symmetry, present a huge obstacle. In this talk I will show how one can simultaneously lift these models to all conformally flat backgrounds by employing a modern approach to conformal gravity as a gauge theory. In the four dimensional case, I will comment on the prospects of further extending these results to Bach-flat spacetimes.

On discrete Fourier analysis for the functions sampled on the weight lattices or model sets of semisimple Lie groups

Pošta, Severin

FNSPE CTU, Prague, Czech republic

A method for finite discrete analysis of almost periodic functions (defined on model sets of semisimple Lie groups) that is entirely based on group theoretical methods, primarily finite groups and their duals is developed and examples of functions based on the standard Fibonacci quasicrystal and two-dimensional quasicrystal are proposed. Infinite families of orbit functions (functions that are symmetric with respect to the affine Weyl group of a semisimple Lie group) are revisited and it is shown that these functions do satisfy the discrete Fourier analysis conditions on the three-dimensional refined fundamental regions of the respective simple Lie groups.

Avalanche statistics in the Raise and Peel model

Povolotsky Alexander

JINR, Dubna, Russia

The Raise and Peel model is a stochastic model of fluctuating interface with non-local avalanche dynamics. Its dynamical rules stem from the structure of a specific representation of the Temperley-Lieb algebra, and its stochastic generator can be represented by the Hamiltonian of the XXZ Heisenberg quantum spin chain with twisted boundary conditions. We describe the recent progress in description of the statistics of the avalanches in the model. We focus on the large deviations of two avalanche currents in the thermodynamic limit, which reveal a phase transition in the behaviour of one current conditioned to atypical values of another one. We also describe a proof of the laws of large numbers for the two currents at arbitrary finite lattices, which in addition proves two earlier conjectures on the structure of the stationary state of the model. The technique is based on the analysis of the largest eigenvalue of the deformed stochastic generator using the Bethe ansatz and Baxter's T-Q relation.

Superfield approach to $\mathcal{N} = 2$ Calogero model

Provorov, Alexander

JINR, Dubna, Russia

In one of the recent papers a supersymmetric extension of the Calogero model was discovered for an arbitrary even number of supersymmetries. In this talk I would like to introduce a superfield description of the model for the simpliest case of $\mathcal{N} = 2$.

Four Constructions of Corner VOAs

Rapcak, Miroslav

Perimeter Institute, Waterloo, Canada

I will discuss a large class of vertex operator algebras appearing naturally in two (mutually dual) 4d gauge theory setups. First, they can be identified with algebras of local operators at junctions of interfaces in maximally supersymmetric Yang-Mills theory. Secondly, they are algebras corresponding to spiked instanton configurations associated to divisors in Calabi-Yau three-folds recently introduced by Nekrasov. After sketching the two configurations for motivational purposes, I will review four conjecturally equivalent constructions of the algebras in terms of (1) quantum Hamiltonian reductions (2) truncations of the W_∞ algebra (3) kernel of screening charges and (4) generalized Miura transformation.

On modeling neutrinos oscillations by geometry methods in the frames of the theory for a fermion with three mass parameters

Red'kov, Viktor

B.I.Stepanov Institute of physics, Republic of Belarus

Joint work with: Ya. Voynova, E. Ovsiyuk, V. Kisel, V. Pletyukhov, V. Gilewsky

Starting from the general Gel'fand-Yaglom approach, we develop the theory for a spin 1/2 fermion, which is characterized by three mass parameters. In presence of external electromagnetic fields or non-Euclidean space-time background with a nonvanishing Ricci scalar curvature, the main wave equation is not split into three separated equations for bispinors, instead a quite definite mixing of three Dirac-like equations arises. It is shown that for Majorana particle, a generalized equation with three mass parameters exists as well. Such a Majorana complicated equation is not split into three separated equations in the curved space-time, if the Ricci scalar does not vanish. We have studied in detail this model, assuming approximation when an external cosmological background is taken into account by a constant Ricci parameter, R = const, and the Cartesian coordinates are used. With the help of a special linear transformation, the system of three linked Majorana equations is split into three separate ones, with modified mass parameters, the last are solved straightforwardly. The spectrum of arising mass parameters is studied analytically and numerically.

Multimode entanglement for fermions

Rouleux, Michel

Aix Marseille Université, Université de Toulon, CNRS, CPT, Marseille, France

We are motivated by tripartite entanglement of undistinguishable fermions. While GHZ or W states involve 3-fold intrication, we consider here 2-fold intrication of 3 fermions in $\mathbf{C}^2$, namely $ab + bc + ca$. More generally, $n + 1$ intricated fermions in $\mathbf{C}^n$ can be represented by the antisymmetric wave function $\det(a_1 - a_0, a_2 - a_0, \cdots, a_n - a_0)$ (affine determinant). We investigate also properties of affine Slater determinants, as expectation values or reduced density matrices.

Soliton surfaces associated with generalized Landau-Lifshitz equation with self-consistent potential

Sagidullayeva, Zhanna

L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakhstan

Joint work with: Nugmanova Gulgassyl, Myrzakulov Ratbay

In this paper, we present soliton surfaces associated with generalized Landau-Lifshitz equation with self-consistent potential. We obtained the first and second fundamental forms. The first fundamental form allow us to calculate the curvature and metric properties of a surface, particularly, length and area of related space. The second fundamental form determines the external geometry of the surface in the vicinity of this point. Together they permit to define extrinsic invariants of the surface and its principal curvatures. The results can be used to describe spin waves in magnets and ferromagnets.

A Generalization of the Quantization of Poisson manifolds

Sako, Akifumi

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Joint work with: Jumpei Gohara, Yuji Hirota

The noncommutative geometry is regarded as one of key concepts to formulate the quantum gravity theory or non-perturbative string theory. There are many ways to construct noncommutative geometry, for example deformation quantization, geometric quantization, C^*-algebra, matrix regularizations and so on. To find the best way for quantum gravity or other physics, more general formulation containing the existing quantization models is useful. We define a generalized quantization of Poisson manifolds as a subcategory of the category of modules over a ring. It is shown that the deformation quantization, geometric quantization, matrix regularizations are included in the generalization, and each pairs of them are essentially equivalence of categories. In addition, universal enveloping algebra derived from Poisson manifolds is also formulated as the generalized quantization of Poisson manifolds.

Search for footprints of quantum spacetime in black hole QNM spectrum

Samsarov, Andjelo

Rudjer Bošković Institute, Zagreb, Croatia

Black hole (BH) perturbation is followed by a ringdown phase which is dominated by quasinormal modes (QNM). These modes may provide key signature of the gravitational waves. The presence of a deformed spacetime structure may distort this signal. In order to account for such effects, we consider a toy model consisting of a noncommutative charged scalar field propagating in a realistic black hole background. We then analyse the corresponding field dynamics by applying the methods of the Hopf algebra deformation by Drinfeld twist. The latter framework is well suited for incorporating deformed symmetries into a study of this kind. As a result, we obtain the BH QNM spectrum that, besides containing the intrinsic information about a black hole that is being analysed, also carry the information about the underlying structure of spacetime.

On properties of parafermionic hyperbolic gamma functions

Sarkissian, Gor

JINR, Dubna, Russia

We show that rarefied elliptic beta integral for lens elliptic gamma functions implies rarefied hyperbolic beta integral for parafermionic hyperbolic gamma functions. Then we show that rarefied hyperbolic beta integral brings to the star-triangle integral relation for the parafermionic hyperbolic gamma functions. We note that parafermionic hyperbolic gamma functions are the building blocks for structure constants and fusion matrix of two-dimensional parafermionic Liouville field theory. The case of the supersymmetric Liouville field theory is considered in much detail and shown that the star-triangle integral relation leads to the Moore-Seiberg identities between the structure constants and fusion matrix.

Worldsheet Instanton Corrections to Five-branes and Waves in Double Field Theory

Sasaki, Shin

Department of Physics, Kitasato University, Sagamihara, Japan

We make a comprehensive study on the string winding corrections to supergravity solutions in double field theory (DFT). We find five-brane and wave solutions of diverse codimensions in which the winding coordinates are naturally included. We discuss a physical interpretation of the winding coordinate dependence. The analysis based on the geometric structures behind the solutions leads to an interpretation of the winding dependence as string worldsheet instanton corrections. In order to show this fact, we give a brief discussion on the origins of these winding corrections in gauged linear sigma model (GLSM). We propose a GLSM that provides a string sigma model whose target spaces are a defect NS5-brane, a Kaluza-Klein vortex and an exotic 5^2_2-brane. They are codimension two objects and are related by T-duality.

This talk is based on a collaboration with Kenta Shiozawa and Tetsuji Kimura, JHEP 07 (2018) 001, JHEP 12 (2018) 095.

Nonlocal two-dimensional Hirota system of equations: Darboux transformation and exact solutions

Shaikhova, Gaukhar

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Joint work with: Guldana Bekova, Kuralay Yesmakhanova, Ratbay Myrzakulov

We study the nonlocal two-dimensional Hirota system of equations by Ablowitz-Musslimani type nonlocal reductions. The Darboux transformation for the nonlocal two-dimensional Hirota system of equations is constructed. By using the Darboux transformation, its exact solutions are obtained.

Para-Hermitian Geometry and Doubled Aspects of Vaisman Algebroid

Shiozawa, Kenta

Kitasato University, Sagamihara, Japan

Joint work with: *Haruka Mori* and *Shin Sasaki*

Double field theory (DFT) is an effective theory of strings that has T-duality as a manifest symmetry. DFT involves a gauge symmetry that originates from the diffeomorphism and the $U(1)$ gauge symmetry of the NSNS B-field. DFT gauge symmetry is closed with the so-called C-bracket, and this mathematical structure is known to be the metric algebroid proposed by Vaisman (the Vaisman algebroid). We show that the Vaisman algebroid is obtained by an analogue of the Drinfel'd double of Lie algebroids. It is known that doubled space-time can

be described by the para-Hermitian manifold $\mathcal{M}$. For the para-Hermitian manifold, we can split the tangent bundle $T\mathcal{M}$ into two maximal isotropic subbundles $L, \tilde{L}$ by using the para-complex structure. We define the external algebra on these subbundles $L, \tilde{L}$, and construct Lie algebroids explicitly. We also construct the Vaisman algebroid in the DFT setup by an analogue of the Drinfel'd double of subbundles $L, \tilde{L}$. The Vaisman algebroid in DFT becomes the Courant algebroid by imposing the strong constraint. We find that the algebraic origin of the strong constraint in DFT is traced back to the compatibility condition needed for $(L, \tilde{L})$ be a Lie bialgebroid. This talk is the latter half of the one by Mori.

Planar skyrmions with localized fermions

Shnir, Yakov

BLTF, Dubna, Russia

We propose a new mechanism of interaction between the solitons related with presence of localized fermions. Since the Atiyah-Patodi-Singer index theorem implies that such modes always exist for any topological soliton, their appearance may significantly alter the usual pattern of interaction. We elaborate this possibility considering, as a particular example, the chiral magnetic Skyrmions coupled to spin-isospin fermions. It is shown that there are sequences of fermionic modes localized on the Skyrmions. We investigate the additional effect of the exchange interaction between the soltions with localized modes and demonstrate the existence of stable system of chiral Skyrmions bounded by the strong attractive interaction mediated by the chargeless fermionic modes.

Physical Phenomena in φ_0 Josephson Junctions

Shukrinov, Yury

BLTP, JINR, Dubna, Russia

When a barrier in the Josephson junction is a noncentosymmetric, i.e., with broken inversion symmetry magnetic metal, then unusual current-phase relation $I = I_c \sin(\varphi - \varphi_0)$ is realised, where the phase shift φ_0 is proportional to the magnetic moment perpendicular to the gradient of the asymmetric spin-orbit potential. Such φ_0 Josephson junctions demonstrate a number of unique features important for superconducting spintronics and modern informational technologies. Here we show that a current sweep along IV-characteristic of φ_0 junctions may lead to both regular and chaotic magnetization dynamics with a series of specific phase trajectories. The origin of these trajectories is related to the ferromagnetic resonance when Josephson frequency coincides with the ferromagnetic one. We demonstrate an appearance of DC component of superconducting current and clarify its role in the transformation of IV-characteristics in resonance region. The presented results might be used for developing novel resonance methods of determination of spin-orbit coupling parameter in the noncentrosymmetric materials. We discuss experiments which can test our results.

Hidden Supersymmetries of Deformed Supersymmetric Quantum Mechanics

Sidorov, Stepan

BLTP JINR, Dubna, Russia

We consider two models of supersymmetric quantum mechanics based on the deformed $\mathcal{N} = 4, 8$ chiral multiplets $(\mathbf{2}, \mathbf{4}, \mathbf{2})$ and $(\mathbf{2}, \mathbf{8}, \mathbf{6})$. These models, constructed via the superfield approaches SU(2|1) and SU(4|1), correspond to supersymmetric extensions of 2 dimensional harmonic oscillator. We quantize them and show that wave functions of the models under consideration possess hidden supersymmetries SU(2|2) and SU(4|2). Also we find that the on-shell model with the hidden supersymmetry SU(2|2) can be achieved in the framework of the standard $\mathcal{N} = 4$, $d = 1$ superfield approach.

Eigenfunctions of generalized Macdonald–Ruijsenaars systems via representation theory of Ding–Iohara–Miki algebra

Silantyev, Alexey

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Joint work with: Junichi Shiraishi

The quantum Macdonald–Ruijsenaars systems are defined by a family of commuting difference operators with trigonometric coefficients. The symmetric polynomial eigenfunctions of these systems are known as Macdonald polynomials. The relation between Macdonald–Ruijsenaars systems and Ding–Iohara–Miki algebra was described in works of Shiraishi. The generalized (or deformed) Macdonald–Ruijsenaars systems (for the A series) was obtained by Sergeev and Veselov. In particular, they found polynomial eigenfunctions of these systems with some deformed symmetricity generalizing the property of symmetry for the deformed case. More general (non-symmetric, non-polynomial) eigenfunctions of Macdonald–Ruijsenaars systems were found by Noumi and Shiraishi in the explicit form. They can be written as correlators of vertex operators arising in the representation theory of the Ding–Iohara–Miki algebra. By introducing another type of vertex operators we construct general (non-symmetric, non-polynomial) eigenfunctions of the generalized Macdonald–Ruijsenaars systems as correlators of these two types of vertex operators.

Hidden Symmetries of Relativistic Hydrogen Atom

Simulik, Volodimir

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The spin s=(1,0) Bose symmetry of the Dirac equation for the free spinor field, proved recently in our papers, is extended for the Dirac equation interacting with external Coulomb field. Relativistic hydrogen atom is modeling here by such Dirac equation. We are able to present both the fermionic and bosonic symmetries known from our papers about the case of non-interacting spinor field. New symmetry operators were found on the basis of new gamma matrix representations of the Clifford and SO(8) algebras, which were found recently in our papers. Hidden symmetries were found both in the canonical Foldy-Wouthuysen and in the covariant Dirac representations. The symmetry operators, which are simple and graceful in the Foldy-Wouthuysen representation, become non-local in the Dirac model.

Poincaré group, CPT and flavor states

Smaldone, Luca

INFN sezione di Napoli, Gruppo collegato di Salerno, Fisciano, Italy

Joint work with: Massimo Blasone, Petr Jizba and Nikolaos Mavromatos

We study the explicit form of Poincaré and discrete transformations of flavor states in a two-flavor scalar model presenting field mixing. We find that, because of its condensate structure, both Poincaré and CPT symmetries are spontaneously broken on flavor vacuum. Its symmetry is then reduced to $E(3)_A \times E(3)_B$. By extending the Fabri-Picasso theorem we show that flavor vacua corresponding to different Lorentz frames are unitarily inequivalent, and that they form a manifold of equal-charged states (flavor vacuum manifold).

Axiomatic models and truth in quantum mechanics (QM): the untruth of no-go theorems in QM. The sixth Hilbert's problem.

Soucek, Jiri

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We define a concept of a QM-model (= the axiomatic theory which is empirically equivalent to standard QM). Then we present the list of known QM-models. The true theorem in QM is a statement which can be proved in all QM-models. In some QM-models the Bell's theorem can be proved (e.g. in the standard model of QM) while in other QM-models the Bell's theorem cannot be proved (e.g. in the hybrid-epistemic model of QM). The same situation is true when other no-go theorems are considered. Thus no-go theorems are not true in QM and the proof of the non-locality of QM is invalid. Then the brief description of the hybrid-epistemic model of QM is given. The relation of these results to the sixth Hilbert's problem is discussed. At the end the recent proof of the inconsistence of the standard QM-model is discussed. The main goal of this paper is to start the axiomatic study of QM, to prove the invalidity of no-go theorems and possibly to identify the right QM-model.

Spin transport in semi-rippled graphene

Smotlacha, Jan

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Spin scattering in nanostructures is a topical subject in mesoscopic physics. In this contribution we analyse the effect of spin-orbit interaction, induced by the curvature of a graphene sheet, on ballisitic electron transport. To this aim we consider a model that describes the graphene based system, composed of a combination of the planar and arc pieces. The dependence of the spin-up and spin-down electron transport on the system parameters is examined. The symmetry between the transmission of spin down electrons from the left side and transmission of spin up electrons from the right side of the considered system is found. We derive the analytical formula for the chiral spin transmission and discuss the conditions for the perfect and negligible transmissions.

The NSVZ relation and the NSVZ scheme for $\mathcal{N} = 1$ non-Abelian supersymmetric theories, regularized by higher covariant derivatives

Stepanyantz Konstantin

M.V.Lomonosov Moscow State University, Moscow, Russia

We discuss, how the exact NSVZ β-function appears in $\mathcal{N} = 1$ supersymmetric non-Abelian gauge theories, regularized by higher covariant derivatives. In particular, we demonstrate that the renormalization group functions defined in terms of the bare couplings satisfy the NSVZ relation in the case of using this regularization. This occurs, because the loop integrals giving the β-function are integrals of double total derivatives with respect to loop momenta. It is also shown that for the renormalization group functions standardly defined in terms of the renormalized couplings the NSVZ scheme can be obtained if the theory is regularized by higher covariant derivatives and only powers of $\ln \Lambda/\mu$ are included into the renormalization constants. These statements are confirmed by the explicit calculations in the three-loop approximation, where the scheme dependence is essential.

Black hole solutions in gravity with nonminimal derivative coupling and nonlinear material fields

Stetsko, Mykola

Ivan Franko National University of L'viv, L'viv, Ukraine

Scalar-tensor theories is the subject of intensive studies in recent years and can be considered as a natural generalization of General Relativity, where apart of standard gravitational degrees of freedom additional scalar degrees of freedom are introduced. Horndeski gravity represents a particular, but very important sub-class of general scalar-tensor theories. It is proved to be the most general scalar-tensor theory which leads to the equations of motion of the second order in derivatives.The second order theories allow to avoid the so-called Ostrogradski instability which appears in higher order theories. In our work we consider some particular case of general Horndeski theory, namely a theory with nonminimal derivative coupling between gravity and scalar field with additional material nonlinear fields minimally coupled to gravity. We obtain static black hole solutions in this framework and investigate their behavior. The results are compared with black hole solutions with same nonlinear field obtained in standard general relativity.

A connection between the classical r-matrix formalism and covariant Hamiltonian field theory

Stoppato, Matteo

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Joint work with: Vincent Caudrelier

We bring together aspects of covariant Hamiltonian field theory and of classical integrable field theories in $1+1$ dimensions. Specifically, our main result is to obtain the classical r-matrix structure within a covariant Poisson bracket for the Lax connection, or Lax one form. This exhibits a certain covariant nature of the classical r-matrix with respect to the underlying spacetime variables. The main result is established by means of several prototypical examples of integrable field theories, all equipped with a Zakharov-Shabat type Lax pair. Full details are presented for: *a*) the sine-Gordon model which provides a relativistic example associated to a classical r-matrix of trigonometric type; *b*) the nonlinear Schrödinger equation and the (complex) modified Korteweg-de Vries equation which provide two non-relativistic examples associated to the same classical r-matrix of rational type, characteristic of the AKNS hierarchy. The appearance of the r-matrix in the covariant Poisson bracket is a signature of the integrability of the field theory rather than a manifestation of (non)relativistic invariance.

On relation between representations of super Yangian and quantum loop superalgebra

Stukopin, Vladimir

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Following V. Toledano-Laredo and S. Gautam approach we study relation between finite-dimensional representations of super Yangian of special linear superalgebra and finite-dimensional representations of quantum loop superalgebra. We establish the equivalence of some categories of representations of Yangian and quantum loop superalgebra. We construct the theory of characters for Yangian and the quantum loop superalgebra using algebraic Bethe anzatz. We describe the K-groups of categories of Yangian modules and quantum loop superalgebra modules.

Multiparticle Calogero model with extended supersymmetry

Sutulin, Anton

BLTP JINR, Dubna, Russian Federation

We explicitly construct a novel rational n-particle Calogero model with an arbitrary even number of supersymmetries. It features Nn^2 rather than Nn fermionic coordinates and increasingly high fermionic powers in the supercharges and the Hamiltonian. We perform then a redefinition of matrix fermions which brings the supercharges to the standard form maximally cubic in the fermions. Finally, we apply a supersymmetric generalization of a "folding" procedure for $A_{2n-1} \oplus A_1$ to explicitly construct the supercharges and Hamiltonian for arbitrary even-N supersymmetric extensions of the B_n, C_n and D_n rational Calogero models.

Indices of orbits of Coxeter groups of non-crystallographic type

Szajewska, Marzena

Institute of Mathematics, University of Bialystok

The even degree indices, as well as the anomaly numbers (the indices of degree 3), are known invariants of finite dimensional representations of simple Lie algebras. The definition and properties of such indices are adapted to individual orbits of the non-crystallographic reflection groups.

Quantifying quantumness of qubits and qutrits by Wigner functions

Torosyan, Astghik

Joint Institute for Nuclear Research, Dubna, Russia

Joint work with: Vahagn Abgaryan, Arsen Khvedelidze

The Wigner quasiprobability distribution (or the Wigner function) gives a qualitative information on many quantum phenomena occurring in various physical systems. Unlike the statistical distributions, the Wigner function takes negative values for some quantum states, and this indicates the existence of truly quantum features that cannot be described within the classical statistical paradigm. In this report, based on the recently elaborated method of construction of the Wigner function of a finite dimensional system, two measures for quantification of non-classicality of a finite-dimensional system,

1. KZ-indicator introduced by A. Kenfack and K. Zyczkowski and defined as an integral over the phase-space manifold of the absolute value of the Wigner function;

2. global indicator of non-classicality defined as the ratio of the volume of orbit space of a state space with non-negative Wigner function to the volume of total orbit space,

will be discussed and exemplified by considering the Hilbert-Schmidt ensemble of qubits and qutrits.

Hidden properties of supersymmetric S-matrix

Trnka, Jaroslav

University of California, Davis, USA

I will discuss the properties of the S-matrix in $\mathcal{N} = 4$ maximally supersymmetric Yang-Mills (SYM) theory in 4 dimensions. I will review some recent work on the planar scattering amplitudes which enjoy a number of surprising analytic properties, including the dual conformal and Yangian symmetries and the intriguing connection to Grassmannian geometry. I will show an explicit evidence that this framework should extend to the full (non-planar) theory.

Asymptotic limits of corrections to the energy of q-boson Zero Range Process

Trofimova, Anastasiia

NRU HSE & Skoltech , Moscow, Russia

The q-boson zero-range process is a one-dimensional stochastic system where the particles hop randomly with an on-site interaction that makes the jump rate dependent only on the local particle number. The stationary measure of this process was studied in detail even thought the full dynamical description is still absent. The general aim of my study was an evaluation of the cumulants of the particle current of interacting particle systems and characterizing their universal scaling behavior in the large system limit. I would like to present the exact integral representations of the two first cumulants. The asymptotic analysis of these representations shows the scaling behavior specific for the Kardar–Parisi-Zhang (KPZ) universality class. The most intriguing part is the derivation of the scaling function describing the crossover between the KPZ and Edwards –Wilkinson (EW) universality classes that takes place in the limit $q \to 1$.

Twistor description of low-spin fields in AdS_5 from quantized (super)particles

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(Super)twistor theory is known to provide deep insights into geometry of 4-dimensional space-time and the structure of (super)conformal field theories. Since the same $SU(2,2|4)$ super-conformal symmetry governs dynamics of both $D = 4$ $N = 4$ super-Yang-Mills theory and IIB superstring/supergravity theory on $AdS_5 \times S^5$ superbackground, that is one of the key arguments in support of the AdS_5/CFT_4 duality, it is natural to examine the possibility of extention of the (super)twistor theory to 5-dimensional anti-de Sitter (super)space. As a first step we aim at working out twistor description of the low-spin fields in AdS_5 with the emphasis on those fields that arise in the compactification spectrum of IIB supergravity on $AdS_5 \times S^5$. Our approach consists in reformulating point (super)particle models on $AdS_5(\times S^5)$ (super)background in terms of (super)twistors. To this end (super)particle's momentum components tangent to AdS_5 (and S^5) are realized as the product of constrained spinor variables. This allows to represent (super)particle's Lagrangian in terms of constrained (super)twistors. Dirac quantization then fixes homogeneity degrees of the (super)particle's wave function in each of the twistor arguments and can also lead to other constraints. To identify respective space-time fields it is helpful to use isomorphism between the quantized (super)twistors and (super)oscillators that can be employed to characterize positive energy unitary irreps of $SU(2,2)$ and its superextensions.

Scattering Problem With Complex And PT-Symmetric Potentials

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We present finite element schemes for solving the Schrödinger equation describing the scattering problem and resonance states. The efficiency of the algorithms and programs is shown by analyzing the scattering problems and resonance states for the Schrödinger equation with continuous (piecewise continuous) real (complex) potentials like single (double) barrier (well).

Transverse Kähler-Ricci flow on the Sasaki space $T^{1,1}$

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In the frame of contact geometry we investigate the transverse Kähler structure on the five-dimensional homogeneous Sasaki-Einstein space $T^{1,1}$. For this purpose a set of local holomorphic coordinates is introduced and a Sasakian analogue of the Kähler potential is given. We describe the deformations of the Sasaki-Einstein structure preserving the Reeb vector field, but modifying the contact form with basic functions. Choosing special basic functions which preserve the transverse metric, we generate families of Sasaki-Einstein metrics. Two convenient particular situations are presented, giving the expressions for the deformed local metrics. We remark that in the case of deformations with such kind of basic functions we have an explicit solution of the equation of the Sasaki-Ricci flow on the underlying manifold.

Boundary entropy of integrable perturbed $SU(2)_k$ WZNW

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We apply the recently developped analytical methods for computing the boundary entropy, or the g-function, in integrable theories with non-diagonal scattering. We consider the particular case of the current-perturbed $SU(2)_k$ WZNW model with boundary and compute the boundary entropy for a specific boundary condition. The main problem we encounter is that in case of non-diagonal scattering the boundary entropy is infinite. We show that this infinity can be cured by a subtraction. The difference of the boundary entropies in the UV and in the IR limits is finite, and matches the known g-functions for the unperturbed $SU(2)_k$ WZNW model for even values of the level.

Bethe States of Quantum Integrable Models Without U(1) Symmetry

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To construct Bethe-type eigenstates of quantum integrable models without $U(1)$ symmetry has been a long standing problem. By constructing a complete basis of the Hilbert space, I show how to obtain eigenstates of such kind of models with the known eigenvalues derived via off-diagonal Bethe Ansatz.

New Topological Constants in MHD

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Noether's theorem connects symmetries to conservation laws in various physical systems. Among the unique symmetries of continuous matter are labelling symmetries which are manifested by Arnold's diffeomorphism group. A special symmetry subgroup of the diffeomorphism is the translation of labelling. This subgroup is connected to conservation laws which suffer a topological interpretation. For example in ideal barotropic fluids the metage translation symmetry subgroup is connected through Noether's theorem to the conservation of helicity. Helicity is a measure of the knottiness of vortex lines and thus a topological constant of motion. The same is true for barotropic or incompressible magnetohydrodynamics (MHD) in which the same subgroup leads to the conservation of cross helicity. Although standard cross helicity is not conserved in non-barotropic MHD it was shown that a new kind of cross helicity which is conserved in the non barotropic case can be introduced. This conservation law was deduced from the variational principle using the Noether's theorem. The symmetry group associated with the new cross helicity was again magnetic metage translations. We show that additional labelling translations symmetries exist which are connected to new and different topological conservation laws.

Soliton surfaces induced by the Fokas-Lenells equation

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In this paper, we study the application of the theory of solitons in differential geometry. The recently proposed soliton equation, which is Fokas-Lenells equation, has been investigated, and its two-dimensional soliton surface in the three-dimensional Euclidean space ($\mathbb{R}^2 \to \mathbb{R}^3$) has been constructed. Thus the connection between the Fokas-Lenells equation and the surface was established by using the Sym-Tafel formula. We find the first and the second quadratic forms, surface area, and Gaussian curvature. The obtained results have various applications in mathematical physics, the geometry of curves and the theory of surfaces.

A Quantum Electromagnetic Theory of the Pions, Muons, Tauons and Pion- or Muon-emitting Particles

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In direct accordance to its experimental charge $-e$, mass 139.569 MeV, spin 0, and decay/production reactions, we represent the pion π^- as a heavy electron e_h^- in spin quantised processional-orbital (P-O) motion at almost the light speed c, similar to the e^-, p neutron model earlier. The P-O kinetic energy current, and two further opposing ones created at π^- decay, resemble confined neutrinos $\bar{\nu}_e$, $\bar{\nu}_\mu, \nu_\mu$. e_h^- has a regular e^-- mass, and in addition an orthogonal excited h- mass-mode

which (the IED picture) is a charge $-e$ oscillation and its electromagnetic radiation generated in the weak potential field of another particle e^+ or p. The h- mass is predicted based on first principles. The muon μ^- is a xy-projected e_h^- in two superposing P-O motions of energy currents $\bar{\nu}_e$ and ν_μ, of normals at angles $\pi - \theta_{1/2}$ and $\theta_{1/2} = \arccos\frac{1}{\sqrt{3}}$ to z axis. The μ^- mass is the geometric xy-projection of π^- mass (M_π), $M_\mu = M_\pi\sqrt{\cos\theta_{1/2}} = 105.66$ MeV. Their antiparticles π^+, μ^+, and the tauons $\tau^\mp$ can be similarly represented. The remaining unstable elementary particles can be constructed as composites of $\pi^\mp, \mu^\mp$, $e^\mp$, p, and/or $\bar{p}$ in certain spin quantised P-O motions (giving $\bar{\nu}, \nu$'s). Formal structures and solutions for the charges, spins and masses have been obtained for n (earlier), Λ, Σ's, Δ, π^0,K's, ρ, etc in accordance to observations.

Soliton and gausson solutions of logarithmic nonlinear wave equation and their applications for polycrystalline metals and alloys

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Wave equations with logarithmic nonlinearity find fruitful applications in different branches of physics - from nuclear physics and condensed-matter theory to particle physics, theory of physical vacuum and quantum gravity. Such a universality can be explained by the fact that one can derive this nonlinearity for a large class of the strongly-interacting many-body systems in which interaction energies predominate kinetic ones, using simple statistical-mechanics arguments and Madelung hydrodynamical presentation. Examples of such systems include Korteweg-type materials which can undergo liquid-solid or liquid-gas phase transitions. One of theory's predictions are large-scale periodical inhomogeneities of density and microhardness, bubbles, cells or grains, caused by existence of multiple soliton and Gaussian-shaped solitary wave solutions for an underlying logarithmic wave equation in the vicinity of a liquid-solid phase transition. Previous works were dealing with generic natural silicate materials in geophysics, such as magmas in volcanic conduits, where the (approximately) periodical flows and structures were known to occur. Here we report a preliminary experimental evidence of above-mentioned periodicity in a grain structure of non-alloy structural steel S235 A570 Grade 36, copper C-Cu C14200, stainless steel X10CrNiTi18-10 AISI 321, and aluminium-magnesium alloy 5083/5056.

Schottky cohomologies for vertex algebras

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Using Schottky procedure of forming a genus g Riemann surface by multiple sewing hangles to a complex sphere, we introduce cohomologies for vertex algebras by sewing procedure for coboundary operators.