# A B S T R A C T S

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# PLENARY SPEAKERS

*Caron-Huot, Simon*

**Unexpected symmetries and causality**

Physical systems sometimes exhibit unexpected, or 'hidden' symmetries. A prominent example is the Kepler problem, whose Laplace-Runge-Lenz vector ensures that planetary orbits form closed ellipses, and accounts for the degeneracies of the hydrogen spectrum. While broken in Nature by relativistic effects, I will describe how it survives in a very special, integrable, model: supersymmetric Yang-Mills theory in the planar limit. I will emphasize the role of relativistic causality as a powerful computational tool in this context.

*Hořava, Petr*

**Aristotelian Supersymmetry**

We introduce and study supersymmetric gauge and matter theories in nonrelativistic spacetimes with Aristotelian symmetries, in diverse dimensions. Under certain cirmunstances, such nonrelativistic theories can naturally flow at low energies to their relativistic super-Poincaré invariant counterparts, thus providing a new mechanism for the short-distance completion of relativistic supersymmetry.

*Iachello, Francesco*

**Algebraic models of quantum many-body systems**

I will give an overview of the method of spectrum generating algebras ($SGA$) and dynamical symmetries ($DS$) and apply it to a class of bosonic systems (*the so-called s-b boson models*) with $SGA \equiv U(n)$. I will then discuss quantum phase transitions ($QPT$) in these systems by introducing the coset spaces $U(n)/U(n-1) \otimes U(1)$. Finally, I will consider spectrum generating superalgebras ($SGSA$) and dynamical symmetries ($SUSY$) of a class of Bose-Fermi systems with $SGSA \equiv U(n/m)$.

*Isaev, Alexey*

**Bethe subalgebras in affine Birman–Murakami–Wenzl algebras and flat connections for q-KZ equations**

Commutative sets of Jucys-Murphyelements for affine braid groups of $A^{(1)}, B^{(1)}, C^{(1)}, D^{(1)}$ types were defined. Construction of R-matrix representations of the affine braid group of type $C^{(1)}$ and its distinguish commutative subgroup generated by the $C^{(1)}$-type Jucys–Murphy elements are given. We describe a general method to produce flat connections for the two-boundary quantum Knizhnik-Zamolodchikov equations as necessary conditions for Sklyanin's type transfer matrix associated with the two-boundary multicomponent Zamolodchikov algebra to be invariant under the action of the $C^{(1)}$-type Jucys–Murphy elements. We specify our general construction to the case of the Birman–Murakami–Wenzl algebras. As an application we suggest a baxterization of the Dunkl–Cherednik elements Y's in the affine Hecke algebra of type A.

*Kac, Victor*

**Integrable Hamiltonian partial differential and difference equations and related algebraic structures**

The related algebraic structures are additive and multiplicative Poisson vertex algebras. This turned out to be an adequate tool for the construction and study of integrable Hamiltonian partial differential and difference equations. The most famous of the former is the KdV equation, describing water waves in narrow channel. The most famous of the latter is the Volterra lattice, describing predator-prey interactions. Some knowledge of Lie algebras, but no knowledge of integrable systems, will be assumed.

*Kobayashi, Toshiyuki*

**Branching problems and symmetry breaking operators**

I begin with general results on restricting representations of reductive groups to their subgroups. Then I will focus on a concrete geometric question arising from conformal geometry, giving the complete classification of conformally covariant symmetry breaking operators for differential forms on the model space. Some of the symmetry breaking operators are differential operators and some others are obtained as the meromorphic continuation of integral operators.

*Lechtenfeld, Olaf*

**Rational Maxwell knots via de Sitter space**

We set up a correspondence between solutions of the YangDMills equations on $\Re\times S^3$ and in Minkowski spacetime via de Sitter space. Some known Abelian and non-Abelian exact solutions are rederived. For the Maxwell case we present a straightforward algorithm to generate an infinite number of explicit solutions, with fields and potentials in Minkowski coordinates given by rational functions of increasing complexity. We illustrate our method with some nontrivial examples.

*Marquette, Ian*

**Higher order superintegrability, Painlevé transcendents and representations of polynomial algebras**

I will review results on classification of quantum superintegrable systems on two-dimensional Euclidean space allowing separation of variables in Cartesian coordinates and possessing an extra integral of third or fourth order. The exotic quantum potential satisfy a nonlinear ODE and have been shown to exhibit the Painlevé property. I will also present different constructions of higher order superintegrable Hamiltonians involving Painlevé transcendents using four types of building blocks which consist of 1D Hamiltonians allowing operators of the type Abelian, Heisenberg, Conformal or Ladder. Their integrals generate finitely generated polynomial algebras and representations can be exploited to calculate the energy spectrum. I will point out that for certain cases associated with exceptional orthogonal polynomials, these algebraic structures do not allow to calculate the full spectrum and degeneracies. I will describe how other sets of integrals can be build and used to provide a complete solution.

*Ragoucy, Eric*

**Bethe vectors, scalar products and form factors in integrable models**

We review our series of works on the nested algebraic Bethe ansatz applied to integrable models based on algebras with rank higher than 2. We present some explicit representations for the Bethe vectors and their scalar products, in the framework of periodic generalized models, that encompass all integrable spin chain models with (twisted) periodic boundary conditions.

*Reshetikhin, Nicolai*

**Hamiltonian surperintegrable systems and their quantization**

A superintegrable system on a $2n$ dimensional phase space has $k \leq n$ commuting integrals of motion. The case $k = n$ corresponds to the Liouville integrability. When $k < n$ the dimension of Liouville tori is $k < n$. The extreme case of $k = 1$ is when the system is maximally superintegrable and, in particular, all compact trajectories are periodic. The model of a hydrogen atom is an example of a superintegrable system. In the first part of the talk I will remind the definition of a superintegrable system and present multiple examples related to Poisson Lie groups. The second part will be focused on the relation between the Racah-Wigner 6j symbols for simple Lie groups and corresponding integrable and superintegrable systems.

*Tarasov, Vitaly*

**Completeness of the Bethe ansatz for integrable models**

I will review results on completeness of the Bethe ansatz for the Gaudin and $XXX$-type models on tensor products of finite-dimensional representations of the Lie algebra $\mathfrak{gl}_N$. Those results are of geometric flavour. For the Gaudin models, the completeness of the Bethe ansatz states an isomorphism of the action of the transfer-matrices with the regular representation of the algebra of functions on an intersection of Schubert cells relative to osculating flags in spaces of quasi-exponentials. In other words, Bethe eigenvectors are in bijection with ordinary differential equations whose spaces of solutions are spanned by quasi-exponentials. For the $XXX$-type models, differential equations are replaced by difference equations with spaces of solutions spanned by quasi-exponentials. Geometric models for the action of the transfer-matrices are available for the $\mathfrak{gl}_2$ case and for tensor products of vector representations for arbitrary $N$. However, the whole picture is not completely worked out yet for $N > 2$.

*Tolstoy, Valeriy*

**All basic quantum quasitriangular Hopf deformations of $\mathfrak{o}(4;\mathbb{C})$ and of its real forms: Euclidean $\mathfrak{o}(4)$, Lorentzian $\mathfrak{o}(3,1)$, Kleinian $\mathfrak{o}(2,2)$ and quaternionic $\mathfrak{o}^*(4)$ symmetries**

Complete classification of nonisomorphic (basic) quantum quasitriangular Hopf deformations of the complex orthogonal Lie algebra $\mathfrak{o}(4;\mathbb{C})$ and of its real forms: Euclidean $\mathfrak{o}(4)$, Lorentzian $\mathfrak{o}(3,1)$, Kleinian $\mathfrak{o}(2,2)$ and quaternionic $\mathfrak{o}^*(4)$ Lie algebras is given in terms of classical $r$-matrices. All the $r$-matrices are skew-symmetric, and they satisfy homogeneous and nonhomogeneous classical Yang-Baxter equation. Using the isomorphisms $\mathfrak{o}(4;\mathbb{C}) \simeq \mathfrak{o}(3;\mathbb{C}) \otimes \mathfrak{o}(3;\mathbb{C})$, $\mathfrak{o}(3;\mathbb{C}) \simeq \mathfrak{sl}(2;\mathbb{C})$ we show that these classical $r$-matrices are multiparametric subordinated sums of standard and Jordanian classical $r$-matrices for $\mathfrak{sl}(2;\mathbb{C})$ and its real forms $\mathfrak{su}(2)$ and $\mathfrak{su}(1,1) \simeq \mathfrak{sl}(2;\mathbb{R})$ and also of Abelian classical $r$-matrices for $\mathfrak{sl}(2;\mathbb{C}) \otimes \mathfrak{sl}(2;\mathbb{C})$ and its real forms. Such structure of the basic classical $r$-matrices makes possible explicitly to find all basic quantum quasitriangular Hopf deformations of $\mathfrak{o}(4;\mathbb{C})$ and of all its real forms: $\mathfrak{o}(4)$, $\mathfrak{o}(3,1)$, $\mathfrak{o}(2,2)$ and $\mathfrak{o}^*(4)$.

*van Holten, Jan-Willem*

**D = 1 Supergravity as a constrained system**

D = 1 supergravity is a framework to model systems with finite numbers of commuting and anti-commuting degrees of freedom in a supersymmetric and reparametrization-invariant way. As a gauge theory the dynamics is restricted by first-class constraints. In this lecture I will describe the pseudo-classical hamiltonian phase-space structure of the systems and the implementation of the constraints. Quantization is straightforward and shown to result in a Dirac theory on curved manifolds.

*Winternitz, Pavel*

**Lie symmetries of Difference, Differential-Difference and Differential -Delay Equations**

Lie group theory and specially Lie algebra theory was originally developed to provide tools for classifying and solving ordinary and partial differential equations. More recently they proved to be useful for studying equations that involve discrete variables and for equations that are nonlocal in that they involve a delay parameter. The talk presents some recent developments in this area.

*Yu, Li-Wei*

**New type of solutions of Yang-Baxter equations, quantum entanglement and related physical models**

Starting from the Kauffman-Lomonaco braiding matrix transforming the natural basis to Bell states, the spectral parameter describing the entanglement is introduced through Yang-Baxterization. It gives rise to a new type of solutions for Yang-Baxter equation(YBE), called the type-II that differs from the familiar solution called type-I of YBE associated with the usual chain models. The Majorana fermionic version of type-II yields the Kitaev Hamiltonian. The introduced $\ell_1$ -norm leads to the maximum of the entanglement by taking the extreme value and shows that it is related to the Wigner's D-function. Based on the Yang-Baxter equation the 3-body S-Matrix for type-II is explicitly given. Different from the type-I solution, the type-II solution of YBE should be considered in describing quantum information. The idea is further extended to $\mathbb{Z}_3$ parafermion model based on $SU(3)$ principal representation. The type-II is in difference from the familiar type-I in many respects. For example, the quantities corresponding to velocity in the chain models obey the Lorentzian additivity $\frac{u+v}{1+uv}$ rather than Galilean rule $(u+v)$. Most possibly, for the type-II solutions of YBE there may not exist RTT relation. Further more, for $\mathbb{Z}_3$ parafermion model we only need the trigonometric Yang-Baxterization. Similar discussions are also made in terms of generalized Yang-Baxter equation with three spin spaces $\{1, \frac{1}{2}, \frac{1}{2}\}$.

# ABSTRACTS OF PARTICIPANTS

*Aboumal, Ismail*

**Superintegrable quantum systems**

We consider a two-dimensional quantum Hamiltonian separable in Cartesian coordinates and allowing a fifth-order integral of motion. We impose the superintegrablity condition and find all doubly exotic superintegrable potentials (i.e., potentials V(x, y)= V1(x) + V2(y), where neither V1(x) nor V2(y) satisfy a linear ordinary differential equation), allowing the existence of such an integral. All of these potentials are found to have the Painlevé property. Most of them are expressed in terms of known Painlevé transcendents or elliptic functions but some may represent new higher order Painlevé transcendents.

*Ahmadov, A.I.*

**Bound State Solution of the Schrödinger Equation at the Finite temperature**

In this study, the bound state solution of the modified radial Schrödinger equation is obtained for the Cornell plus inverse quadratic potential. Herein, the developed scheme is used to overcome the centrifugal part at the finite temperature. The energy eigenvalues and corresponding radial wave functions are defined for any $l \neq 0$ angular momentum case via the Nikiforov-Uvarov methods. The zero temperature limit of the energy spectrum and eigenfunctions is also founded. It is shown that analytical results can be applied to the charmonium and bottomonium masses at finite temperature, furthermore, the present approach can successfully be apply to the quarkonium systems at the finite temperature as well.

*Alcock-Zeilinger, Judith M.*

**Hermitian Young projection and unitary transition operators of $\mathsf{SU}(N)$ on $V^{\otimes m}$**

The representation theory of $\mathsf{SU}(N)$ on a tensor product space of the form $V^{\otimes m}$ plays an important role in a variety of fields in physics, in particular in quantum chromodynamics. The irreducible representations of $\mathsf{SU}(N)$ on $V^{\otimes m}$ can easily be classified, and counted, by means of Young tableaux and corresponding Young projection operators. However, in practical examples we often desire a *Hermitian* version of Young projection operators, and a construction of the latter will be discussed in this talk. Since some of the Hermitian Young projection operators necessarily project onto equivalent irreducible representations of $\mathsf{SU}(N)$, it is also important to provide a construction of unitary *transition operators* between them. The construction of both, the Hermitian Young projection operators and the unitary transition operators, will be presented in the birdtrack formalism. This talk will conclude with a brief outlook on the representation theory of $\mathsf{SU}(N)$ on more general tensor product spaces, such as, in particular, $V^{\otimes m} \otimes (V^*)^{\otimes n}$.

*Alekseev, Oleg*

**Conformal field theories of nonlinear stochastic Laplacian growth**

Stochastic Laplacian growth (SLG) describes diffusion-driven unstable nonlinear dynamics of random curves — boundaries of two-dimensional clusters. The problem is ill-defined, because some clusters develop cusplike singularities within a finite time. We show that the ultraviolet regularization of the problem gives rise to the one-dimensional shocks waves propagating along the boundaries of the clusters, which can be described by complex Burgers equation. We also elaborate and develop the relation between SLG and Liouville conformal field theories with $c \geq 25$ on the Schottky double. In particular, we show that the martingales (the observables, whose expectation values are constant in time) are connected to degenerate representations of the Virasoro algebra, and can be written in terms of conformal correlation functions.

*Alfimov, Mikhail*

**BFKL spectrum of $\mathcal{N} = 4$ SYM: non-Zero Conformal Spin**

We developed a general non-perturbative framework for the BFKL spectrum of planar $\mathcal{N} = 4$ SYM, based on the Quantum Spectral Curve (QSC). It allows one to study the spectrum in the whole generality, extending previously known methods to arbitrary values of conformal spin $n$. We show how to apply our approach to reproduce all known perturbative results for the Balitsky-Fadin-Kuraev-Lipatov (BFKL) Pomeron dimension and get new predictions. In particular, we re-derived the Faddeev-Korchemsky Baxter equation for the Lipatov spin chain with non-zero conformal spin reproducing the corresponding BFKL kernel eigenvalue. We also get new non-perturbative analytic results for the Pomeron dimension in the vicinity of $|n| = 1,\ \Delta = 0$ point and we obtained an explicit formula for the BFKL intercept function for arbitrary conformal spin up to the 3-loop order in the small coupling expansion and partial result at the 4-loop order. In addition, we implemented the numerical algorithm of N. Gromov, F. Levkovich-Maslyuk and G. Sizov for the non-zero conformal spin case. From the numerical result we managed to deduce an analytic formula for the strong coupling expansion of the intercept function for arbitrary conformal spin.

*Alkalaev, Konstantin*

**Large-$c$ superconformal torus blocks**

We study large-$c$ $SCFT_2$ on a torus specializing to one-point superblocks in the $\mathcal{N} = 1$ Neveu-Schwarz sector. Considering different contractions of the Neveu-Schwarz superalgebra related to the large central charge limit we explicitly calculate three superblocks, $osp(1|2)$ global, light, and heavy-light superblocks, and show that they are related to each other. We formulate the $osp(1|2)$ superCasimir eigenvalue equations and identify their particular solutions as the global superblocks. It is shown that the resulting differential equations are the Heun equations. We study exponentiated global superblocks arising at large conformal dimensions and demonstrate that in the leading approximation the $osp(1|2)$ superblocks are equal to the non-supersymmetric $sl(2)$ block.

*Alves, Victor*

**Solutions for the mixed $P_{III-V}$ equation**

The group-theoretical approach by Weyl symmetry groups to the Painleve equations is well known, for example the $P_V$ equation from the $\mathcal{A}_3^{(1)}$ group. Here we consider a deformation on the Weyl symmetric group $\mathcal{A}_3^{(1)}$ which gives rise to a mixed Elliptic-$P_{III-V}$ model. We next study its rational solutions in terms of polynomials and classical special functions.

*Aniello, Paolo*

**Square integrable representations: from generalized coherent states to open quantum systems**

Group representations play a central role in theoretical physics. We will argue that, in particular, a remarkable role is played by the so-called square integrable representations of locally compact groups. Specifically, the properties of these representations turn out to be fundamental in the definition of families of generalized coherent states, in the phase-space formulation of quantum mechanics and the associated star product formalism, and in some recent applications to the theory of open quantum systems and quantum information science that will be discussed in the talk.

*Antoine, Jean-Pierre*

**Beyond Hilbert space: RHS, PIP and all that**

We review the successive formalisms that can be used for quantum mechanics, all of them going beyond the standard Hilbert space formulation : Rigged Hilbert Spaces (RHS), partial inner product spaces (PIP spaces), etc. Some emphasis will be put on spectral properties of observables. Examples will be given.

*Aschheim, Raymond*

**Constructing numbers in quantum gravity: infinions**

Based on the Cayley-Dickson process, a sequence of multidimensional structured natural numbers (infinions) gives a path from quantum information to quantum gravity. Octonionic structure, the exceptional Jordan algebra, and the $\mathfrak{e}_8$ Lie algebra are encoded on a graph with $E_9$ connectivity, decorated by integral matrices. With the magic star, a toy model for a quantum gravity is presented with its naturally emergent quasi-crystalline projective compactification.

*Asselmeyer-Maluga, Torsten*

**Hyperbolic groups, 4-manifolds and Quantum Gravity**

4-manifolds have special topological properties which can be used to get a different view on quantum mechanics. One important property (connected with exotic smoothness) is the natural appearance of 3-manifold wild embeddings (Alexanders horned sphere) which can be interpreted as quantum states in particular in Quantum Gravity. The description of this states is given by using non-commutative geometry. The relation between wild embeddings and quantum states can be confirmed by using the Turaev-Drinfeld quantization procedure. Every part of the wild embedding admits a hyperbolic geometry uncovering a deep connection between quantum mechanics and hyperbolic geometry. Then the corresponding symmetry is used to get a dimensional reduction from 4 to 2 for infinite curvatures leading to a regularization of singularities. Physical consequences will be discussed.

*Avan, Jean*

**Dynamical centers for an elliptic quantum algebra**

We identify generating functionals that satisfy dynamical exchange relations with the Lax matrices defining the face-type elliptic quantum algebra $B_{q,\lambda}(gl^2)_c$, when the central charge takes the two possible values $c = \pm 2$. These generating functionals are constructed as quadratic trace-like objects in terms of the Lax matrices. The obtained structures are characterized as "dynamical centers", i.e. the centrality property is deformed by dynamical shifts. For these values, the functionals define (genuine) abelian subalgebras of $B_{q,\lambda}(gl^2)_c$

*Babalic, Elena Mirela*

**B-type Landau-Ginzburg models on Stein manifolds**

I summarize the rigorous description of the open-closed topological quantum field theory resulting from the quantization of B-type Landau-Ginzburg models with Stein target spaces and discuss a few classes of examples.

*Bäck, Per*

**The hom-associative Weyl algebras**

In this talk, I will give a brief introduction to non-associative, non-commutative polynomial rings known as hom-associative Ore extensions, and examples thereof. In particular will I discuss the so-called hom-associative Weyl algebras and their properties, these being generalizations of the classical first Weyl algebras to the non-associative setting.

*Bai, Chengminng*

**Deformations and their controlling cohomologies of $\mathcal{O}$-operators**

We establish a deformation theory of a kind of linear operators, namely, $\mathcal{O}$-operators in consistence with the general principles of deformation theories. On one hand, there is a suitable differential graded Lie algebra whose Maurer-Cartan elements characterize $\mathcal{O}$-operators and their deformations. On the other hand, there is an analogue of the André-Quillen cohomology which controls the deformations of $\mathcal{O}$-operators. Infinitesimal deformations of $\mathcal{O}$-operators are studied and applications are given to deformations of skew-symmetric $r$-matrices for the classical Yang-Baxter equation.

*Beige, Almut*

**Scattering light through semi-transparent mirrors**

In this contribution, we discuss the quantization of the electromagnetic field near semi-transparent mirrors. These are thin conducting flat surfaces with finite transmission, reflection and absorption rates and with wave packets approaching the mirror from both sides. Our model uses the same notion of photons as in free space and accounts for the presence of mirror images and the possible exchange of energy between the electromagnetic field and the mirror surface. When considering limiting cases, our approach reproduces well-known results but it also paves the way for the modeling of more complex systems with applications in quantum technology.

*Beneduci, Roberto*

**On the role of Positive Operator Valued Measures in Quantum Mechanics**

We review some particular aspects of the mathematical properties and the physical meaning of positive operator valued measures (POVMs) and elaborate on some recent results. We start with a general introduction to the topic. Then we analyze the measurement process in order to motivate the introduction of POVMs in quantum mechanics and introduce the concept of covariance with respect to a symmetry group. We also show how POVMs generalize the concept of quantum observable. We then focus on commutative POVMs that are relevant to quantum mechanics since they model certain standard forms of noise in quantum measurements and provide optimal approximators as marginals in joint measurements of incompatible observables (e.g., Position and Momentum). In particular, we analyze two integral representations of commutative POVMs and show that one can be derived from the other. Later we show how POVMs can be used to describe the measurement of incompatible non-commuting observables. One of the advantages of POVMs with respect to self-adjoint operators is indeed that two self-adjoint operators are compatible if and only if they commute while two non-commuting POVMs can be compatible. At last we analyze the case of POVMs that are covariant with respect to a symmetry group. For such POVMs a Radon-Nikodym derivative with respect to a scalar measure can be introduced. Finally we elaborate on some recent results on the Radon-Nikodym derivative of a POVM.

*Bergeron, Geoffroy*

**Quantum groups and multivariate q-Krawtchouk polynomials**

We provide an interpretation of multivariate q-Krawtchouk polynomials as matrix elements of corepresentations of quantum groups. We focus on the bivariate case and consider the corepresentations of $SL(3)_q$

*Bergshoeff, Eric*

**Gravity and the planar spin-2 Schrödinger equation**

I will give a short review of the frame-independent formulation of Newtonian gravity, called Newton-Cartan Gravity, and explain why there is a renewed interest into non-relativistic gravity in general. I will discuss, as a particular application, a recent proposal for an Effective Field Theory describing a massive spin-2 mode (the so-called GMP mode) in the Fractional Quantum Hall Effect.

*Bering, Klaus*

**Independence of gauge-fixing in a higher-order BV formalism**

In the context of Batalin-Vilkovisky (BV) quantization with a second-order BV Delta operator, the independence of gauge-fixing was established already in the seminal paper of Batalin and Vilkovisky from 1981 via infinitesimal change of integration variables. Witten showed in 1990 that geometrically, this can be viewed as an application of Stokes' theorem for differential forms. In 1996 we proposed together with Damgaard a proof of gauge-fixing independence via integration by parts in the path integral, which also works for higher-order BV Delta operators. Such higher-order BV Delta operators can e.g. appear from operator ordering issues in the path integral. In this talk, we show how to establish independence of gauge-fixing via infinitesimal change of integration variables in the higher-order case. The trick is to introduce the pertinent homotopy operator.

*Berntson, Bjorn*

**Integrable delay-differential equations**

Delay-differential equations are differential-difference equations where the shifts and derivatives are taken with respect to a single variable. I will review previous work on identifying integrable equations in this class and introduce a new approach based on analogy with the classical Painlevé equations. Properties of equations isolated by this approach will be discussed.

*Bertrand, Sébastien*

**Integrable Hamiltonian systems with magnetic field via circular parabolic-type integrals of motion**

For integrable Hamiltonian systems, the Hamilton-Jacobi equations can be solved by separation of variables in a suitable coordinate system. In the absence of magnetic field and in low dimension, lists of integrable (and superintegrable) systems together with the coordinate system(s) allowing separation of variables are already well known. However, cases admitting non-zero magnetic fields are less known. Hence, in this presentation, we will consider the integrability and superintegrability of 3D classical Hamiltonian systems. We will focus on natural Hamiltonian systems admitting a static non-zero electromagnetic field mainly via circular parabolic-type integrals of motion. This is a joint work with L. Snobl and A. Marchesiello.

*Bibikov, Petr*

**Derivation of R-matrix from the corresponding Hamiltonian density**

It is well known that the Hamiltonian density of an integrable spin chain may be obtained as a derivative of the corresponding R-matrix (in the braid group representation). Here it will be presented several algorithms for solution of the inverse problem. How to obtain the R-matrix basing on the corresponding Hamiltonian density.

*Blasco, Alfonso*

**The Garnier system on curved spaces**

The Garnier system is constructed on the $N$-dimensional sphere and the hyperbolic space by requiring to keep integrability of the initial (flat) Euclidean Hamiltonian. Furthermore, the curved "generalized" Garnier system, understood as the superposition of the Garnier system with $N$ Rosochatius (or Winternitz) terms is also achieved. In particular, on the sphere, the latter is interpreted as a superposition of an anisotropic oscillator with a quadratic central perturbation plus $N$ noncentral oscillators potentials. In all the resulting expressions the (sectional) constant curvature of the space $\kappa$ enters as a "classical" deformation parameter in such a manner that the Euclidean Garnier Hamiltonian along with its integrals of motion are recovered from the curved systems through the smooth flat limit $\kappa \to 0$. Our results are also illustrated by computing several trajectories and level plots for the potential for the flat and curved systems.

*Bleher, Pavel*

**The Pfaffian Sign Theorem and Exact Solution of the Dimer Model on a Triangular Lattice**

We will discuss an exact solution for the partition function and the monomer-monomer correlation function for the dimer model on the triangular lattice. We prove the Pfaffian Sign Theorem, and as an application we obtain an asymptotic behavior of the partition function with periodic boundary conditions with an exponentially small error term. In the second part of the talk we will discuss the long distance asymptotic behavior of the monomer-monomer correlation function.
The first part of the talk is based on a joint work with Brad Elwood and Dražen Petrović, and the second one on a joint work with Estelle Basor.

*Borowiec, Andrzej*

**Hopf algebroids and deformations of quantum phase space**

Extended covariant quantum phase space and its deformations in the category of Hopf algebroids are discussed with some details. The Drinfeld twist techniques are shown to be very effective in this context. In particular, two methods of twist quantization will be compared. Finally, some examples related with the light-cone kappa-deformation are presented in the explicit form.

*Braun, Lukas*

**Invariants of fundamental representations of $\mathrm{SL}_n$ and colored hypergraphs**

Classical invariant theory studies invariants of linear groups and their relations. The action of $\mathrm{SL}_2$ on symmetric tensors was a main subject in the nineteenth century. That is to say, a low dimensional acting group was combined with a relatively complicated representation of the group. We pursue the opposite strategy by observing the action of higher dimensional special linear groups on antisymmetric tensors, i.e. we consider invariants of (sums of) fundamental representations of $\mathrm{SL}_n$. To any such invariant, we associate a colored hypergraph and we allow certain operations on these hypergraphs. This allows us to substantially simplify the hypergraphs and to use graph theoretic results for a very effective determination of the ring of invariants. This directly generalizes the *fundamental theorems for systems of vectors and linear forms*. As an explicit example, we observe the group $\mathrm{SL}_4$.

*Brus, Adam*

**Multivariate Chebyshev-like polynomials of the second and fourth kind**

With use of the multivariate trigonometric functions the discrete sine transforms are generalized to antisymmetric and symmetric multivariate discrete sine transforms. Some interpolation with use of these transforms is shown. Next the Chebyshev polynomials of the second and fourth kind are generalized to orthogonal polynomials of several variables using the multivariate trigonometric functions. The general form of recurrence relations for these polynomials is obtained. The continuous and discrete orthogonality relations for these polynomials are shown. Then the multivariate discrete sine transforms are used to obtain cubature formulas for these polynomials.

*Bureš, Martin*

**On the effect of compactification of extra dimensions on the spectrum of hydrogen atoms**

The effect of the dimensionality of spacetime on physical laws is an interesting question per se. However, in the view of modern theories, aspiring to unify gravity with the remaining forces, this question becomes also very important.
The presented research address our investigations of how the presence of additional, space-like dimensions would affect atomic physics. The main part of the work is focused on the effect of an extra spatial dimension on the stability and energy spectrum of the non-relativistic hydrogen atom with a potential defined by Gauss' law. We found that when the radius $R$ of the extra compactified dimension is less than a quarter of the Bohr radius, the atom is stable, along with negative energy eigenstates. This negative spectrum was examined numerically, using Hamiltonian diagonalization techniques.

*Buring, Ricardo*

**The orientation morphism: from graph cocycles to deformations of Poisson structures**

It is known that cocycles in the non-oriented graph complex with the vertex-expanding differential $d$ yield universal flows on the spaces of Poisson structures on affine manifolds. We present an explicit and relatively elementary proof explaining how and why this "orientation" process works. The presentation is based on the proof by Jost (2013), which in turn is based on the outline by Willwacher (2010), itself based on the seminal work by Kontsevich (1996). As an illustration, for the tetrahedral flow $\mathcal{Q}_{\mathrm{tetra}}(\mathcal{P})$ this explains the vanishing of its Poisson differential $\partial_{\mathcal{P}}(\mathcal{Q}_{\mathrm{tetra}}(\mathcal{P})) = [\![\mathcal{P}, \mathcal{Q}_{\mathrm{tetra}}(\mathcal{P})]\!]$ via graphical differential consequences of the Jacobi identity $[\![\mathcal{P}, \mathcal{P}]\!] = 0$ (for a Poisson structure $\mathcal{P}$). We had found that factorization before using brute force, jointly with A. Bouisaghouane (2017). Our present reasoning also shows how $d$-coboundaries are mapped to universally $\partial_{\mathcal{P}}$-trivial deformations $\mathcal{Q}(\mathcal{P}) = \partial_{\mathcal{P}}(\mathfrak{X})$. The results along the way will be illustrated by examples.

*Butorac, Marijana*

**Principal subspaces of higher level standard modules for twisted affine Lie algebras of type $A_{2l-1}^{(2)}$, $D_l^{(2)}$, $E_6^{(2)}$ and $D_4^{(3)}$**

In this talk we describe combinatorial bases of principal subspaces of standard modules of level $k \geq 1$ with highest weight $k\Lambda_0$ for the twisted affine Lie algebras of type $A_{2l-1}^{(2)}$, $D_l^{(2)}$, $E_6^{(2)}$ and $D_4^{(3)}$. By using the theory of vertex operator algebras, we find combinatorial bases of principal subspaces in terms of twisted quasi-particles, which are twisted analogues of quasi-particles, originally used by F. L. Feigin, A. V. Stoyanowski and G. Georgiev for principal subspaces of affine Lie algebra of type $A_l^{(1)}$. From combinatorial bases, we obtain the characters of principal subspaces.

*Calmelet, Colette*

**Invariant solutions of Jensen's Equations**

We study the system of two nonlinear PDE's for flows driven by a localized surfactant monolayer on the free surface of a thin viscous film (Jensen's equations). We find the classical Lie symmetry group of the system, and use the set of its subgroups to generate the invariant and partially invariant solutions of Jensen's equations. We find several classes of exact solutions of the system, and discuss their properties and their interpretation. We show that some previously known results are special cases of our solutions.

*Campoamor-Stursberg, Rutwig*

**Solving degeneracies in the Clebsch-Gordan problem of simple Lie algebras**

The external labelling problem is analyzed in the context of the Clebsch-Gordan series of simple Lie algebras and the resolution of degeneracies. A complete basis of orthonormal labelling operators is constructed that separate multiplicities in the tensor product of multiplets. Some properties of the separating operators are inspected.

*Cao, Junpeng*

**Bethe states of the integrable spin-$s$ chain with generic open boundaries**

Based on the inhomogeneous $T-Q$ relation and the associated Bethe ansatz equations obtained via the off-diagonal Bethe ansatz, we construct the Bethe-type eigenstates of the $SU(2)$-invariant spin-$s$ chain with generic non-diagonal boundaries by employing certain orthogonal basis of the Hilbert space.

*Carrasco, Jose*

**Generalized Negativities, Formal Group Theory and Spin Chains**

We present a new class of generalized negativity measures, which are computable and multi-parametric measures of entanglement possessing a group-theoretical structure. The logarithmic negativity and its generalizations are fundamental information measures for the description of open quantum spin chains. Indeed, it can replace the standard Rényi and von Neumann entropies in contexts where these entropic measures can not be properly defined.

*Catto, Sultan*

**Octonionic Methods in Field Theory**

Some new applications of octonion algebra and octonionic analysis to group theory and higher dimensional field theories will be presented. Work is based on joint collaboration with professors Cestmir Burdik and Amish Khalfan.

*Çayiç, Zehra*

**Dynamics of squeezed states of a generalized quantum parametric oscillator**

Time-evolution of squeezed states of a generalized quantum parametric oscillator are found using the squeeze operator $\hat{S}(z)$ and the evolution operator $\hat{U}(t, t_0)$ is obtained by the Wei-Norman algebraic approach. Properties of these states are investigated according to the complex parameter of the squeeze operator and the time-variable parameters of the generalized quadratic Hamiltonian $\hat{H}(t)$. An exactly solvable model is constructed to illustrate explicitly the behaviour of the time-evolved squeezed states.

This work is supported by TÜBİTAK, Research Project No: 116F206.

*Cederwall, Martin*

**$L_\infty$ algebras for extended geometry**

Extended geometry is a unified framework for double geometry, exceptional geometry, etc. In the talk, I will explain the structure of gauge transformations (generalised diffeomorphisms) in these models. They are generically infinitely reducible, and arise as derived brackets from an underlying Borcherds superalgebra or tensor hierarchy algebra. The infinite reducibility gives rise to an $L_\infty$ structure, the brackets of which have universal expressions in terms of the underlying superalgebra.

*Chadzitaskos, Goce*

**Two dimensional harmonic oscillator in a sector of the plane and graded angular momentum theory**

We present the solution of a two–dimensional harmonic oscillator in a sector of a plane following an old observation of Marcos Moshisky (1984). M. Moshinsky is known to have devoted much of his studies to the quantum harmonic oscillator. According to his proposal we show the connection with the graded angular momentum theory. The grading is the way how to chose the eigenvectors in the case of a sector of a plane from eigenvectors of two dimensional isotropic ordinary harmonic oscillator. We describe all simultaneous N-gradings of the n–dimensional representation space. The quantum angular momentum theory is determined by SU(2) irreducible representations. Subsequently we study the harmonic oscillator in a sector of a plane, and we show the connections of the eigenvalues of the oscillator in a sector of a plane and the graded subspaces of the Hilbert space of two dimensional isotropic harmonic oscillator.

*Charalambous, Kyriakos*

**Lie and non-Lie symmetries for a chain of equations arising from a nonlinear diffusion-convection equation**

In this talk we present the Lie and potential symmetries for a chain of equations, up to the sixth-order, which arise from the generalisation of the second-order nonlinear diffusion-convection equation of the form

$$u_t = (u^n u_x)_x + u^m u_x.$$

The complete list of similarity reductions is presented with the employment of the appropriate optimal system. Exact solutions of these equations are constructed when it is possible.

*Chiribella, Giulio*

**Data compression for ensembles of identically prepared quantum systems**

One of the consequences of the No Cloning Theorem is that many copies of the same quantum state contain more information than just one copy. But what kind of information? And how much? A natural way to approach these questions is provided by the task of quantum data compression, where information is defined as the minimum amount of of memory needed to store the quantum state. Knowing the ultimate compression limit is important for the design of quantum machines with finite memory, and also for the design of communication networks where quantum data collected at different nodes are transmitted to a central location for joint processing. In this talk I will present recent results on the optimal compression of identically prepared particles, highlighting the interplay between physical and information-theoretic aspects, suggesting applications, and discussing open problems.

*Choi, Taeseung*

**Representation and Dynamical Equation for Parity-Extended Poincaré group**

We derive the two spin operators, whose squares are the second Casimir of Poincaré group. The two derived spin operators admit the left- and the right-handed representations of complexified $su(2)$ algebra. These two representations are building blocks of the representations of the parity-extended Poincaré group. The direct sum of two representations corresponds to free massive elementary field with spin $s$. Using the parity operation in the parity-extended Poincaré group for spin 1/2 fields, we derived the first-order dynamical equation similar to the free Dirac equation.

*Conte, Robert*

**Quantum correspondence for Painlevé VI**

Given any Lax pair of $PVI$, one can build a linear generalized heat equation with coefficients independent of the nonlinear field (Suleimanov 1994, D.P. Novikov 2009). Its identification to the time-dependent Schrödinger equation of quantum mechanics ("quantum correspondence") is easy in the elliptic representation of $PVI$ (Zabrodin and Zotov 2012), but *ad hoc* in its usual rational representation (Suleimanov 1994). We identify the reason for this difficulty: the classical Hamiltonian (not unique) must be equal to the logarithmic derivative of a tau-function, which is not the case of Suleimanov. Selecting a Hamiltonian equal to anyone of the four tau-functions of Painlevé 1906 does realize the quantum correspondance in the rational representation.

*Cruz y Cruz, Sara*

**Group approach to the paraxial propagation of Laguerre-Gaussian modes in a parabolic medium**

A group-theoretical approach to the paraxial propagation of Laguerre-Gaussian (LG) modes, based on the factorization method, is presented. It is shown that the su(1,1) and the su(2) algebras generate the spectrum of propagation constants at any fixed transversal plane. The complete set of LG modes is decomposed into hierarchies that are used to establish the representation spaces of SU(1,1) and SU(2). The corresponding families of generalized coherent states are constructed and the variances of the canonical variables are determined in connection with the propagation factor of each set of modes.

*Czuchry, Ewa*

**Quantum Toda-like regularisation of the Mixmaster anisotropy**

Regularisation approach to the study of the quantum dynamics of the Mixmaster universe is presented. This allows to approximate the anisotropy potential with the explicitly integrable periodic 3-particle Toda system. Such approach is based on a covariant Weyl-Heisenberg integral quantization which naturally amplifies the dynamical role of the underlying Toda system by smoothing out the three canyons of the anisotropy potential.

*Dahm, Rolf*

**On Spin II**

Having previously identified the photon field with a (special) linear Complex, we give a brief account on identifications and reasoning so far. Then, in order to include spinorial degrees of freedom into the Lagrangean description, we discuss the mapping of lines to spins based on an old transfer principle by Lie. This introduces quaternionic reps and relates to our original group-based approach by SU(4) and SU*(4) $\cong$ SL(2,H), respectively. Finally, we discuss some related geometrical aspects in terms of (spatial) projective geometry which point to a projective construction scheme and algebraic geometry.

*Danner, Aaron J.*

**Applications of superintegrability in problems of classical optics**

Maximally superintegrable systems play an important role in mechanics because all bound trajectories of particles in such systems are closed. Moreover, recently it has become clear that thanks to the close analogy between mechanics and optics, every maximally superintegrable system has an optical partner, a so-called absolute optical instrument–a region of space in which all bound ray trajectories of light are closed. Absolute instruments provide perfect (stigmatic) optical imaging, so they act like lenses free of any optical aberrations, and have found use, e.g. in the design of invisible cloaks. We will present a comprehensive theory of absolute optical instruments based on the Hamilton-Jacobi equation of mechanics, derive their optical properties and present a number of examples. Despite the knowledge already available in this field, there are still many open problems to be solved; applying methods of mechanics to optical problems could be invaluable.

*Daszkiewicz, Marcin*

**Noncommutative Sprott systems and their jerk dynamics**

In this article we provide the noncommutative Sprott models. 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 (noncommutative) jerk dynamics as well as, we study numerically as an example, the deformed Sprott-A system.

*de Guise, Hubert*

**Sum rules and coset functions in multiphoton interferometry**

I will discuss sum rules in photon coincidence rates in the context of interferometry. These can be evaluated using group coset functions and sums of immanants of the scattering matrix describing the optical network. In particular, we will show how the scattering matrix can be replaced with a coset matrix containing 0s, a feature that simplifies the evaluation of immanants. We will also discuss how the sum rule can be expressed in terms of sums of moduli squared of immanants

*De Palma, Giacomo*

**The quantum conditional Entropy Power Inequality and a new uncertainty relation for the conditional Wehrl entropy**

We prove the quantum conditional Entropy Power Inequality for bosonic quantum systems. This fundamental inequality determines the minimum quantum conditional entropy of the output of the beam-splitter or of the squeezing when the two inputs are conditionally independent given the memory and have given quantum conditional entropies. We exploit the quantum conditional Entropy Power Inequality to prove a new fundamental uncertainty relation for the conditional Wehrl entropy. This relation determines the minimum conditional Wehrl entropy among the quantum states with a given quantum conditional entropy. These fundamental results will play a key role in quantum information and communication, and will e.g. find application in security proofs of QKD protocols.

*del Olmo, Mariano A.*

**Lie algebras, spherical harmonics and rigged Hilbert spaces**

In this communication we continue our study of the coexistence on an appropriate framework of discrete and continuous basis, connected with special functions supporting representations of certain Lie algebras of physical interest. In particular, we present the case of the spherical harmonics that support representations of SO(3) and SO(3, 2). We show that this framework is provided by rigged Hilbert spaces. The continuity of the operators of the above mentioned Lie algebras is proved by the use of suitable topologies in the involved spaces.

*Deriglazov, Alexei A.*

**Corrections to Lense-Thirring and frame-dragging effects due to gravimagnetic moment of a rotating body.**

We compute exact Hamiltonian (and corresponding Dirac brackets) for spinning particle with gravimagnetic moment in an arbitrary gravitational background. Vanishing gravimagnetic moment corresponds to the Mathisson-Papapetrou-Tulczyjew-Dixon (MPTD) equations. Unit gravimagnetic moment leads to modified MPTD equations with improved behavior in the ultra-relativistic limit. So we study the modified equations in the leading post-Newtonian approximation. They have different behavior as compared with MPTD equations: A) If a number of gyroscopes with various rotation axes are freely traveling together, the angles between the axes change with time. B) For specific binary systems, gravimagnetic moment gives a contribution to frame-dragging effect with the magnitude, that turns out to be comparable with that of Schiff frame dragging. So the modified equations imply a number of qualitatively new effects, that could be used to test experimentally, whether a rotating body in general relativity has null or unit gravimagnetic moment.

*Díaz-Bautista, Erik*

**Partially coherent states in graphene**

Graphene is a material that since its discovering has exhibited interesting electronic properties. In this sense, the interaction between its electrons and magnetic fields has become into an interesting research subject due to its technological implications. In this work, we employ a symmetric gauge to describe this system and build the *partially* coherent states for the interaction of electrons in graphene with a magnetic field which is orthogonal to the layer surface. We also evaluate the corresponding probability and current densities as well the mean energy value.

*Ding, Xiang-Mao*

**Cluster algebras and matrix integrals**

Cluster algebras were originated from the study of canonical basis of quantum groups, as well as the investigation of the total positivity in semi-simple Lie theory. It is well known that the formal matrix integrals with cubic potential are the generating function of discrete surfaces for a given topology. In this presentation, we try to establish certain relationships between matrix integrals and cluster algebras. We propose that these surfaces are also the geometric models of cluster algebras.

*Dobrev, Vladimir*

**Multiparameter Quantum Minkowski Space-Time and Quantum Maxwell Equations Hierarchy**

Earlier we have proposed new q-Maxwell equations which are the first members of an infinite new hierarchy of q-difference equations. We have used an indexless formulation in which all indices are traded for two conjugate variables, $z, \bar{z}$. We proposed also new q-Minkowski coordinates which together with $z, \bar{z}$ can be interpreted as the six local coordinates of a $SU_q(2,2)$ flag manifold. In the present paper we generalise the main ingredients of this construction to the multiparameter case using the seven-parameter quantum group deformation of GL(4) and U(gl(4)) and the four-parameter quantum group deformation of SL(4) and U(sl(4)). The main result is the explicit presentation of the multiparameter quantum Minkowski space-time within the corresponding deformed flag manifold.

*Dodonov, Viktor*

**Variance uncertainty relations for several observables based on the Clifford algebras**

The uncertainty relations for an arbitrary set of N observables were derived for the first time by Robertson in 1934, and many special cases and generalizations were studied since that time. Unfortunately, such inequalities are too complicated in the most general form, because they contain, in addition to N variances of the observables and N(N-1)/2 mean values of commutators, numerous combinations of N(N-1)/2 covariances. I show a generalization of Robertson's scheme, which allows one to get rid of all covariances for N=3 and N=4. These "magic numbers" are related to the existence of remarkable Clifford algebras with three (the Pauli matrices) and four (the Dirac matrices) basic elements.

*Doebner, Heinz-Dietrich*

**Views on Symmetries and Theoretical Quantum Physics**

The appreciation of my activity for the Colloquia and other Series and my work in our field will be read by chairman Mariano del Olmo and Gerald Goldin as representative of the Standing Committee. In my answer I will indicate past and the present situation in symmetry including group theoretical methods and their application in physics and other in sciences and try to select some of possible development in the next future.

*Drigo Filho, Elso*

### Vibrational ground state energy for confinned molecules

The ground state energies for three confinned biatomic molecules (nitogen, litium and NaH) are determined by using a linear combination of atomic eigenfunction. The approach proposed allows us to build eigenfunctions based on confined atomic wave functions, obtained from the supersymmetric quantum mechanics formalism, to be used in the variational method. The potential used to simulate the molecular bound is the Morse one and the confinement is analyzed by introducing two barriers with the minimum of the potential inside this region. The approach used here was previous used to describe the hydrogen molecule. The results permit to conclude that the aproach can be extended for other biatomic molecules.

*Dvoeglazov, Valeriy*

### Generalized Equations and Their Solutions in the (S,0)+(0,S) Representations of the Lorentz Group- II.

We continue the discussion of several explicit examples of generalizations in relativistic quantum mechanics. In the first part we discussed the generalized spin-1/2 equations for neutrinos. Particularly, we found relations between the well-known solutions and the **dark** 4-spinors in the Ahluwalia-Grumiller **elko** model. They are also not the eigenstates of the helicity. Next, the $u-$ and $v-$ 4-spinors have solutions with $p_0 = \pm E_p = \pm\sqrt{\mathbf{p}^2 + m^2}$. The same is true for higher-spin equations. The relations to the recent Ziino works about doubling the Fock space have been discussed. We re-consider this possibility on the quantum field level for both $S = 1/2$ and higher spin particles. Next, we postulate the non-commutativity of 4-momenta, and we derive the mass splitting in the Dirac equation. Finally, the equations obtained by means of the Gersten-Sakurai method and those of Weinberg for spin-1 particles have been mentioned.

*Ecker, Jill*

### The Low-Dimensional Algebraic Cohomology of the Virasoro Algebra

The main focus of this presentation lies on the proof of the one-dimensionality of the third algebraic cohomology of the Virasoro algebra with values in the adjoint module. Because we are working with pure algebraic cohomology, our results are valid for any concrete realization of the Witt and the Virasoro algebra.

The talk starts with a brief introduction of the Witt and the Virasoro algebra. In a second step, the Chevalley-Eilenberg cohomology of Lie algebras is described, including the description of tools for computing this cohomology, such as the Hochschild-Serre spectral sequence. The proof of our main result consists of two parts. The first part consists in proving that the third algebraic cohomology of the Virasoro algebra with values in the Witt algebra is isomorphic to the third cohomology of the Witt algebra with values in the adjoint module. This proof uses the Hochschild-Serre spectral sequence. The second part consists in proving the one-dimensionality of the third algebraic cohomology of the Witt and the Virasoro algebra with values in the trivial module. Although the second part uses elementary algebra, the proof per se is not elementary, but somewhat intricate.

*Ellinas, Demosthenes*

**Region Operators Theory: ISp(2,C) Transformations and Entangled Points**

Quantum mechanical region operators (generalized observables), defined as operator valued measures over classical phase space or alternatively as operators ensuing from quantization of phase space characteristic functions according to various quantization schemes, are studied. The problem of constructing the region operator associated to a characteristic function with support over given phase space domain is treated by means of positive trace increasing maps (pti maps), in their operator sum representation. This general construction problem, for 1D quantum systems, is investigated in the framework of the quantum symplectic inhomogeneous group ISp(2,C). Appropriate pti maps with generators systematically identified with one parameter sub-groups of ISp(2,C), are presented in a unifying manner for a variety of phase space domains. Examples of domains e.g. include sets of points, line segments and rotated line segments, circles and disks, straight and rotated lines, canonical polygons, squeezed line segments, as well as lines related to Radon transform reconstruction problems in phase space. Finally quantum entanglement treated from the region operator point of view, is shown for some exemplary cases of entangled bipartite systems, to give rise to a geometrical manifestation of its nature, in terms of region operators with support on non classical areas viz. on entangled points.

*Escobar, A.M. Ruiz*

**General Nth order superintegrable systems separating in polar coordinates**

The general description of superintegrable systems, with one polynomial integral of second order in the momenta and one more of $N$ order, in a two-dimensional Euclidean space is presented. We consider Hamiltonian systems allowing separation of variables in polar coordinates. Both the classical and the quantum cases are discussed. The main properties of *standard* and *exotic* potentials are established as well. In particular, unlike the *exotic* potentials the general form of the *standard* ones satisfies a linear ODE. In the quantum case, we conjecture that a new infinite family of *exotic* potentials written in terms of the sixth Painlevé transcendent occurs.

*Faux, Michael*

**A graph-theoretic underpinning for conformal supergravity**

Off-shell representations of supersymmetry algebras may be classified and catego- rized using decorated N-regular, N-edge colored bipartite graphs known as Adinkras. These expose surprising connections with coding theory, and lend a fresh perspec- tive on open problems in field theory and string theory, for example by suggesting an off-shell context for N=4 Super Yang Mills theory. Adinkras are further enriched upon generalizing to local conformal supersymmetry. We will explain recent developments in the ongoing development of superconformal Adinkras, and how these provide powerful tools in the search for new physics.

*Fedorchuk, Vasyl*

**On symmetry reduction and invariant solutions of some partial differential equations**

Symmetry reduction is one of the most powerful tools to investigate partial differential equations (PDEs) with non-trivial symmetry groups. In particular, for this purpose, we can use a classical Lie method. In my report, I plan to present a short review of the results concerning symmetry reductions of some PDEs with non-trivial symmetry groups, which were obtained using the classical Lie method.

*Foldes, Juraj*

**Symmetry properties of evolutionary problems**

In this talk we will focus on a natural question whether solutions of symmetric problems are necessary symmetric. Although the answer to this question is NO in general, one can formulate very general and natural conditions such as positivity that will guarantee affirmative answer. Even more delicate question is whether the space of symmetric solutions is globally attractive, that is, if an evolution starting with arbitrary (positive) initial conditions converges to symmetric functions. We formulate sufficient conditions on both bounded and unbounded domains which guarantee such asymptotic symmetry. Also, we show that the shape of the domain can simplify the dynamics and we prove nontrivial convergence results - convergence of a solution to an equilibrium. If we drop positivity assumption then the problem is much more delicate and very chaotic dynamics can occur, however, we show that under mild assumptions on the initial conditions, a partial symmetry of the limit set can be still recovered.

*Freytes, Hector*

**Approximate transformations of entangled states by majorization**

Our proposal is based on the problem of deterministic transformations of an initial pure entangled quantum state into a target pure entangled quantum state by using local operations and classical communication (LOCC). A celebrated result of Nielsen says that this transformation is possible if and only if the majorization relation between the probability vectors obtained by taking the squares of the Schmidt coefficients of the initial and target states, holds. In general, this condition is not fulfilled. What we show is a strategy to deal with approximate entanglement transformations based on the properties of the majorization lattice. Our proposal is inspired by the observation that fidelity does not respect the majorization relation in general. Further, the transformation of an initial bipartite pure state into a target one by LOCC and entangled-assisted by a catalyst defines a partial order, so-called trumping majorization, that is based on tensor products and the majorization relation. We also show that the trumping majorization partial order is indeed a lattice for four dimensional probability vectors and two dimensional catalysts. In addition, we show that the subadditivity and supermodularity of the Shannon entropy on the majorization lattice are inherited by the trumping majorization lattice.

*Fukusumi, Yoshiki*

**Bipartition of torus and partition functions**

Entanglement is a famous information theoretic tool which can characterize many body systems. Especially for 1d spin chain at criticality, it is closely related to conformal field theory and evaluated by CFT. Recently, entanglement spectrum is considered as some of the generalized quantity to characterize entanglement. However, calculating or explaining the behavior of entanglement spectrum are difficult without ansatz or numerical calculation of the systems. Motivated by this problem, we will show some nontrivial relations between the torus partition function and the cylinder partition functions for CFTs.

*Furey, C.*

**Generations: three prints, in colour**

From just the complex octonions (an $8\mathbb{C}$ dimensional algebra) we will see how it is possible to generate the $SU(3)_C$ representations corresponding to not one, but three generations of quarks and leptons. This talk will assume no prior knowledge of the division algebras.

*Gaboriaud, Julien*

**The q-Askey scheme and automorphisms of the q-oscillator algebra**

It will be shown how families of q-orthogonal polynomials along a branch of the q-Askey scheme can be obtained from the continuous q-Hermite polynomials by using repeatedly some automorphisms of the q-oscillator algebra. This bottom-up approach will be seen to readily provide connection formulas for the polynomials in play.

*Gahramanov, Ilmar*

**Chiral symmetry breaking in supersymmetric theories as an inversion relation for lattice spin models**

Recently, there has been observed an interesting correspondence between supersymmetric quiver gauge theories with four supercharges and integrable lattice models of statistical mechanics such that the two-dimensional spin lattice is the quiver diagram, the partition function of the lattice model is the partition function of the gauge theory and the Yang-Baxter equation expresses the identity of partition functions for dual pairs. This correspondence is a powerful tool which enables us to generate new integrable models. The inversion relation for the lattice models has an interesting counterpart on supersymmetry side of the correspondence, namely, it is related to the chiral symmetry breaking of the corresponding supersymmetric gauge theory.

*Gazeau, Jean-Pierre*

**From classical to quantum models: the regularising role of integrals, symmetry and probabilities**

The talk focuses on the regularising role of integrals, symmetry and probabilities in building a quantum model from a classical one. This quantisation procedure will be described in simple terms through one of the most basic examples of Mechanics. Starting from (quasi-) probability distribution(s) on the Euclidean plane viewed as the phase space for the motion of a point particle on the line, i.e. its classical model, I will show how to build corresponding quantum model(s) and associated probabilities (e.g. Husimi) or quasi-probabilities (e.g. Wigner) distributions. The regularizing role of such procedures based on Weyl-Heisenberg symmetry will be highlighted, with examples like motions with variable mass, smoothing of classical singular potentials.

*Gevorkyan, Ashot*

**Quantum Vacuum, the Structure of *"Empty"* Space-Time and the Quintessence**

We have considered the possibility of forming massless structure particles with spin 1 (vector bosons-*hion*s). Using stochastic equations of the Weyl-Langevin type, it is proved that as a result of random fluctuations of massless vector fields, in the vacuum arise excitations in the form of statistically stable quantized formations localized on two-dimensional topological manifolds. The wave state and geometric structure of *hion* are studied in the case when the particle is free as well as when it interacts with a random environment. The latter breaks the symmetry of the quantum state of the *hion* and lead the particle to spontaneous transitions to other massless and mass states. The problem of entanglement of two *hions* with opposite projections of the spin +1 and -1, respectively, and the formation of a scalar boson with zero spin are investigated in detail. The properties of the scalar field (dark energy-*quintessence*) are analyzed and it is shown that it is a Bose-Einstein condensate (BE) consisting of massless zero-spin bosons. The problem of the decay of a scalar boson and the degree of stability of a BE condensate are studied. The structure of *empty* space-time is analyzed in the context of the new properties of quantum vacuum.

*Ghezelbash, Masoud*

**Deformed Hidden Conformal Group for Rotating Black Holes**

It is recently conjectured that generic non-extremal Kerr black hole could be holo- graphically dual to a hidden conformal field theory in two dimensions. Moreover, it is known that there are two CFT duals (pictures) to describe the charged rotating black holes which correspond to angular momentum J and electric charge Q of the black hole. Furthermore these two pictures can be incorporated by the CFT duals (gen- eral picture) that are generated by SL(2,Z) modular group. The general conformal structure can be revealed by looking at charged scalar wave equation in some appro- priate values of frequency and charge. In this regard, we consider the wave equation of a charged massless scalar field in background of Kerr-Sen black hole and show in the near region, the wave equation can be reproduced by the Casimir operator of a local SL(2,R) times SL(2,R) hidden conformal symmetry. We can find the exact agreement between macroscopic and microscopic physical quantities like entropy and absorption cross section of scalars for Kerr-Sen black hole. We then find an extension of vector fields that in turn yields an extended local family of SL(2, R) times SL(2, R) hidden conformal symmetries, parameterized by one parameter. For some special val- ues of the parameter, we find a copy of SL(2,R) hidden conformal algebra for the charged Gibbons-Maeda-Garfinkle-Horowitz-Strominger black hole in the strong deflection limit.

*Goldin, Gerald A.*

**Diffeomorphism Group Representations in Nonrelativistic and Relativistic Quantum Theory**

Classification of the unitary representations of the group of diffeomorphims of physical space and its semidirect products provides a unified description of diverse nonrelativistic quantum systems. In this talk we review briefly the main results, and highlight a possible approach to relativistic quantum theories based on hierarchies of such representations.

*Gombor, Tamas*

**New boundary transfer matrices for classical sigma models**

The 2d principal models without boundaries have symmetry group $G \times G$. The possible classical symmetries with integrable boundaries found so far are $H \times H$ or $G_D$ where $H$ is a subgroup of $G$ for which $G/H$ is symmetric space and $G_D$ is the diagonal subgroup of $G \times G$. A common property of these known boundary conditions is that they do not contain any free parameters. We have found new integrable boundary conditions for which the remaining symmetry groups are either $G \times H$ or $H \times G$ and they contain one free parameter. The related boundary transfer matrices are also described.

*Gomes, José Francisco*

**The Algebraic Construction of Integrable Hierarchies, Solitons and Backlund Defects.**

We shall discuss the construction of the mKdV hierarchy from the algebraic point of view and observe that the space component of the Lax operator plays a role of an universal algebraic object. This fact induces a systematic construction of an infinite number of time evolution equations with a common Lie algebraic structure. Moreover, we shall show that by an universal gauge transformation we can relate two field configurations of a given member of the hierarchy. Such gauge transformation generates the Backlund transformation (BT) for the entire hierarchy. We explicitly construct the BT of the first few integrable models associated to positive and negative grade-time evolutions and show that such framework can be employed to describe integrable defects. Solutions of these transformations for several cases describing the transition from vacuum to one-soliton determines a single condition for the Backlund parameter. The same follows for the scattering of two one-soliton solutions.

*Górska, Katarzyna*

**The Mittag-Leffler function as a universal tool in description of the relaxation phenomena**

The Mittag-Leffler functions generalise the exponential function. They play the important role in complex analysis, theory of special functions and fractional calculus in which the standard derivatives are replaced by integro-differential operators responsible for the memory (non-local) effects. The Mittag-Leffler function, being the eigenfunction of the Caputo fractional derivative, describes the Cole-Cole relaxation providing us with an example of non-Debye relaxation. Generalisations of the Mittag-Leffler function are related to another dielectric relaxation patterns, e.g. the Havriliak-Negami. I will show how the composition law of Mittag-Leffler functions leads to the suitable evolution equation.

*Góźdź , Andrzej*

**Partner groups and quantum numbers**

For every group G one can define the corresponding "intrinsic" group $\bar{\mathrm{G}}$. The groups G and $\bar{\mathrm{G}}$ are called the partner groups. They are anti-isomorphic and they commute. The last property is important in applications to quantum physics. A problem of quantum numbers labelling irreducible representations of the partner groups is considered. The proposed method is a generalization of an idea of transformation to the generalized intrinsic frame. As a generic pattern the quantum rotor Hamiltonian is used. A few examples of applications of partner groups to nuclear physics (collective nuclear motion, intrinsic point symmetries, etc) are shown.

*Grabowiecka, Zofia*

**The decoration of Coxeter-Dynkin diagrams and the Schläfli symbol as two methods to describe polytopes generated by finite reflection groups.**

The aim of this talk is to compare two different methods describing the structure of convex polyhedra of a Coxeter group, namely the decoration of a Coxeter-Dynkin diagram and the Schläfli symbol. The idea behind the two techniques will be presented and the advantages of the decoration of diagrams approach will be given. Both methods will be illustrated using polytopes which are single orbits of a finite reflection (Coxeter) group in 3 dimensions.

*Grabowski, Janusz*

**On a Lie's theorem about integrability by quadratures**

Integrability of a vector field means that you can find in an algorithmic way its flow in a given coordinate system. The existence of additional compatible geometric structures may play a relevant role and it allows us to introduce other concepts of integrability. Our aim is to develop the study of integrability in the absence of additional compatible structures, and more specifically the classical problem of integrability by quadratures, i.e. to study under what conditions you can determine the solutions by means of a finite number of algebraic operations (including inversion of functions) and quadratures of some functions. We present a substantial generalisation of a classical result by Lie in this direction. Namely, we prove that all vector fields in a finite-dimensional transitive and solvable Lie algebra of vector fields on a manifold can be integrated by quadratures.

*Grekov, Andrei*

**Supersymmetric generalization of the qKZ-Ruijsenaars correspondence**

In the work of Z. Tsuboi, A. Zabrodin and A. Zotov the quantum-classical duality between the Heisenberg spin chains and the classical Ruijsenaars-Schneider models was generalized to the case of the graded spin chains, associated with $gl(N|M)$-superalgebra. My talk will be devoted to a natural quantization of this duality. It generalizes the well-known Matsuo-Cherednik construction and take the form of the mapping between the solutions of qKZ-equations with a graded R-matrix and the wave functions of the quantum Ruijsenaars-Schneider systems.

*Gresnigt, Niels G.*

**Braids, normed division algebras, and Standard Model symmetries**

This talk looks at the possibility of unifying two promising attempts at understanding the origin of the internal symmetries of leptons and quarks. It is shown that each of the four normed division algebras over the reals admits a representation of a circular braid group. For the complex numbers and the quaternions, the represented circular braid groups are $B_2$ and $B_3^c$, precisely those used to construct leptons and quarks as framed braids in the Helon model of Bilson-Thompson. It is then shown that these framed braids coincide with the states that span the minimal left ideals of the complex octonions, shown by Furey to describe one generation of leptons and quarks with unbroken $SU(3)_c$ and $U(1)_{em}$ symmetry.

*Griess, Robert L.*

**Integral forms in vertex operator algebras**

An integral form in an algebra is the integral span of a basis which is closed under the product. For an integral form in a vertex operator algebra (VOA), we require closure under the given countably many products, plus a few additional conditions. Of particular interest are $G$-invariant integral forms where $G$ is a finite subgroup of the automorphism group. We mention a subset of recent results on (1) integral forms in lattice type VOA; (2) infinite dimensional graded representations of Chevalley-Steinberg groups (over any commutative ring) on vertex algebras which extend their natural action on the adjoint module; (3) the case of a $G$-invariant integral form in the Moonshine VOA where $G$ is the full automorphism group, isomorphic to the Monster sporadic simple group; (4) maximal $G$-invariant integral forms in degree 2 summands of dihedral VOAs.

*Grundland, Michel A.*

**Soliton surfaces obtained via $CP^{N-1}$ sigma models**

This talk is devoted to the study of an invariant formulation of completely integrable $CP^{N-1}$ Euclidean sigma models in two dimensions, defined on the Riemann sphere, having finite actions. Surfaces connected with the $CP^{N-1}$ models, invariant recurrence relations linking the successive projection operators and immersion functions of the surfaces are discussed in detail. Making use of the fact that the immersion functions of the surfaces satisfy the same Euler-Lagrange equations as the original projector variables, we derive surfaces induced by surfaces and prove that the stacked surfaces coincide with each other, which demonstrates the idempotency of the recurrent procedure. We also show that the $CP^{N-1}$ model equations admit larger classes of solutions than the ones corresponding to rank-1 Hermitian projectors.

*Guerrero, Julio*

**On the momentum space quantization of a particle on the sphere**

We perform the momentum-space quantization of a particle moving on the sphere $S^n$, by using a non-canonical method entirely based on symmetry grounds. The more relevant result is the fact that both the generalized Fourier transform and the scalar product defining the carrier Hilbert space in momentum representation deviate notably from the naively expected expressions. In fact the scalar product is defined through a non-trivial (convolution) kernel, under a double integral, traced back to the non-trivial topology of configuration space, even though momentum space as such is flat. We shall focus on the sphere $S^1$ but these results generalize straightforwardly to any dimension.

*Gusev, Alexander A.*

**High Accruracy Finite Element Method for Elliptic Multidimensional Boundary Value Problems**

High accruracy finite element method for elliptic multidimensional boundary value problems is elaborated. The shape functions are constructed in an analytical form by means of matching of the multivariate interpolating (Lagrange or Hermite) polynomials. The benchmark calculations of the elliptic multidimensional boundary value problems are given.

*Gutierrez Ruiz, Daniel*

**Mapping of symmetries through the Kustaanheimo-Stiefel Transformation on the Klein-Gordon equation with a Coulomb potential and a modified mass**

We focus on the Klein-Gordon equation with a Coulomb potential to show that in order to remove the dependence of the energy on the orbital quantum number, the mass must be redefined with a difference given by the potential itself so that the degeneracy is restored. We study how this modified Klein-Gordon equation can be obtained from spontaneous symmetry breaking in N=4 Super Yang-Mills. Next, we apply the Kustaanheimo-Stiefel Transformation (KST), which relates the two-dimensional hydrogen atom with the two-dimensional harmonic oscillator, to the modified Klein-Gordon equation in the extended phase space, showing that the KST is a nonholonomic canonical transformation within the framework of the extended phase space formalism. Finally, we identify how the generators of rotations in the plane and the generators of the Laplace-Runge-Lenz symmetry, which form the SO(3) group, are affected. This will lead to a relation among the integrals of motion of the hydrogen atom with the generators of the symmetry group SU(2) of the harmonic oscillator.

*Gutierrez-Sagredo, Ivan*

**Drinfel'd double structures for the Poincaré Lie algebra**

All non-isomorphic Drinfel'd double (DD) structures for the Poincare Lie algebra in (1+1) and (2+1) dimensions are explicitly constructed. In the (1+1) case two DD structures for the (non-trivially centrally extended) Poincare algebra are found. In (2+1) dimensions, there exist eight non-isomorphic DD structures for the Poincare Lie algebra. Each of the (1+1) and (2+1) DD structures here found generates a quantum Poincare algebra whose properties are analyzed. By imposing the corresponding Minkowski space-times to be coisotropic Poisson homogeneous spaces with respect to the Lorentz subgroup some of these deformations are naturally selected, and their associated Poisson Minkowski spacetimes are constructed.

*Hashimoto, Takaaki*

**Covariant Projective Representation of Symplectic Group on Discrete Phase Space**

The phase point operator $\Delta(q,p)$ is the quantum mechanical counterpart of the classical phase point $(q,p)$. The discrete form of $\Delta(q,p)$ was formulated for an odd number of lattice points by Cohendet et al. and for an even number of lattice points by Leonhardt. Both versions have symplectic covariance which is of fundamental importance in quantum mechanics, especially in Weyl quantization. However, the procedure for constructing the projective unitary representation of the symplectic group that appears in the covariance relation is not yet known. We show in this talk the existence and uniqueness of the representation, and describe an explicit method to construct it using the Euclidean algorithm.

*Hatzinikitas, Agapitos*

**The short-time limit of the Dirichlet partition function and the image method**

In this paper we rigorously derive the $t \to 0^+$ asymptotics of the free partition function $Z_\Omega(t)$ for a diffusion process on tessellations of the d-dimensional Euclidean space $\mathbb{E}^d$, $d = 1, 2, 3$ with an absorbing boundary. Utilising the path integral approach and the method of images for domains which are compatible with finite reflection subgroups of the orthogonal group $\mathbb{O}_d$, we solve this problem following a group theoretic method which was lacking from the literature.

*Her, Hai-Long*

**Moduli spaces of zeta-instantons**

Let $(X, \omega, \lambda)$ be an exact symplectic manifold, where $\omega$ is the symplectic 2-form and $\lambda$ is a 1-form such that $\omega = d\lambda$, with contact-type boundary. Choose an almost complex structure $J$ compatible with $\omega$. Given a superpotential $W : X \to \mathbb{C}$ which is a $J$-holomorphic Morse function inducing the structure of symplectic Lefschetz fibration. To these data physicists associate a Landau-Ginzburg model. For any two non-degenerate critical points $x$ and $y$ of $W$ and a specific phase $\zeta$, one can obtain the $\zeta$-solitons and the associated $\zeta$-instanton equation. We study the moduli space of solutions of $\zeta$-instanton equation and give a Morse-Bott type formalism. The transversality and compactness of relevant moduli spaces are verified. When we consider all critical points of $W$, this formalism can apply to more general moduli spaces. Based on analysis of these moduli spaces, some algebraic structures, such as Floer type homology, Fukaya type $A_\infty$ category and the web-based formalism formulated by physicists, can be constructed.

*Hernández Heredero, Rafael*

**Recursion operators for integrable non-evolutionary equations**

We will deal with formal and non-formal recursion operators of partial differential equa- tions of the form $q_{tt} = F(q, q_x, ...., q_n, q_t, q_{tx}, ...., q_{tm})$. A system admitting a formal recursion operator is deemed integrable under the *symmetry approach* to integrability. A formal recursion operator is a pseudodifferential operator $\Re$ of the form $\Re := L + MD_t$ with $L$ and $M$ pseudodifferential operators in the derivation $D_x$ satisfying the symmetry condition $F(L + MD_t) = (\bar{L} + MD_t)F$. Here $\bar{L} := L + 2M_t + [M, V]$ and $F = D_t - U - VD_t$ is the linearization operator of the PDE. We are thus confronted with solving an equation over pseudodifferential operators in two derivations, a rather nontrivial problem in principle. In the solving process there appear obstructions, written as conditions over the rhs $F$ of the PDE, that are interpreted as integrability conditions.

*Hnatic, Michal*

**Mirror symmetry breaking in toy models of developed turbulence**

Field-theoretic toy models of developed turbulence are formulated. Passive scalar admixture model, active vector admixture model, stochastic model of linearized Navier-Stokes equation - commonly known as A models, are analyzed in the case of mirror symmetry breaking. Breaking of this symmetry leads to the appearance of exponentially growing fluctuations of vector field in large spatial scale region. To conserve self-consistency (renormalizability) and stability of the A models, the concepts of running constants and spontaneous symmetry breaking, known from quantum-field models of high energy physics, are introduced. The running constants - coupling constant and turbulent Prandtl number are calculated in two loop approximation. Spontaneously generated uniform vector field, which eliminates exponential instabilities, is calculated in the leading order.

*Horzela, Andrzej*

**Hermite coherent states: expected and unexpected properties**

Hermite polynomials in one and/or two complex variables are used to construct one-particle and/or bipartite coherent states satisfying the resolution of identity, the latter treated as their fundamental property within our approach. Such obtained states depend on one parameter and appear to be not only coherent but also squeezed and, in the case of bipartite states, simultaneously squeezed and non-factorizable. Both these properties disappear in the limit which brings our scheme to the standard two dimensional Bargmann case.

*Hounkonnou, Mahouton Norbert*

**Zinbiel algebras and bialgebras: main properties and related algebraic structures**

This work provides a characterization of left and right Zinbiel algebras. Basic identities are established and discussed, showing that Zinbiel algebras are center-symmetric, and therefore Lie-admissible algebras. Their bimodules are given, and used to build a Zinbiel algebra structure on the direct sum of the underlying vector space and a finite-dimensional vector space. In addition, their matched pair is built, and related to the matched pair of their sub-adjacent Lie algebras. Besides, Zinbiel coalgebras are introduced, and linked to their underlying Lie coalgebras and coassociative algebras. Moreover, the related Manin triple is defined, and used to characterize Zinbiel bialgebras, and their equivalence to the associated matched pair.

*Hrivnák, Jiří*

**Discrete Cosine and Sine transforms on Honeycomb Lattice**

The discrete Fourier-like analysis of generalized cosine and sine functions on the two-dimensional honeycomb lattice is presented. The theoretical background stems from the concept of Weyl-orbit functions, discretized simultaneously on the weight and root lattices of the Weyl group $A_2$. The introduced class of extended Weyl-orbit functions generalizes periodicity and boundary properties of the one-dimensional cosine and sine functions. Three types of discrete complex Fourier-Weyl transforms and three types of real-valued Hartley-Weyl transforms are detailed. Examples of unitary transform matrices and interpolation behavior of the discrete transform is demonstrated. Consequences of the developed discrete transforms for transversal eigenvibrations of the mechanical graphene model are discussed.

*Huet, Idrish*

**Dihedral Invariant Polynomials in the effective Lagrangian of QED (II)**

We present a new group-theoretical technique to calculate weak field expansions in some Feynman diagrams using invariant polynomials of the dihedral group. In particular we show results obtained for the first coefficients of the three loop effective lagrangian of 1+1 QED in an external constant field, where the dihedral symmetry appears. Our results suggest that a closed form involving rational numbers and the Riemann zeta function might exist for a finite external field.

*Hussin, Véronique*

**Holomorphic solutions with constant curvature of the supersymmetric Grassmannian sigma model**

We use the gauge invariance of the supersymmetric Grassmannian sigma model $G(M,N)$ in order to get a canonical form for the holomorphic solutions of the model. In particular, the constant curvature holomorphic solutions of the supersymmetric $G(2,4)$ sigma-model are analyzed in detail. These solutions have constant curvature $\kappa_0 = \frac{2}{r}, \quad r = 1,2,3,4$, inherited from their bosonic part. For the solutions corresponding to $r = 3$ and $r = 4$, we obtain a criterion for getting the general supersymmetric solutions. The cases of $r = 1$ and $r = 2$ do not satisfy this criterion and we give some of the solutions with polynomial behavior.

*Ishkhanyan, Artur*

**Discretization of Natanzon potentials**

We show that the Natanzon family of potentials is necessarily dropped into a restricted set of distinct potentials involving a fewer number of independent parameters if the potential term in the Schrödinger equation is proportional to an energy-independent parameter and if the potential shape is independent of both energy and that parameter. In the hypergeometric case only six such potentials exist, all five-parametric. Among these, only two (Eckart, Pöschl-Teller) are independent in the sense that each cannot be derived from the other by specifications of the involved parameters. Discussing the solvability of the Schrödinger equation in terms of the single-confluent Heun functions, we show that in this case there exist in total fifteen seven-parametric potentials, of which independent are nine. Six of the independent potentials present different generalizations of the hypergeometric or confluent hypergeometric ones, while three others do not possess hypergeometric sub-potentials. The result for the double- and bi-confluent Heun equations produces the three independent double- and five independent bi-confluent six-parametric Lamieux-Bose potentials, and the general five-parametric quartic oscillator potential for the tri-confluent Heun equation.

*Ishkhanyan, Tigran*

**The third five-parametric hypergeometric quantum-mechanical potential**

We introduce the third *five-parametric* ordinary hypergeometric energy-independent quantum mechanical potential, after the Eckart and Pöschl-Teller potentials, which is proportional to an arbitrary variable parameter and has a shape that is independent of that parameter. Depending on an involved parameter, the potential presents either a short-range singular well (which behaves as inverse square root at the origin and vanishes exponentially at infinity) or a smooth asymmetric step-barrier (with variable height and steepness). The general solution of the Schrödinger equation for this potential, which is a member of a general Heun family of potentials, is written through fundamental solutions each of which presents an irreducible linear combination of two Gauss ordinary hypergeometric functions.

*Itin, Yakov*

**Quadratic invariants of the elasticity tensor and their applications**

We study the quadratic invariants of the elasticity tensor in the framework ofits unique irreducible decomposition. This decomposition generates the direct sum reduction of the elasticity tensor space. The corresponding subspaces are completely independent and even orthogonal relative to the Euclidean (Frobenius) scalar product. We construct a basis set of seven quadratic invariants that emerge in a natural and systematic way. Moreover, the completeness of this basis and the independence of the basis tensors follow immediately from the direct sum representation of the elasticity tensor space. We define the Cauchy factor of an anisotropic material as a dimensionless measure of a closeness to a pure Cauchy material and a similar isotropic factor is as a measure for a closeness of an anisotropic material to its isotropic prototype. For cubic crystals, these factors are displayed explicitly and cubic crystal average of an arbitrary elastic material is derived.

*Itoyama, H.*

**Discrete Painleve system and the double scaling limit of the matrix model for irregular conformal block and gauge theory**

We study the partition function of the matrix model of finite size that realizes the irregular conformal block for the case of the $\mathcal{N} = 2$ supersymmetric $SU(2)$ gauge theory with $N_f = 2$. This model has been obtained by two of us as the massive scaling limit of the $\beta$ deformed matrix model representing the conformal block. We point out that the model for the case of $\beta = 1$ can be recast into a unitary matrix model with log potential and show that it is exhibited as a discrete Painlevé system by the method of orthogonal polynomials. We derive the Painlevé II equation, taking the double scaling limit in the vicinity of the critical point which is the Argyres-Douglas type point of the corresponding spectral curve. By the 0d-4d dictionary, we obtain the time variable and the parameter of the double scaled theory respectively from the sum and the difference of the two mass parameters scaled to their critical values.

*Iyudu, Natalia*

**Koszulity for potential algebras and related questions**

We consider certain potential algebras: Sklyanin, contraction algebras, homology of moduli spaces of pointed curves $M_{0,6}$ of genus zero. The facts we prove for them, using in particular, Gröbner bases theory, include Koszulity, Hilbert series calculation, Calabi-Yau, PBW, etc. This is joint work with A. Smoktunowicz [IMRN, 2018], and S.Shkarin [J.Algebra, 2017]

*Ivankov, Petr*

**Moduli space of noncommutative flat connections and finite-fold nomcommutative coverings**

If we regard classical differential geometry then the moduli space of flat connections depends on the fundamental group. Here we consider the noncommutative generalization of this result. This work states the correspondence between noncommutative coverings and flat connections.

*Ivanov, Evgeny*

**New Deformations of $\mathcal{N}=4$ and $\mathcal{N}=8$ Supearsymmetric Mechanics**

We present two types of new deformations of extended supersymmetric mechanics. The first one generalizes $SU(2|1)$ mechanics worked out earlier and encompasses various models of the “curved” $SU(2|2)$ and $SU(4|1)$ mechanics as deformations of the flat $\mathcal{N}=8$ mechanics models. Another type is a generalization of the $\mathcal{N}=4$ mechanics associated with the multiplets $(\mathbf{4},\mathbf{4},\mathbf{0})$ and involving hyper-Kähler $d=1$ sigma models in the bosonic sector. This kind of deformation results in $\mathcal{N}=4$ models with quaternion–Kähler $d=1$ sigma models as the bosonic core. We give both the superfield and component formulations of the new models of supersymmetreic mechanics, and consider some simple examples.

*Iwata, Yoritaka*

**Angular momentum algebra based on $B(X)$-module**

A module over the Banach algebra ($B(X)$-module) has been introduced based on the logarithmic representation of infinitesimal generators [1-3]. In those works a set of generally-unbounded infinitesimal generators are characterized as a module over the Banach algebra. In this paper angular momentum algebra is discussed as an application of $B(X)$-module. Consequently angular momentum algebra is verified by means of unbounded infinitesimal generators.

*Jafarzade, Shahriyar*

**A New Integrable Ising-type Model from 2d $\mathcal{N}=(2,2)$ Dualities**

In this talk, firstly, I will review one of recent development in the connection between integrable lattice models in statistical mechanics to supersymmetric quiver gauge theories. This connection is called Gauge/Yang Baxter Equation (YBE) correspondence. According to this correspondence the equality of supersymmetric indices of dual theories leads to the solution of YBE. Then, I will show a new solution that we found to the YBE using supersymmetric gauge theory computations. In two dimensional lattice model which corresponds to our solution, Boltzmann weights are represented in terms of $\theta$-function and spin gets continous values on $[0,2\pi)$.

*Jakimowicz, Grzegorz*

**Tangent lifts of bi-Hamiltonian structures**

We construct several Poisson structures on the tangent bundle TM to a Poisson manifold M using the Lie algebroid structure on the cotangent bundle T*M. We also show that bi-Hamiltonian structure from M can be transferred to its tangent bundle TM. Moreover, we present how to find Casimir functions for those Poisson structures and we discuss some particular examples.

*Jakobsen, Hans Plesner*

**$q$ versions of the Dirac and Maxwell equations for $su_q(n,n)$ and their covariance**

When moving from $SU(n,n)$ to $\mathcal{U}_q(su(n,n))$ one must replace ordinary polynomials in commuting variables with quadratic (and non-commutative) algebras. Indeed, there are two such algebras: $\mathcal{A}_q^{\pm}$ with a pairing that generalizes the pairing between polynomials and differential operators. Here, some care must be asserted since the usual recipe for defining differential operators as duals of multiplication operators does not have to distinguish between left and right multiplication operators. We resolve these problems by using a somewhat novel quantization of the Weyl Algebra. We also present a number of pairings between highest weight modules and ($q$ analogues of) holomorphically induced representations. In the end we can write down explicit matrix-valued systems of operators that have covariance properties. Specializing to $q = 1$ we even there get new covariant differential operators (along with the known ones) for $SU(n, n)$.

*Jakubczyk, Dorota*

**The one-dimensional Hubbard model in the limit of $u >> t$.**

I revisit the one-dimensional Hubbard model in the case of strong correlations, i.e., for on-site repulsion constant strongly grater than hopping constant $u >> t$, and assume that each atom has only a single relevant orbital. I present in details the example of half-filled system with four number of atoms. I confirm that when the sites are almost independent atoms, i.e., in the atomic limit, the spin-spin coupling term appears, every site carries exactly one electron and hopping is suppressed. I compare the results with one-dimensional Heisenberg Hamiltonian using the translational and unitary symmetries.

*Jarvis, Peter D.*

**Systematics and Symmetry in Molecular Phylogenetics Modelling**

We present and analyze the probabilistic models of molecular phylogenetics which have been intensively used in recent years in biology as the cornerstone of attempts to infer and reconstruct the ancestral relationships between species. We bring a lens of mathematical physics to bear on the formulation of the theoretical models, focussing on the applicability of group and representation theory to guide model specification and to exploit the multilinear setting of the models in the presence of underlying symmetries. We analyze coalgebraic properties of the generators associated to rate matrices underlying the models, and possibilities to marry these with the graphical structures (trees and networks) which form the search space for inferring evolutionary trees. Finally we analyse aspects of multipartite entanglement which are shared between descriptions of quantum states on the physics side, and the multi-way tensor probability arrays arising in phylogenetics. In particular we characterize the Markov invariant rings for binary characters in the triplet and quartet cases, in comparison with their corresponding three- and four-qubit counterparts.

*Kanel Belov, Alexei*

**Automorphisms of Weyl Algebra and a Conjecture of Kontsevich**

My talk concerns recent progress made in the positive resolution of Kontsevich's conjecture, which states that, in characteristic zero, deformation quantization of affine space preserves the group of symplectic polynomial automorphisms, i.e. the group of polynomial symplectomorphisms in dimension $2n$ is canonically isomorphic to the group of automorphisms of the corresponding $n$-th Weyl algebra. The conjecture is positive for $n = 1$ and open for $n > 1$. The procedure utilizes the following essential features. First, the Weyl algebra over an algebraically closed field of characteristic zero may be identified with a subalgebra in a certain reduced direct product (reduction modulo infinite prime) of Weyl algebras in positive characteristic – a fact that allows one to use the theory of Azumaya algebras and is particularly helpful when eliminating the infinite series. Second, the lifting is performed via a direct homomorphism $AutW_n \to AutP_n$ which is an isomorphism of the tame subgroups (that such an isomorphism exists is known due to our prior work with Kontsevich) and effectively provides an inverse to it. Finally, the lifted automorphism is the limit (in formal power series topology) of a sequence of lifted tame symplectomorphisms; the fact that any polynomial symplectomorphism has a sequence of tame symplectomorphisms converging to it is our development of the work of D. Anick on

approximation and is very recent.
In order to make approximation work (this is not trivial at all because the ind-schemes are not reduced) , we play with Plank constants and use singularity trick see http://arxiv.org/abs/1707.06450 and http://arxiv.org/abs/1512.06533 for details.

*Kerner, Richard*

**Quarks as a mathematical puzzle**

Quarks cannot propagate outside the nucleons or mesons, but inside they seem to behave at high energies as almost free. An alternative approach to color dynamics is proposed. It is based on the observation that the $Z_2 \times Z_3 = Z_6$ cyclic group generated by the sixth root of unity can be put into one-to-one correspondence with three colors and three anti-colors. If we identify 0 as "colorless", or "white", there are two ternary and three binary combinations of roots yielding zero. Combining spin with color, and including particle-antiparticle symmetry, we arrive at 12-component objects, satisfying generalized Dirac equation whose solutions cannot propagate alone due to the complex wave vectors, but can form propagating combinations via ternary or binary products. Relativistic invariance realized via non-standard complex realizations of the Lorentz group is also discussed.

*Kirschner, R*

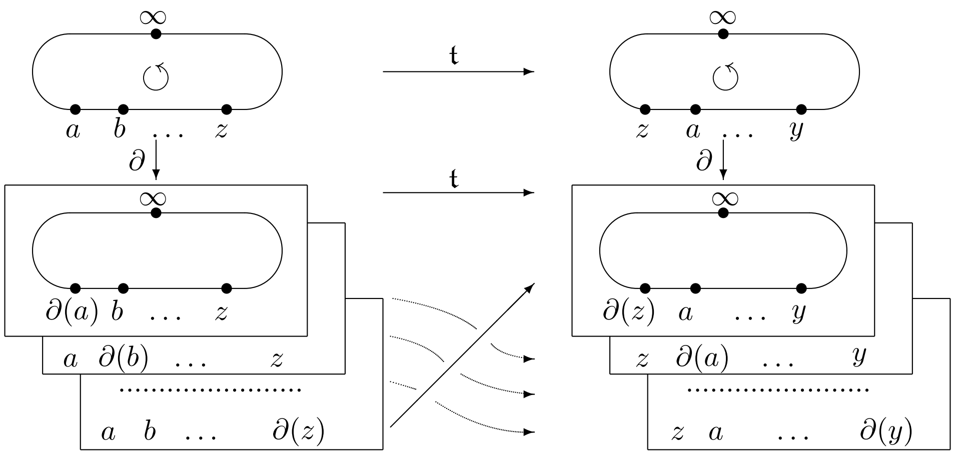
**Yangians of orthogonal and symplectic types and Lie algebra representations**

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 related Lie algebra representations are studied.

*Kiselev, Arthemy V.*

**Cyclic words and the noncommutative geometry of quasicrystal space-time tilings**

The Leibniz rule for derivations is invariant under cyclic shifts $\mathfrak{t}$ of co-multiples within the arguments of derivations $\partial$ (see the figure). We explore the implications of this principle. First, we construct a class




of noncommutative bundles in which the base is a (quasi)crystal tiling of an affine manifold $M^m$ (e.g., we take a regular affine lattice in $\mathbb{E}^m$ for a given root system); the base is equipped with a sheaf of algebras of walks along the cells. The fibres are the algebras of cyclic words $(a) \in \mathcal{A} = \text{Free}\,(a^1, \ldots, a^n)/\sim$, that is, the quotients of free algebras of words in an alphabet $\langle a^i \rangle$ over the linear relation of equivalence $a \sim \mathfrak{t}(a)$. The evaluation of generators $a^i := s^i\big(x, \vec{\mathsf{x}}^{\pm 1}\big)$, by using words which are written in the lattice edge alphabet $\vec{x}^{\pm 1}$ and weighted by scalar functions on $M^m \ni x$, is viewed as sections of the noncommutative bundle.

In the frames of this recent field-theoretic extension of the Kontsevich formal noncommutative geometry (1992), the structures of differential calculus are realised by cyclic words. Binary operations amount to the topological pair of pants $\mathbb{S}^1 \times \mathbb{S}^1 \to \mathbb{S}^1$ that unlock two necklaces and join them into one. The construction of function(al)s, variational multivectors, and covectors is natural; relations between the Batalin–Vilkovisky Laplacian, variational Schouten bracket, and Poisson structures are established in a regular way.

Now, in the combinatorial geometry of quasicrystal tilings of the manifolds $M^m$, we study a possibility of introducing the standard elements of differential geometry, namely the Riemann curvature tensor, metric, and Christoffel symbols.

*Klauder, John. R*

**Solving the Insoluble: A New Rule for Quantization**

The rules of canonical quantization normally offer good results, but sometimes they fail, e.g., leading to quantum triviality (= free) for certain examples that are classically nontrivial ($\neq$ free). A new procedure, called Enhanced Quantization, relates classical models with their quantum partners differently and leads to satisfactory results for all systems. This contribution features enhanced quantization procedures and provides highlights of two examples, a rotationally symmetric model and an ultralocal scalar model, for which canonical quantization fails while enhanced quantization succeeds.

*Koçak, Aygül*

**Kaleidoscope of Quantum Coherent States and Units of Quantum Information**

The Schrödinger cat states, constructed from Glauber coherent states and applied for description of qubits are generalized to the kaleidoscope of coherent states, related with regular n-polygon symmetry and the roots of unity. This quantum kaleidoscope is motivated by our method of classical hydrodynamics images in a wedge domain, described by $q$-calculus of analytic functions with $q$ as a primitive root of unity. First we treat in detail the trinity states and the quartet states as descriptive for qutrit and ququat units of quantum information. Normalization formula for these states requires introduction of specific combinations of exponential functions with mod 3 and mod 4 symmetry, which are known also as generalized hyperbolic functions. We show that these states can be generated for an arbitrary $n$ by the Quantum Fourier transform and can provide in general, qudit unit of quantum information. The average number of photons in kaleidoscope of coherent states is given by the ratio of two consecutive mod n exponential functions. Relations of our states with quantum groups, multi-qudit entangled states and quantum calculus are discussed.

*Koide, Tomoi*

**Second Law of Thermodynamics induced by Symmetry analogous to Pseudo-Hermiticity in Nonequilibrium Physics**

Symmetries of Lagrangian are associated with conservation laws. Because the time scale of the change of conserved quantities are slower than that of non-conserved ones, it is possible to say that symmetries determine macroscopic physics. The second law of thermodynamics is another important macroscopic law but the relation to symmetry is not well understood. In this work, we consider classical thermal relaxations and map these Markovian processes to the unrecognized probability theory proposed by Schrödinger, reciprocal process. Then we introduce a new symmetry attributed to the reciprocal process and show that the second law of thermodynamics is obtained as the direct influence of this symmetry. Note that a non-trivial metric operator can be introduced for the state vector of

the reciprocal process and the introduced symmetry is regarded as a kind of pseudo-Hermiticity (or PT symmetry) in quantum mechanics. Therefore the present calculation will help us understand the possible generalization of quantum mechanics from the point of view of the probability theory.

*Kojima, Takeo*

**Wakimoto realization of the quantum affine superalgebra $U_q(\widehat{sl}(M|N))$**

Bosonization is a powerful method to study representation theory of infinite-dimensional algebras and its application to mathematical physics, such as calculation of correlation functions. We give a bosonization of the quantum affine superalgebra $U_q(\widehat{sl}(M|N))$ $(M, N = 1, 2, 3, \cdots)$ for an arbitrary level $k \in \mathbf{C}$, which we call Wakimoto realization. We give screening operators that commute with $U_q(\widehat{sl}(M|N))$ for level $k \neq -M+N$. We give bosonizations of the vertex operators. They are necessary ingredients for calculating correlation functions. In the $q \to 1$ limit we also obtain new bosonization of the affine superalgebra $\widehat{sl}(M|N)$. For level $k = 1$, bosonizations of the quantum affine algebra $U_q(g)$ have been obtained in many cases $g = (ADE)^{(r)}, (BC)^{(1)}, G_2^{(1)}, \widehat{sl}(M|N), osp(2|2)^{(2)}$. Bosonization of an arbitrary level $k \in \mathbf{C}$ is completely different from those of level $k = 1$. For level $k \in \mathbf{C}$, bosonizations of only $U_q(\widehat{sl}(N))$ and $U_q(\widehat{sl}(M|N))$ have been obtained, and that of $U_q(\widehat{sl}(M|N))$ was obtained by the present author.

*Kondratyev, V.N.*

**Self-Organized Criticality in Superferromagnets**

Superferromagnetism (SFM) was invoked to specify the structures involving quantum confined objects, e.g., atomic clusters, quantum dots, nanocrystals referred for hereafter as, simply, NC. Such systems are of fundamental interest for a study of interactions, transport processes and phase features at fairly wide range of various parameters, e.g., coupling constants, densities, Coulomb blockade gaps etc. We consider magnetodynamics of NC arrays by employing the randomly jumping interacting moments (RJIM) model including quantum fluctuations due to the dot discrete level structure, inter-dot coupling and disorder. Magnetic 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 criticality (SOC) the magnetization evolves as 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 SOC in magnetic NC assemblies. We find strong correlations in jump amplitude distributions characterizing, thereby, a system with respect to SOC and a disorder.

*Koornwinder, Tom*

**Dualities in the $q$-Askey scheme and degenerate DAHA**

The Askey-Wilson polynomials satisfy a duality property which means that the variable $z$, where $x = (z + z^{-1})/2$, and the degree $n$ occur in the explicit expression in a similar and to some extent exchangeable way. This duality returns in the non-symmetric case and in the underlying algebraic structures: the Askey-Wilson algebra and the double affine Hecke algebra (DAHA). The duality property also survives in the degenerations of the (non-symmetric) Askey-Wilson polynomials and the corresponding algebras, following the arrows in the ($q$-)Askey scheme. We will discuss this for the DAHA and the non-symmetric Askey-Wilson polynomials. See also our preprint `arXiv:1803.02775`.

*Korbelář, Miroslav*

**On Clifford groups in quantum computing**

In single or composite quantum systems with finite-dimensional Hilbert space the finite Weyl-Heisenberg group of unitary operators defines the quantum kinematics and the states of the quantum register. The corresponding Clifford group in quantum information is then defined as the group of unitary operators leaving the Weyl-Heisenberg group invariant (its normalizer). The quotient of this normalizer by the Weyl-Heisenberg group (with respect to U(1)) exactly corresponds to the group of symmetries of the Pauli gradings of quantum operator algebras. In particular, all single as well as composite finite quantum systems given by a finite abelian group $A$ are covered within this correspondence. We provide a formula for the order of the group of these symmetries $\mathrm{Sp}(A)$ for non-trivial cases of composite systems.

*Kornyak, Vladimir V.*

**A New Algorithm for Irreducible Decomposition of Representations of Finite Groups**

One of the central problems of group theory and its applications in physics is the decomposition of linear representations of groups into irreducible components. In general, the problem of splitting a module over an associative algebra into irreducible submodules is quite nontrivial. For vector spaces over finite fields, the most efficient is the Las Vegas type algorithm called *MeatAxe*. This algorithm played an important role in solving the problem of classification of finite simple groups — "the enormous theorem". However, the approach used in the *MeatAxe* is ineffective in characteristic zero, whereas quantum-mechanical problems are formulated just in Hilbert spaces over fields of characteristic zero. Our algorithm deals with representations over such fields, and its implementation copes with dimensions up to hundreds of thousands, which is not less than the dimensions available for the *MeatAxe* in the much easier context of finite fields. Examples of computations are given.

*Kowalski, Krzysztof*

**On the coherent states in the relativistic quantum mechanics**

In spite of the importance and a long history of the coherent states the problem of their relativistic generalization remains open. We discuss the coherent states for a spin-0 relativistic particle on a line.

*Kozyrev, Nikolay*

**The curved WDVV equations and superfields**

In a few recent papers we considered the construction of the $N = 4$ supersymmetric mechanics on curved spaces within the Hamiltonian formalism. It was found that the structure functions, entering the supercharges and the Hamiltonian, have to obey some modified version of the WDVV equations, which we called the "curved WDVV equations". In this talk, the superfield version of this construction is considered. It is shown that for any given solution of the curved WDVV equations, the third order Codazzi tensor together with the metric, one may find the appropriate modification of the $N = 4$ linear multiplet constraints and find the superfield Lagrangian by solving a simple differential equation. As a side consequence, it is found that the curved WDVV equations can only be solved on spaces, which metric becomes a second derivative of a scalar is some distinguished system of coordinates.

*Krivonos, Sergey*

**$N$-extended supersymmetric Calogero models**

We proposed new $N$-extended supersymmetric $su(n)$ spin-Calogero model as a direct supersymmetrization of the bosonic $su(n)$ model. Using the generalized reduction procedure adopting to the supersymmetric case, we succeeded in the explicit construction of the $n$-particles Calogero model with $N$-extended supersymmetry upon the reduction.

*Kunitomo, Hiroshi*

**Heterotic string field theory and new relations extending $L_\infty$ algebra**

The Neveu-Schwarz sector, describing space-time bosons, of heterotic string field theory has been constructed based on the WZW-like formulation, where closed string products satisfying $L_\infty$ algebra are important ingredients. We extend this formulation to incorporate the Ramond sector, describing space-time fermions, and attempt to complete a heterotic string field theory. Since the action is non-polynomial in the Ramond string field $\Psi$ we expand the action in the power of $\Psi$, and construct it order by order by requiring gauge invariance. It is found that the action at quartic and higher order can be written by using another kind of string products called gauge products, which have been introduced as supplementary ingredients. We determine the action and gauge transformation up to octic order by means of new relations among these products which is a kind of extension of the $L_\infty$ algebra.

*Kuru, Şengül*

**Supersymmetric partners of the hyperbolic step potential by using anti-bound states**

The scattering produced by exactly solvable one dimensional hyperbolic step potential, which has an asymmetric character, is analyzed. This potential has neither bound states nor resonances, but it has anti-bound states. Then, the supersymmetric partners, which are the series of Rosen–Morse II potentials, are constructed by using just the wave functions of the anti-bound states. The Wigner reflection and transmission time delays for the hyperbolic step and such SUSY partners are also computed. The results show that the time delay is related with the number of excited states of the partner Hamiltonians. For completeness, time delays for the hyperbolic step potential in the classical case are also obtained. It is shown that the results of the quantum and classical cases have striking similarities.

*Kuwata, Seiichi*

**Quaternion-based generalization of conformal maps**

For the conformal map in two dimensions, the local rescaling factor of metric amounts to that of surface element. To avoid the restriction on the functional form of the metric in $d$ dimensions ($d > 2$), we generalize the conformal map in such a way that the volume element ($d$ form), not the metric (quadratic form), is invariant up to local rescaling. For $d = 4$, quaternions are available to formulate such a generalized conformal map, as complex analysis is useful for the conventional conformal map.

*Kuznetsova, Zhanna*

**Observational consequences of light-like deformations of the Poincaré algebra from (extended) jordanian twist.**

In the talk I discuss the observational consequences of the light-like deformations of the Poincaré algebra induced by the jordanian and the extended jordanian classes of Drinfeld twists. Twist-deformed generators belonging to a universal enveloping algebra close non-linear $W$-algebras. In some cases the $W$-algebra is responsible for the existence of bounded domains of the deformed generators. The Hopf algebra coproduct implies associative non-linear additivity of the multi-particle states. A subalgebra of twist-deformed observables is recovered whenever the twist-deformed generators are either hermitian or pseudo-hermitian with respect to a common invertible hermitian operator.

*Kycia, Radosław Antoni*

**Topological analysis of nuclear pasta phases**

Nuclear matter under extreme pressure as in the inner layers of neutron stars form exotic topological states. The states between core and inner crust were recently investigated using Monte Carlo simulations [arXiv:1606.03646 astro-ph.HE]. They were named nuclear pasta phases as their topology resembles Italian dishes. The topology plays extremely important role in these phases and it is supposed that it can be used to determine physical properties of these states like stability, which is unresolved. In the presentation mathematical analysis in terms of algebraic topology is presented. The presentation is based on [Phys. Rev. C 96, 025803 (2017)]. The homology groups for these states are calculated as well as the Euler characteristics which agrees with the numerical results of [arXiv:1606.03646 astro-ph.HE]. These topological characteristics provide deep insight into the nature of the pasta phases.

*Lattanzi, A.*

**Solutions to the free-spinless-particle (1+1)D Salpeter equation: a non-local description for relativistic bodies**

The spinless Salpeter equation is a non-local relativistic version of the Schrödinger equation. Solutions of the (1+1)D free-particle equation for assigned initial conditions are presented and compared with the corresponding well-known solutions of the (1+1)D Schrödinger equation. The asymptotic analysis of the obtained solutions gives reason for their peculiar features. Also, an analogy between the relativistic evolution and the optical free-propagation is established. The characteristics of the analyzed solutions demonstrate that the apparent problematic non-locality of the Salpeter equation does not alter the light-cone structure of Relativity in accordance with the Heisenberg principle. In order to inspect the onset of the specific behaviour of the solutions of the Salpeter equation, a new equation is introduced, the Pearcey equation, as a *trait d'union* at the $4^{th}$ order of approximation in the particle momentum between the non-relativistic and relativistic evolution. A careful study of the solutions and symmetries of the Pearcey equation highlights the emergence of the relativistic behaviour.

*Lávička, Roman*

**Separation of variables for polynomials on superspaces**

Separation of variables is well-understood e.g. for scalar-valued polynomials in $k$ variables on the $m$-dimensional Euclidean space with the underlying symmetry given by the orthogonal group $O(m)$. This is the decomposition of polynomials into classical spherical harmonics. In this talk, we focus on separation of variables for polynomials in $k$ variables on the $(m|2n)$-dimensional superspace, i.e., the superspace with $m$ bosonic and $2n$ fermionic variables. The symmetry considered is given by the Lie superalgebra $osp(m|2n)$. We review recent results on the one variable case. It is known that, in the non-exceptional cases when the superdimension $M = m - 2n$ is not even nor negative, the decomposition of polynomials is irreducible and is quite analogous as in the orthogonal case. On the other-hand, in the exceptional cases, the decomposition is not irreducible but only indecomposable. Moreover, we explain a possible approach to the several variable case. The talk is based on results obtained jointly with V. Souček and D. Šmíd.

*Lazaroiu, Calin Iuliu*

**B-type Landau-Ginzburg models on open Riemann surfaces**

I describe B-type open-closed topological Landau-Ginzburg on arbitrary open Riemann surfaces (which need not be affine algebraic and in particular may have infinite genus or an infinity of ends), giving a complete characterization of their bulk state spaces and of the category of topological D-branes.

*Lê, Hông Vân*

**Strongly homotopy Lie algebras and deformation of calibrated submanifolds**

Calibrated submanifolds play an important role in the geometry of manifolds with special holonomy, in higher dimensional gauge theory and in string theory as "super-symmetric cycles" or "branes". In this talk I shall present a new approach to deformation of closed calibrated submanifolds using the Frölicher-Nijenhuis bracket and strongly homotopy Lie algebras. Our approach encompasses the deformation theory of closed complex submanifolds as a partial case. My talk is based on arXiv:1804.05732.

*Lecian, Orchidea Maria*

**Modular structures and extended-modular-group- structures after Hecke pairs**

The cases for which modular structures rather than modular-group measures can be analyzed for non-arithmetic groups, i.e. also i the cases for which Gelfand triples (rigged spaces) have to be substituted by Hecke couples. The results hold also for (also non-abstract) groups, i.e. with measures on (manifold) boundaries (an the to-be-associated vonNeumann non-abstract algebras). The second commutator group for the generalized Hecke group is compatible with the extended modular group. Algebroid constructions are used for which the existence of an inverse map (which is an isomorphism) from the fiber in ensures the well-posedness of the action of modular structures on Lie Groups on equivalence classes of compositions of actions on Lie groups between the C*algebra and the definition of the action at least of modular structures by the existence of opportune (equivalence classes of) intertwiners for the equivalence classes of actions on fibrations.
Interpretation in particle theory physics and phenomenoly can be therefore specified also for Wigner-Bargman particles.
Further results about congruence (extended sub-)groups for non-arithmetical groups are presented; the corresponding construction of tori alternative to the free diffeomorphism group is provided.
This is done after the definition of gradings for Vinberg groups; differently, the definition does not apply for Weyl groups (or other bigger groups containing reflections, because they are locally free).

*Lei, C.*

**Selective correlations and the Desargues property**

The Desargues property, which is well known in the context of projective geometry, is presented in the context of both classical and quantum physics. In a classical context, the Desargues property implies that there exists selective correlation in the outputs of two logical circuits with the same input. In a quantum context, the Desargues property implies that there exists selective correlation in two experiments each of which involves two successive projective measurements. These selective correlations could be used in classical and quantum technologies.

*Lemay, Jean-Michel*

**Introducing the bivariate Bannai-Ito polynomials**

The univariate Bannai-Ito polynomials have arisen in the classification of P-and Q- polynomials association schemes. Their characterization has been developed recently and they have been seen to be related to the Lie superalgebra $\mathfrak{osp}(1,2)$ and to superintegrable models on the 2-sphere. Higher dimensional generalizations have inferred the existence multivariable versions of these polynomials. We shall now present a bivariate extension. An explicit expression of the Tratnik type will be offered. The consistency of the various truncations conditions will be discussed. The orthogonality relation and other properties will be given. The polynomials will be shown to correspond to specific q = -1 limits of the bivariate q-Racah polynomials of Gasper and Rahman.

*Lescot, Paul*

**Symmetries of partial differential equations and stochastic processes in mathematical physics and in finance**

In the study of the symmetries of a partial differential equation, the Lie algebra of isovectors appears in a natural way. We recall its definition, and consider some of its remarkable subalgebras.
This extends the framework of our joint work with J.-C. Zambrini and H. Quintard concerning the Hamilton-Jacobi-Bellman equation, We are also able to treat the heat equation with potential, the Black-Scholes and Frey equations of Mathematical Finance, and the heat equation for the square of the Laplacian. We then discuss stochastic processes related to these equations. Some of these results will appear in L.Valade's PhD Thesis.

*Leung, Naichung Conan*

**ADE bundles over rational surfaces**

In this talk, I will explain my joint work with Yunxia Chen and Jiajin Zhang on ADE bundles over rational surfaces and related geometric structures. This project was originally motivated from Physical duality between F-theory and Heterotic String theory.

*Levichev, Alexander*

**One Possible Application of the Chronometric Theory of I.E. Segal: A Toy Model of Quarks and Gluons**

The key feature of the model is an infinite sequence of canonical immersions of groups: $U(2)$ into $U(3)$, $U(2)$ into $U(4)$, and so on. We refer to these groups as to **levels**: $U(2)$ the $0^{th}$ level (that is, our common), $U(3)$ the $1^{st}$, $U(4)$ the $2^{nd}$ and so on. Levels relate to (quarks) **generations** whereas **flavor** and **color** are also defined purely mathematically. According to the model, each quark can be interpreted as a proton pushed to a deeper level. The model seems to be compatible with detection of point-like constituents within the proton in highly inelastic electron-proton scattering (and with elastic electron-quark scattering). To introduce gluons, we deal with tensor product (related to a proton-antiproton pair). At each level, gluon can be interpreted as a colored photon. Not each and every feature of the model coincides with the corresponding standard assumption about quarks and gluons. In particular, the total number of colors is level-dependent. The model predicts three (rather than two) quarks of the $4^{th}$ generation.

*Li, Yunnan*

**Quantum queer supergroups and Berezinians**

In this talk, we first introduce the quantum coordinate superalgebra $A_q(n)$ of type Q, derived from the quantized universal enveloping superalgebra of queer Lie superalgebra. Referring to Manin's approach to the quantum general linear supergroup, we consider the extension problem from this $A_q(n)$ to a Hopf superalgebra, so-called the quantum queer supergroup. In particular, we confirm the existence of a special grouplike element maybe central in such Hopf superalgebra, called the quantum queer Berezinian, as the queer super analogue of quantum determinant. Some questions unsolved will also be raised for further discussion.

*Lledó, María*

**Conformal superspaces, projectivity and their quantization.**

Superconformal space is a compactification of the Minkwski superspace whose complexification is a superflag manifold. It is known that not all superflags are superprojective, but for a spacetime of dimension 4 and supersymmetry N=1 it is so, and we give an explicit embedding in terms of the super versions of Plücker and Segre embeddings. This embedding, together with the property of being an homogeneous superspace is used as a basis for the quantization in terms of quantum supergroups.
In this paper we describe the state of the art of the subject and propose several paths to progess: extensions to higher supersymmetry, a different approach to quantization (as a coadjoint orbit) and a closer look to physical applications.

*Lopatkin, Viktor*

**Derivations of Leavitt path algebras**

A module of outer derivations of a Leavitt path algebra, with coefficients in an associative commutative ring with unit, is described. We shall explicitly describe a set of generators of the module and relations among them. We shall also describe a Lie algebra structure of outer derivation algebra of the Toeplitz algebra. Finally, we shall show that every derivation of a Leavitt path algebra can be extended to a derivation of the corresponding $C^*$-algebra.

*Lukierski, Jerzy*

**$N$-extended nonrelativistic SUSY with central charges and $N = 4$ Galilean superparticle models**

We consider the general $N$-extended $d = 3$ Galilean SUSY with arbitrary central charges, describing nonrelativistic counterpart of Haag-Łopuszanski-Sohnius classification of $N$-extended $D = 4$ Poincare superalgebras. For $N = 4$ case we consider in more detail the dynamical realizations, providing various$N = 4$ $d = 3$ nonrelativistic superparticle models. We analyse the (super)phase space constraints and obtain two types of superparticle models: with 1/2 BPS states (half of unbroken SUSY) or 1/4 BPS states (one quarter of unbroken SUSY).

*Manchak, J.B.*

**Is the Universe As Large As It Can Be?**

We seek to cast doubt on the requirement of spacetime inextendibility within the context of general relativity; it is not clear that our universe is "as large as it can be."

*Mangum, Chad*

**Fermionic Representations of Twisted Toroidal Lie Algebras**

Lie algebra representation theory has been significant in various areas of mathematics and physics for several decades. In this talk, we will discuss one instance of this theory, namely certain representations of twisted (2-)toroidal (Lie) algebras, which we view as universal central extensions of twisted multi-loop algebras. The usual loop algebra realization generalizes the familiar realization of affine Kac-Moody algebras. To facilitate our study of the representation theory, however, we will discuss a new realization given by generators and relations; this is similar to a realization by Moody, Rao, and Yokonuma in the untwisted case. Subsequently, we will discuss an application, namely fermionic free field representations, which are similar to those of Feingold and Frenkel in the case of affine algebras.

*Marchesiello, Antonella*

**Superintegrable 3D systems in a magnetic field and separation of variables**

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. We show that the leading structure terms of the second order integrals responsible for integrability should be considered in a more general form than for the case without magnetic field.

*Marrani, Alessio*

**On the Physics of Exceptional Periodicity**

We unravel various physical applications of the novel mathematical framework of Exceptional Periodicity, especially in relation to higher-dimensional Yang-Mills theories, supersymmetries and super-Ehlers symmetries.

*Martina, Luigi*

**Asymptotic symmetries and gravitational waves**

We illustrate the isomorphism between the conformal Carroll group and the BMS group in describing the symmetry properties of the asymptotically flat spaces in GR. Moreover, the Carroll group emerges also as isometry group of a class of plane gravitational waves, which we will consider in order to describe the so-called gravitational memory effect.

*Masáková, Zuzana*

**Linear mappings preserving mathematical quasicrystals**

An aperiodic cut-and-project scheme is a lattice $L \in \mathbb{R}^s$ together with projections $\Pi_1 : \mathbb{R}^s \to \mathbb{R}^n$, $\Pi_2 : \mathbb{R}^s \to \mathbb{R}^{s-n}$ satisfying i) $\Pi_1$ restricted to $L$ is injective; ii) $\Pi_2(L)$ is dense in $V_2$; iii) $\Pi_2$ restricted to $L$ is injective. If $\Omega$ is a bounded subset of $V_2$ with non-empty interior, then

$$\Sigma(\Omega) = \{\Pi_1(x) : x \in L \text{ and } \Pi_2(x) \in \Omega\}$$

is a model set with the acceptance window $\Omega$. Note that the assumption iii) imposed on the cut-and-project scheme guarantees that the set $\text{Per}(t) = \{t \in V_1 : t + \Sigma(\Omega) \subset \Sigma(\Omega)\}$ contains only the origin, i.e. the set $\Sigma(\Omega)$ is not periodic in any direction. For a given linear mapping $A : \mathbb{R}^n \mapsto \mathbb{R}^n$, we study the following questions:

a) existence of an aperiodic cut-and-project scheme such that $A(\Pi_1(L)) \subset \Pi_1(L)$,

b) existence of an aperiodic cut-and-project scheme and an acceptance window $\Omega$ such that the model set $\Sigma(\Omega)$ satisfies $A(\Sigma(\Omega)) \subset \Sigma(\Omega)$.

In our contribution, we characterize mappings $A$, inducing a positive answer to the question a) and b), respectively. We also determine the minimal dimension $s$ of the lattice $L$ in the corresponding cut-and-project scheme. We thus follow up the results of Baake, Lagarias, Moody, etc., where only scalings, rotations and scaled rotations were considered. Joint work with J. Mazáč and E. Pelantová.

*Mason, Geoffrey*

**Rational conformal field theories with two primary fields - the Mathur-Mukhi-Sen theorem revisited**

In 1988, Mathur, Mukhi and Sen proposed a method for classifying rational conformal field theories using the differential equation satisfied by their characters. They considered in detail the case when there are just two characters. We will revisit this theory, working in the axiomatic framework of rational vertex operator algebras (VOA). Recent advances in the theory of vector-valued modular forms permit a novel description of the two characters in terms of Gauss hypergeometric series evaluated at a hauptmodul. This leads to a complete and mathematically rigorous solution of the MMS problem as follows: assume that $V$ is a rational VOA with exactly two irreducible modules, and that the module characters furnish a 2-dimensional irreducible representation of the modular group. Then $V$ is either the Lee-Yang model (Virasoro VOA of central charge $-22/5$) or one of seven affine algebras of level 1, of types $A_1, A_2, G_2, F_4, D_4, E_6, E_7$. In this talk I will outline the main steps in the proof of this result, emphasizing the rôle of hypergeometric series in the solution.

*Megías, Eugenio*

**Non-Abelian Anomalies of Hadronic Fluids in Thermal Equilibrium**

We study the role of non-Abelian anomalies in hydrodynamics. To this end, we compute the local functional that solves the anomaly equations, and obtain the Bardeen-Zumino terms that covariantize the currents. To study the effects of the anomaly when the symmetry is spontaneously broken, we determine the Wess-Zumino-Witten action at the lowest and first order in derivatives. We particularize these results to a background with an electromagnetic field and chiral imbalance for two flavors. We use this to study some features of the non-dissipative constitutive relations, and present explicit results for the corresponding anomalous transport coefficients. In particular, we discuss the chiral electric effect.

*R. Méndez-Fragoso*

**Analytical solutions of the Gross-Pitaevskii equation for ultra-cold matter wave packet confined by waveguide impurities**

A Bose-Einstein condensate (BEC) can move on waveguides generated by atom chips and serves as a test bed for ultra-cold matter studies. A good model for this system is to consider the non-linear Schrödinger equation with an attractive square well potential with finite height that represents the impurity. In particular, we are interested in contact impurities within the main impurity that we model by delta potentials. In previous works, we have obtained analytical solutions for the attractive square well potential with a delta potential at the origin, as a model for an impurity. In this contribution, these solutions are used to obtain the energy spectrum when there are several impurities inside the square well. The energy of the ground state is analyzed until reaching the de-localization threshold, as well as its coexistence with excited states and as a function of the positions of the contact impurities. This analysis makes possible to systematically find the properties of this type of system and to characterize its reflection and transmission properties as a function of the distribution of the impurities.

*Miller, Willard Jr.*

**Toward classification of semidegenerate 3D superintegrable systems**

Superintegrable systems of 2nd order in 3 dimensions with exactly 3-parameter potentials are intriguing objects. Next to the nondegenerate 4-parameter potential systems they admit the maximum number of symmetry operators, but their symmetry algebras don't close under commutation and not enough is known about their structure to give a complete classification. Examples are known for which the 3-parameter system can be extended to a 4th order superintegrable system with a 4-parameter potential and 6 linearly independent symmetry generators. We use Bôcher contractions of the conformal Lie algebra $so(5,\mathbb{C})$ to itself to generate a large family of 3-parameter systems with 4th order extensions, on a variety of manifolds, all from Bôcher contractions of a single "generic" system on the 3-sphere. We give a contraction scheme relating these systems. The results have myriad applications for finding explicit solutions for both quantum and classical systems.

*Milson, Robert*

**Superintegrability and Exceptional Operators**

An exceptional operator is a second-order operator that admits polynomial eigenfunctions for all but a finite number of "exceptional" degrees. There have been a number of recent examples of higher-order superintegrable systems related to exceptional operators. It may be reasonably expected that there exists a procedure for extending an arbitrary exceptional operator to a superintegrable operator of higher order. As a consequence, the classification problem for exceptional operators may be expected to play an important role in the theory of superintegrable systems. In this talk we will review the status of the classification problem and hilite the unresolved questions that stand in the way of a full classification.

*Mitrović ,Melanija*

**Constructive Semigroups with Apartness: (Development of) a New Algebraic Theory**

The theory of constructive semigroups with apartness is a *new approach* to semigroup theory, and not a new class of semigroups. Of course, our work is partly inspired by classical semigroup theory, but, on the other hand, it is distinguished from it by two significiant aspects: first, we use *intuitionistic logic* rather than classical, secondly, our work is based on the notion of *apartness* (between elements, elements and sets). Here, the focus is on E. Bishop's approach to constructive mathematics (**BISH**). Applications of the classical theory of semigroups in Physics, Engineering and Theoretical Computer Science are well established and known. The main purpose of this presentation is to make some sort of understanding of constructive semigroup theory in Bishop's style position for those (classical) algebraists as well as for the ones from others scientific areas who apply algebraic knowledge.

*Moroz, Alexander*

**A general constraint polynomial approach**

Inspired by the Kus constraint polynomials in the quantum Rabi model, a general constraint polynomial approach has been recently developed. It (i) reproduced known constraint polynomials for the usual and driven Rabi models and (ii) immediately generated hitherto unknown constraint polynomials for the two-mode, two-photon, and generalized Rabi models, implying that the eigenvalues of corresponding polynomial eigenfunctions can be determined algebraically. The constraint polynomial approach is shown to replace a set of algebraic equations of the functional Bethe Ansatz method by a single polynomial constraint. The usefulness of the method is demonstrated for a number of quasi-exactly solvable potentials of the Schrödinger equation, such as two different sets of modified Manning potentials with three parameters, an electron in Coulomb and magnetic fields and relative motion of two electrons in an external oscillator potential, a perturbed double sinh-Gordon system, and the hyperbolic Razavy potential. The role of parity is emphasized. A pair of complex conjugate roots $V_3$ in the modified Manning potentials with three parameters are shown to provide a non-hermitian example with real energies.

*Mostafazadeh, Ali*

**Dynamical formulation of time-independent scattering and new exactly solvable scattering potentials in two-dimensions**

The discovery of new exactly solvable scattering potentials is a rare event in the history of quantum physics. In this talk we report such a discovery. Specifically, we introduce a class of scattering potentials in two dimensions and use a recently developed dynamical formulation of time-independent scattering theory to obtain an exact and closed-form expression for their scattering amplitude. This class consists of complex potentials supported in an infinite strip in the x-y plane with a specific periodic y-dependence and an essentially arbitrary x-dependence. They model certain active optical slab systems with potential applications in generating quantum states with entangled momentum along one direction and quantized momentum along the other. Our results also suggest means for devising directional and multimode lasers.

*Motegi, Kohei*

**Izergin-Korepin approach to symmetric functions**

Izergin-Korepin analysis is originally a method to characterize the properties of the domain wall boundary partition functions (DWBPF) of the six-vertex model, initiated by Korepin, and Izergin later found the Izergin-Korepin determinant of the DWBPF based on its characterization. Recently, we found a natural way to extend the Izergin-Korepin analysis from the DWBPF to the wavefunctions. In this way, one can compute the explicit forms of the wavefunctions under various boundary conditions and various six-vertex type integrable models, and various symmetric functions such as the elliptic Schur functions appear as their explicit forms. These integrable model representations of symmetric functions open doors to derive new algebraic identities for symmetric functions. We illustrate the Izergin-Korepin analysis on the wavefunctions and applications to algebraic identities of symmetric functions by several models and boundary conditions.

*Motlochová, Lenka*

**Dual Root-Lattice Discretization of Weyl-Orbit Functions**

The discrete properties of Weyl-orbit functions are crucial in processing of multidimensional digital data and related Fourier methods. The Weyl-orbit functions sampled on finite fragments of the dual weight lattice are recently studied in several papers and the results are used in deriving numerical integration formulas, interpolation methods and others. Among the Weyl group invariant lattices, the second most prominent lattice is the dual root lattice. In this talk, the explicit formulas of the discrete orthogonality relations of the Weyl-orbit functions sampled on fragments of the scaled dual root lattice are presented. Examples of the corresponding discrete transforms are shown. Possible applications to other related methods and applications of this discretization are discussed.

*Moylan, Patrick*

**(Heisenberg-)Weyl Algebras and Representations of Poincaré Groups**

In a recent work we described a novel construction of the unitary representations of Poincaré groups based on Lie fields techniques. In particular, we gave explicit description of unitary irreducible representations of the Poincaré groups in 2, 3 and 4 space-time dimensions as unitary operators on the representation spaces of the Schrödinger representation of the (Heisenberg-)Weyl algebra of index $r =$ 1, 2, and 3 , respectively. Here we describe the equivalence of our representations with those obtained from standard approach based on the Wigner-Mackey construction of the unitary representations of the Poincaré groups.

*Muraki, Hisayoshi*

**Open KdV hierarchy and minimal gravity on disk**

We show that the minimal gravity of Lee-Yang series on disk is a solution to the open KdV hierarchy proposed for the intersection theory on the moduli space of Riemann surfaces with boundary.

*Murase, Atsushi*

**Modular curves and symmetries of Hecke type**

We give a characterization of modular curves and modular polynomials by a single symmetry of Hecke type. In the proof, we use the theorem of André, which characterizes modular curves in terms of special points.

*Musonda, John*

**Reordering in a multi-parametric family of algebras**

The main object of this talk is the multi-parametric family of algebras generated by $Q$ and the set $\{S_j\}_{j\in J}$ satisfying commutation relations of the form $S_jQ = \sigma_j(Q)S_j$, where $\sigma_j$ is some function for which the expression $\sigma_j(Q)$ makes sense. However, through a linear transformation of the $S_j$-generators, we introduce and consider another equivalent multi-parametric family of algebras. We derive general reordering formulas for these algebras and apply the results to the description of commutative subalgebras. We give operator representations for particular cases of $\sigma_j$, and in particular, we show that some multi-parameter deformed symmetric difference and multiplication operators satisfy defining relations of the corresponding algebras. Finally we consider the algebras also in the context of $(\sigma, \tau)$-derivations and Ore extensions.

*Nazmitdinov, Rashid*

**Cyclic symmetry and self-organization of charged particles in circular geometry**

The basic principles of self-organization of one-component charged particles, confined in disk and circular parabolic potentials, are proposed. A system of equations is derived, that allows to determine equilibrium configurations for arbitrary, but finite, number of charged particles that are distributed over several rings. The main idea is based on the cyclic symmetry and periodicity of the Coulomb interaction between particles located on several rings. Our approach reduces significantly the computational effort in minimizing the energy of equilibrium configurations and demonstrates a remarkable agreement with the values provided by molecular dynamics calculations. With the increase of particle number $n \geq 180$ we find a steady formation of a centered hexagonal lattice that smoothly transforms to valence circular rings in the ground state configurations for both potentials.

*Negro, Javier*

**Spectrum of carbon nanotubes under transverse magnetic fields**

The aim of this work is to study the energy spectrum of electronic states in a nanotube under a transverse magnetic field. The massless Dirac-Weyl equation plus additional boundary conditions has been used to describe the low energy states of this system. In order to get a simple model, the particular case of a singular magnetic field approximated by Dirac delta distributions has been considered. It is shown that there is a degeneracy corresponding to periodic solutions with a null axial momentum $k_z = 0$. Besides, there may be present a kind of sporadic degeneracy for non-vanishing values of $k_z$, which are explicitly computed in the present example. The proof of these properties is obtained by means of the supersymmetric structure of the Dirac-Weyl Hamiltonian.

*Nekouee, Zohreh*

**The comparing $FRW$ and Gödel background with Finsler and Riemannian geometries**

In this paper, we employ two geometries as Riemannian and Finsler geometry. In that case, we take two metrics background as $FRW$ and Gödel metrics. They play important role in explanation of several phenomena in cosmology. And then, we calculate the Killing vectors of correspondence two metrics by using two geometries. Also, we obtain the generators of algebra and compare two geometries from Killing vector point of view. Finally, we achieve the commutation relations of such geometries from two metrics background.

*Nemkov, Nikita*

**On some generic properties of non-degenerate Virasoro conformal blocks**

Conformal blocks in 2D CFTs are best studied in cases of degenerate, i.e. finite-dimensional representations of the Virasoro algebra or in certain limits, e.g. of light/heavy operators or large central charge. We will instead focus on the non-perturbative properties of generic representations. The main theme will be the modular transformations but we will also comment on interesting exact solutions which do not originate with BPZ-equations.

*Nishiyama, Kyo*

**Fourier transform of the Riesz distribution on enhanced symmetric cone**

We define an enhanced space of symmetric matrices and a natural action of the general linear group on it. There are only finitely many orbits, and hence, it becomes a prehomogeneous space (over $\mathbb{R}$ or $\mathbb{C}$). We classify all the orbits and determine b-functions. We also calculate conormal bundles of orbits and holonomy diagrams explicitly in low rank cases. For classical symmetric cone, there are lots of works on the associated gamma functions (Gindikin gamma functions) and the theory of analytic continuation of the Riesz distributions and so on with applications to infinite dimensional unitary representations in mind. We begin the study in this direction for the enhanced symmetric cone, and in particular, we prove the formula for analytic continuation of the Riesz distribution and get a formula of its Fourier transform. The enhaced Riesz distribution is intimately related to meromorphic family of intertwiners between degenerate principal series of $Sp_{2n}(\mathbb{R})$ and $GL_n(\mathbb{R})$ induced from maximal parabolic subgrouops. We also discuss their analytic continuations and Fourier transforms.

*Nisticò, Giuseppe*

**Single particle relativistic quantum theories settled by symmetry, via group theoretical methods**

Some problematic aspects of the known quantum theories of a single relativistic particle yet wait for a theoretical clarification. In 1958 Felshbach and Villars [Rev.Mod.Phys., 30(1958)24] wrote: "[...] in discussion with many of our colleagues we have found that there is considerable confusion about some aspects of relativistic wave mechanics". Since that time several works have been carried out that improved the understanding of these theories, without, however, fully attaining the solution of the problematic matter. For instance, Newton and Wigner [Rev.Mod.Phys. 21(1949) 400] find out that the unique position operator that can describe a meaningful notion of position for a spin 0 particle is the operator known as *Newton and Wigner* operator; but Barut and Bracken in [Phys.Rev. D23(1981)2454] show that such an operator makes inconsistent their own theory. On the other hand, Jordan and Mukunda [Phys.Rev. 132(1963)1842] checked the consistency of position operators with symmetry principles and particular covariance properties that they stipulate should hold, and find that the Newton and Wigner operator is satisfactory for spin 0 particle, but it cannot be maintained for higher spin particles. The situation is quite different for the case of a non-relativistic particle, whose quantum theory can be obtained [Proc.R.Soc.A 20160629(2017)] through a purely deductive development based on physical principles, that effectively exploits powerful group theoretical methods. e.g. of Wigner theory and Mackey imprimitivity theory. This method has the advantage of making completely transparent how the formalism, with its interpretation, is implied by the basic physical principles, so that the theoretical predictions are directly explained and interpreted, without the need of introducing concepts that are not deducible. In the present work we pursue the group theoretical method for the relativistic particle case to implement physical principles. In doing so we obtain a clarification of several problematic aspects, like those above indicated, that affect the current theories.

*Novák, Jan*

**Group theory in causal set approach to quantum gravity and one mathematical problem**

We present basic postulates of causal set approach to quantum gravity. We study symmetry preservation, extension breaking and generation in this theory. We show the emergence of cosmological constant, which is in concordance with observations. We formulate one mathematical problem from combinatorical topology at the end and we discuss the possible usage to quantum gravity problematics.

*Novotný , Petr*

**On $(\alpha, \beta, \gamma)$–derivations of Jordan algebras**

The definition of derivations of Jordan algebras is generalized by considering complex multiples of original terms. Dimensions of obtained spaces of linear operators are new invariant characteristics of Jordan algebras. These invariant characteristics form a complete set of invariants for indecomposable Jordan algebras up to dimension four. Values of these invariants for all semisimple Jordan algebras are obtained.

*Olive, Marc*

**Effective computation of SO(3) and O(3) linear representations symmetry classes**

We propose a general algorithm to compute all the symmetry classes of any SO(3) or O(3) linear representation. This method relies on the introduction of a binary operator between sets of conjugacy classes of closed subgroups, called the *clips*. We compute explicit tables for this operation which allows to solve definitively the problem.

*Ongonga, Elvice Omondi*

**Classification of low-dimensional hom-Lie algebras**

For any n-dimensional hom-Lie algebra, a system of polynomial equations is obtained from the hom-Jacobi identity, having structure constants of both the skew-symmetric bilinear map and twisting linear endomorphism. These equations are expressed as linear system in structure constants of the twisting linear endomorphism and thus represented as linear maps. We give a description of realization of three-dimensional and four-dimensional hom-Lie algebras, for kernel solutions of the minimum dimension. We further give some examples of four- dimensional Hom-Lie algebras constructed from a general nilpotent linear endomorphism.

*Ostapenko, Vadim*

**Quantization of semisimple conjugacy classes in the exceptional group $G_2$**

We construct an equivariant quantization of semisimple conjugacy classes of the exceptional group $G_2$. We realize the quantized polynomial algebra on a class by linear operators on some $U_q(\mathfrak{g}_2)$-module. Namely, with every point $t$ of a fixed maximal torus we associate a highest weight module $M_t$ over $U_q(\mathfrak{g}_2)$, and represent the quantized polynomial algebra of the class of $t$ by linear operators on $M_t$. Quantizations corresponding to different points of the same orbit of the Weyl group are isomorphic. Thus we get in this way several isomorphic representations for each semisimple conjugacy class.

*Palmkvist, Jakob*

**Generators and relations for (generalized) Cartan superalgebras**

In Kac's classification of finite-dimensional Lie superalgebras, the contragredient ones can be constructed from Dynkin diagrams similar to those of the simple finite-dimensional Lie algebras, but with additional types of nodes. For example, $A(0,n-1) = \mathfrak{sl}(1|n)$ can be constructed by adding a "gray" node to the Dynkin diagram of $A_{n-1} = \mathfrak{sl}(n)$, corresponding to an odd null root. The Cartan superalgebras constitute a different class, where the simplest example is $W(n)$, the derivation algebra of the Grassmann algebra on n generators. I will in my talk present a novel construction of $W(n)$, from the same Dynkin diagram as $A(0,n-1)$, but with additional generators and relations. I will then generalize this result to the exceptional Lie algebras $E_n$, which can be extended to infinite-dimensional Borcherds superalgebras, in the same way as $A_{n-1}$ can be extended to $A(0,n-1)$. In this case, the construction leads to so called tensor hierarchy algebras, which provide an underlying algebraic structure of gauged maximal supergravity and exceptional field theory.

*Paoletti, Roberto*

**Equivariant Asymptotics of Szegö kernels under Hamiltonian $U(2)$ and $SU(2)$ actions**

Let $M$ be complex projective manifold, and $A$ a positive line bundle on it. Assume that $U(2)$ acts on $M$ in a Hamiltonian manner, and that this action linearizes to $A$. Then there is an associated unitary representation of $U(2)$ on the associated algebro-geometric Hardy space. If the moment map is nowhere vanishing, the isotypical component are all finite dimensional; they are generally not spaces of sections of some power of $A$. We study the local and global asymptotic properties the isotypical component associated to a weight $k\,\boldsymbol{\nu}$, when $k \to +\infty$. A similar analysis is carried out in the case of $SU(2)$.

*Parlakgörür, Tuğçe*

**Apollonius Representation and Geometry of Entangled Qubit States**

The Apollonius representation for qubit states, determined by symmetric qubit states with respect to generalized circles in complex plane is proposed. The Shannon entropy, concurrence, Cayley hyperdeterminant and fidelity between symmetric states in Apollonius representation are constant along Apollonius circles. These circles become integral curves for entanglement characteristics as distances, areas, volumes and inner product metrics. Hydrodynamic and geometric interpretation of concurrence in terms of stream function and conformal metric is developed. This work is supported by TUBITAK Grant 116F206.

*Pashaev K., Oktay*

**Quantum Group Symmetry for Kaleidoscope of Hydrodynamic Images and Quantum States**

The hydrodynamic flow in several bounded domains is formulated by the image theorems, like the two circle theorem, the wedge and the strip theorems. This allows one to construct this flow as the $q$-periodic extension of the one, given in the whole plane. Depending on geometry of the domain, parameter $q$ has different geometrical meanings and values. In the special case of the wedge domain, with $q$ as a primitive root of unity, the set of images appears as a regular polygon kaleidoscope. By interpreting complex potential of the flow as the wave function in the Fock-Barman representation, we find mod $n$ projection operators in the space of quantum coherent states, related with operator $q$-numbers. They determine the kaleidoscope of quantum states with quantum group symmetry of q-oscillators.

*Pati, Kishor Chandra*

**Splints of root systems of Basic Lie superalgebras**

Splints of root systems of simple Lie algebras appear naturally on the studies of embedding of reductive subalgebras. A splint can be used to construct branching rules, as implementation of this idea simplifies calculation of branching coefficients. We extend the concept of splints to basic Lie superalgebras case as these algebras have wide applications in physics. In this context we have determined the splints of root system of all basic Lie superalgebras and hope to contribute towards a small step in the direction of representation of these algebras.

*Pato, Mauricio Porto*

**Pseudo-Hermitian Wigner matrices**

By the end of the last century, it has been found that the invariance of a non-Hermitian Hamiltonian under the combined Parity and Time Reversal transformation ($PT$ symmetry) makes its eigenvalues to be real or complex conjugate. This triggered the interest of finding in the context of Random Matrix Theory (RMT) ensembles with similar properties. In my talk, I will show that the RMT Hermitian Wigner matrices can be made non-Hermitian in such a way that the statistical independence and the Gaussian distribution of their matrix elements are preserved and, as desired, eigenvalues become real or complex conjugate. This is done by imposing to the matrices the condition that they are connected to their adjoint by a similarity transformation $A^\dagger = \eta A \eta^{-1}$, where $\eta$ is a fixed Hermitian matrix. In general terms, this condition defines the so-called pseudo-Hermitian class of operators. Statistical properties of the ensemble thus constructed will be presented for the orthogonal, the unitary and the symplectic class of random matrices.

*Pedrak, Aleksandra*

**Quanym algebraic motion and partner groups**

The space of classical motions is understood as a set of points which build up the configuration space. The physical system can change position along a trajectory. This kind of motions are generated by a transformation group and some evolution operator, which are characteristic to this physical system. The generalization of this idea is a construction of a quantum motion. It is based on construction of Hilbert space of quantum states on a group of motion of this quantum system. This is especially very useful in more abstract spaces which are used for example in atomic, nuclear models. During the seminar the construction of the quantum motion algebra on partner groups (the group itself and the corresponding intrinsic group) will be introduced. The physical meaning of this construction will be explained, the analysis of properties of this construction with respect to the relation between generating group and symmetry group of a physical system will be introduced, the example of this construction in case of compact Lie group will be shown.

*Pevzner, Michael*

**Symmetry breaking operators for anti-de Sitter spaces**

It may happen that the intertwining operators appearing in branching laws of infinite-dimensional representations of reductive Lie groups are realized by differential operators. An example of this phenomenon is given by the celebrated Rankin-Cohen brackets. We will explain the algebraic and geometric nature of these operators and present a general method for their effective construction. As an application we consider the problem of constructing and classifying all linear differential operators $\mathcal{E}^i(X) \to \mathcal{E}^j(Y)$ between the spaces of differential forms on a pseudo-Riemannian manifold $X$ and those on its totally geodesic hypersurface $Y$, that intertwine multiplier representations of the Lie algebra of conformal vector fields. Extending the recent results in the Riemannian setting obtained in a joint work with T. Kobayashi and T. Kubo we give a complete classification of such symmetry breaking operators in the case where both $X$ and $Y$ are of constant sectional curvature, illustrated by the examples of anti-de Sitter spaces and hyperbolic spaces.

*Piątek, Marcin*

**Classical elliptic conformal blocks and elliptic solitons**

We will discuss some implications of the correspondence between the classical limit of the simplest BPZ equation for the five-point function and the $BC_1$ Inozemtsev integrable model. The latter is nothing but the Schrödinger spectral problem for a class of finite–gap Treibich–Verdier (TV) potentials built out of the Weierstrass elliptic $\wp$–function. We will describe consequences of the aforementioned identification for the theory of elliptic solitons, i.e., the solutions of the Korteweg–de Vries equation given by the above-mentioned TV potentials. Other implications, in particular for the study of modular properties of $\mathcal{N} = 2$ gauge theories and the correspondence between sphere and torus correlation functions in Liouville theory will be also discussed if time permitting.

*Pietrykowski, Artur R.*

**Scalar field dynamics in Kerr-AdS and classical conformal blocks.**

It is known that the Klein-Gordon equation in the Kerr AdS5 background can be reduced to the two (angular and radial) Heun equations by a separation of variables. On the other hand, the Heun equation with the accessory parameter determined by the 4-point classical conformal block on the sphere, and a pair of the Floquet type linearly independent solutions one can get from the classical limit of the second order BPZ equation for the simplest two 5-point degenerate spherical conformal blocks. Therefore, one may consider an idea of the formal correspondence between the dynamics of a scalar field in Kerr AdS5 and the two-dimensional CFT. We disscuss the conjectured correspondence and its possible applications to the computation of the quasinormal modes of the Kerr black hole in the 5-dimensional AdS spacetime.

*Planat, Michel*

**Congruence links of Bianchi groups for quantum computing**

Previous work of the author emphasized the interest of using congruence subgroups of the modular group $\Gamma = PSL(2, \mathbb{Z})$ for defining appropriate fiducial states useful both for $d$-dimensional universal quantum computing and informationally complete quantum measurements (IC-POVMs) [arxiv 1709.06768]. The relationship to topological quantum computing through 3-manifolds was explored [arxiv 1802.04196] but the related trefoil knot 3-manifold is non hyperbolic . A natural generalization of $\Gamma$ consists of the fundamental group of a principal congruence subgroup in a Bianchi orbifold $\mathbb{H}^3/PSL(2, O_d)$, where $O_d$ denotes the integer ring $\mathbb{Q}(\sqrt{-d})$. I focus on the congruence subgroup $\Gamma_d(I)$ with $d = 3$ and ideal $I = (5 + \sqrt{-3})/2$ which is the fundamental group of Thurston's link complement $T$ (whose 2-skeleton is the Klein's quartic, see e.g. 1802.01275 and references therein). Under $(1, 1)$-slope Dehn fillings, the 336 symmetries of $T$ manifest themselves as many other links (and principal congruence subgroups or not) that serve in the construction of the aforementioned IC-POVMs.

*Pogosyan, George*

**Elliptic basis for the Zernike system**

The differential equation that defines the Zernike system, originally proposed to classify wavefront aberrations of the wavefields in the disk of a circular pupil, had been shown to separate in three distinct coordinate systems obtained from polar coordinates on a half-sphere. Here we find and examine the separation in the generic elliptic coordinate system on the half-sphere and its projected disk, where the solutions, separated in Jacobi coordinates, contain Heun polynomials.

*Poletaeva, Elena*

**On representations of finite $W$-algebras**

A finite $W$-algebra is a certain associative algebra attached to a pair $(\mathfrak{g}, e)$, where $\mathfrak{g}$ is a complex semisimple Lie algebra and $e \in \mathfrak{g}$ is a nilpotent element. J. Brown, J. Brundan and S. Goodwin described the finite $W$-algebra $W_{m|n}$ attached to the principal (regular) nilpotent orbit in $\mathfrak{gl}(m|n)$ and classified simple $W_{m|n}$-modules.
We study representations of the finite $W$-algebra for the Lie superalgebra $Q(n)$ associated with the regular even nilpotent coadjoint orbit and obtain a classification of simple $W$-modules.

*Polizzi, Francesco*

**Representations of braid groups and construction of projective surfaces**

Braid groups are an important and flexible tool used in several areas of science, such as Knot Theory (Alexander's theorem), Mathematical Physics (Yang-Baxter's equation) and Algebraic Geometry (monodromy invariants). In this talk we will focus on their algebraic-geometric aspects, explaining how the representation theory of higher genus braid groups can be used to produce new interesting examples of projective surfaces defined over the field of complex numbers.

*Post, Sarah*

**Rank-2 Racah and Askey-Wilson Algebras**

In this talk, we will discuss rank-2 extensions of the Racah and Askey-Wilson algebras. The rank-2 extension of the Racah algebra arises from the symmetry algebra associated with the generic superintegrable system on the 3-sphere. We will discuss inter-basis expansions coefficient and their connection with 9j-symbols and bivariate Racah polynomials. A q-algebra extension, the Askey-Wilson algebra in the rank-2 case will be presented and the algebraic structure discussed in detail.

*Povolotsky, Alexander*

**Large deviations of avalanches in the Raise and Peel model**

The Raise and Peel model is the model of fluctuating interface. Its height grows by random deposition of tiles onto the substrate and decreases by avalanche-like evaporation of tiles. In the talk we describe the large deviation functions for two quantities characterizing the avalanche dynamics in the Raise and Peel model: the number of tiles removed by avalanches and the number of global avalanches extending through the whole system. To this end, we exploit their connection to the groundstate eigenvalue of the XXZ model with twisted boundary conditions. We evaluated the cumulants of the two quantities asymptotically in the limit of the large system size. The first cumulants, the means, confirm the exact formulas conjectured from analysis of finite systems. We discuss the phase transition from critical to non-critical behaviour in the rate function of the global avalanches conditioned to an atypical values of the number of tiles removed by avalanches per unit time.

*Puttarprom, Chisanupong*

**Ruijsenaars-Schneider system and its hierarchy**

We know that the Ruijsenaars-Schneider system is a 1-parameter extended class of the Calogero-Moser system. Then in the present work, we expand the Lax matrices and equations of motion, both discrete-time and continuous-time, with respect to the parameter. What we have is a new hierarchy of the integrable 1-dimensional $N$-body systems. These systems possess the Lagrangian structure which are satisfied a novel variational principal for Lagrangian 1-form structure.

*Quesne, Christiane*

**Generation of position-dependent mass Schrödinger equations with two known eigenstates in a deformed supersymmetric framework**

A method is devised to construct infinite families of quasi-exactly solvable position-dependent mass Schrödinger equations with known ground and first excited states in a deformed supersymmetric (DSUSY) framewok. It is shown that, for a given position-dependent mass, the first two superpotentials of a DSUSY hierarchy can be built from some generating function $W_+(x)$ and its accompanying function $W_-(x)$. To guess some function $W_+(x)$ valid for an infinite family of potentials, we consider for the latter a family of extensions of some exactly solvable deformed shape invariant (DSI) potential. We then show that the first two members of such an extension family may also be endowed with a DSI property, provided some constraint conditions relating the potential parameters are satisfied, in other words they may be conditionally deformed shape invariant (CDSI). The compatibility conditions between the two sets of constraint conditions, corresponding to the first two steps of the hierarchy, then lead to potentials with known ground and first excited states. From the associated functions $W_+(x)$ and $W_-(x)$, the form of such functions valid for any member of the family is inferred, which enables us to solve the problem in full generality. The method is illustrated by an example.

*Ragnisco, Orlando*

### Novel results on superintegrable systems

My talk will consist of two disjoint sections. In section 1 I will describe a model of quasi-maximally superintegrable ND Hamiltonian, both classical and quantum, which exhibits possibly interesting confining properties, resembling those associated with the singular Taub-NUT model. In section 2 a special case of the classical Perlick System of type II will be illustrated.

*Ramazashvili, Revaz*

### Hidden symmetry, Kramers degeneracy in a magnetic field, and Zeeman spin-orbit coupling in antiferromagnetic conductors

I will briefly review the Zeeman spin-orbit coupling, arising in a commensurate Néel antiferromagnet in magnetic field, applied transversely to the staggered magnetization. The field tends to lift the degeneracy of the electron spectrum. However, a hidden symmetry protects double degeneracy of Bloch eigenstates at special momenta in the Brillouin zone. The effective $g$-factor vanishes at such points, and thus acquires a substantial momentum dependence, which turns a textbook Zeeman term into a spin-orbit coupling. After describing the symmetry underpinnings of the Zeeman spin-orbit coupling, I will compare it to its intrinsic counterparts such as Rashba coupling, then show how Zeeman spin-orbit coupling may survive in the presence of intrinsic spin-orbit coupling, and then will outline some of the experimental and diagnostic opportunities it may provide.

*Rasin, Alexander*

### Bäcklund Transformations and Infinitesimal Symmetries

The Gardner method, traditionally used to generate conservation laws of integrable equations, is generalized to generate symmetries. The method is demonstrated for the KdV, Camassa-Holm, Boussinesq and Sine-Gordon equations. The method involves identifying a generating symmetry which depends upon a parameter; expansion of this symmetry in a (formal) power series in the parameter then gives the usual infinite hierarchy of symmetries. For some cases it is possible to get two hierarchies of symmetries. We show that the obtained symmetries commute, discuss the connection between the symmetries of continuous integrable equations and their discrete analogs.

*Rastelli, Giovanni*

### Twisted products of Hamiltonians: from complete separation to block-separation

Classical Stäckel systems, related to complete separation of Hamilton -Jacobi equation, can be understood as the decomposition of a n-dimensional natural Hamiltonian H into n one-dimensional Hamiltonians, given by the separated equations. The n-dimensional dynamics can be reconstructed from the one-dimensional ones up to time-reparametrizations. The characterization of the complete separation is coordinate-free and determined by n quadratic in the momenta first-integrals in involution. The existence of less than n quadratic first-integrals in involution can determine a partial separation (block-separation) of the system, with similar relations between the global and the separated dynamics. All these types of separation arise from a particular twisted-product structure of H. We review the classical results about complete separation and introduce new results and characterization of block-separation.

*Rapčák, Miroslav*

**Representation Theory of Vertex Operator Algebras and Gukov-Witten Defects**

A large class of vertex operator algebras can be engineered from junctions of interfaces in maximally supersymmetric Yang-Mills theory in four dimensions. This viewpoint provides an intuitive way to study vertex operator algebras. Moreover, this perspective establishes a connection to many physical and mathematical problems. I will describe the role of Gukov-Witten defects in four dimensions as vertex operator algebra modules. I will determine the Zhu algebra of a class of (finitely but generically non-freely generated) W-algebras $Y_{L,M,N}$ and use them to construct Zhu algebras of more complicated ones. Techniques discussed in this talk play an important role in various generalizations of the AGT correspondence and ramification of the geometric Langlands program.

*Rauch, Stefan*

**Number of integrals required for integrability**

For a general autonomous dynamical system of n equations each integral of motion reduces the order by one. Then all together n-1 functionaly independent integrals are sufficient for integrability by quadratures unless the system has some additional structure. For instance a Hamiltonian system of 2n equations becomes completely integrable when independent and commuting integrals are known.
It may seem surprising that there are non-trivial integrable dynamical systems that become integrable when any given, prescribed number of integrals with m between 1 and n-1 is known.
For separable potential systems and for cofactor-pair Newton systems a knowledge of 2 quadratic w.r.t. velocities and functionally independent integrals of motion which depend on all dynamical variables, implies existence of n integrals of motion and also the hamiltonian integrability.
For triangular systems of n Newtons equations, it appears that knowledge of only 1 essential (depending on all dynamical variables), quadratic w.r.t. velocities integral of motion implies existence of further n-1 integrals and makes possible sequential separability of equations of motion.
I shall discuss relationship between the structure of equations of motion, the number of integrals and integrability for several types of dynamical equations.

*Rausch de Traubenberg, Michel*

**Dihedral Invariant Polynomials in the effective Lagrangian of QED (I)**

We present a new group-theoretical techique to calculate weak field expansions in some Feynman diagrams using invariant polynomials of the dihedral group. In particular we show results obtained for the first coefficients of the three loop effective lagrangian of 1+1 QED in an external constant field, where the dihedral symmetry appears. Our results suggest that a closed form involving rational numbers and the Riemann zeta function might exist for a finite external field.

*Rebocho, Maria das Neves*

**On symmetric semi-classical orthogonal polynomials and some of their extensions**

This talk concerns semi-classical orthogonal polynomials on the real line (the ones related to weights, $w$, satisfying $w'/w =$ rational function) and some of their standard modifications. We will focus on the so-called direct problem for Laguerre-Hahn orthogonal polynomials, that is, we take the sequences of orthogonal polynomials whose Stieltjes function, $S$, satisfies a Riccati type differential equation with polynomial coefficients, $AS' = BS^2 + CS + D, \ \ A \neq 0$, and we seek formulae for the three-term recurrence relation coefficients of the orthogonal polynomials, given $A, B, C, D$. The symmetric case under the restriction $\max\{\deg(C) - 1, \max\{\deg(A), \deg(B)\} - 2\} = 2$ will be described in detail: we deduce non-linear difference equations for the recurrence relation coefficients, some of them identified as discrete Painlevé equations.

*Reuvers, Robin*

**Lower bound on entanglement in subspaces defined by Young diagrams**

Eigenvalues of 1-particle reduced density matrices of $N$-fermion states are upper bounded by $1/N$, resulting in a lower bound on entanglement entropy. In this talk, I discuss the optimal eigenvalue bound for all other subspaces defined by Young diagrams in the Schur–Weyl decomposition of $\otimes^N \mathbb{C}^d$. I also mention the numerical algorithm that facilitated the search for a proof.

*Ricotta, Regina Maria*

**Semi-analytical results of the DNA thermal denaturation in Peyrard-Bishop-Dauxois model**

The thermal denaturation of the DNA is analyzed analytically through the Peyrard-Bishop-Dauxois (PBD) model of DNA with a new mathematical methodology. In this model a non-harmonic interaction is used to simulate the stacking interaction. The methodology employed is based on the variational method adapted to determine the ground state energy of a Schrödinger-like equation with position-dependent mass. In this work this approach is extended to determine the melting temperature for DNA by solving a Schrödinger-like equation.

*Rios, Michael*

**Higher Yang-Mills from Exceptional Periodicity**

Building on an observation that relates certain gradings of the exceptional Lie algebras to Yang-Mills theories up to 14-dimensions, the novel mathematical framework of exceptional periodicity is used to investigate higher Yang-Mills theories beyond D=14, to arbitrary dimension. A dual description, extending the relationship between cubic Jordan algebras over normed division algebras and the exceptional Lie algebras, is also invoked to investigate extremal black hole charge spaces valued in a class of Vinberg's T-algebras. Both dual descriptions hint at a more general description of quantum gravity, in infinite dimensions.

*Ritter, Lisa*

**Scattering of Deformed Two-Dimensional Coulomb Potential**

Scattering theory is a perturbation theory studying self-adjoint operators on a Hilbert space. For quantum theory, we have our momentum operator, $-p^2/2m$, being perturbed by varying potentials. Scattering amplitudes are found by normalizing ingoing asymptotic states and finding the amplitude of the associated outgoing asymptotic state. The Smorodinsky-Winternitz potential is a deformation of the Coulomb potential found by looking for quantum systems with dynamical symmetries. Because it has this symmetry, the potential remains superintegrable despite the change in potential. Superintegrability has been shown to be associated with exact solvability of the bound states in terms of special functions. In this presentation, the scattering amplitude of the system will be found, thus extending exact solvability to the scattering states.

*Rivelles, Victor O.*

**Gauge Field Theories for Continuous Spin Particles and Tachyons**

Some of the irreducible unitary representations of the Poincaré group are infinite dimensional. In the massless case they are called continuous spin particles and in the massive case they are named spin $s$ tachyons and continuous spin tachyons. We will present a recent proposal for a gauge field theory on a cotangent bundle for continuous spin particles and continuous spin tachyons and discuss its properties.

*Rodrigues, M. Manuela*

**The multi-dimensional time telegraph equation and the telegraph process with Brownian time**

In this talk we present some results concerning the fundamental solution (FS) of the multidimensional time-fractional telegraph equation with time-fractional derivatives in the Caputo sense. In the Fourier domain the FS is expressed in terms of a multivariate Mittag-Leffler function. The Fourier inversion leads to a representation of the FS in terms of a H-function of two variables. An explicit series representation of the FS, depending on the parity of the dimension, is presented. As an application, we study a telegraph process with Brownian time. Finally, we present some moments of integer order of the FS, and some plots of the FS for some particular values of the dimension and of the fractional parameters.

*Rosenhaus, V.*

**SUB-SYMMETRIES: properties, and applications**

We introduce a sub-symmetry of a differential system as an infinitesimal transformation of a subset of the system that leaves the subset invariant on the solution set of the entire system. We discuss the geometrical meaning, and properties of a sub-symmetry, and relation to regular and conditional symmetries. We demonstrate how to find sub-symmetries of a system, and give examples of sub-symmetries for some physically interesting systems. We show that a sub-symmetry is a considerably more powerful tool than a regular symmetry with regard to deformation of conservation laws, and decoupling a differential system. We discuss a correspondence between sub-symmetries and conservation laws for a large class of non-Lagrangian systems, and demonstrate an analogue of the first Noether Theorem for sub-symmetries.

*Rouleux, M.*

**The semi-classical Bogoliubov-de Gennes Hamiltonian with PT-symmetry: generalized Bohr-Sommerfeld quantization rules**

Bogoliubov-de Gennes (BdG) Hamiltonian describes the dynamics of a pair of quasi-particles in SNS junctions. A narrow metallic lead, with few transverse channels, connecting two superconducting contacts, is identified with a 1-D structure $|x| \leq L - \ell/2$, $\ell \ll L$ measuring the "penetration length". Interaction with the supraconductor bulk is modeled through the complex order parameter, $\Delta_0 e^{i\phi(x)/2}$ for $|x| \geq L+\ell/2$, $\phi(x) = \mathrm{sgn}(x)\phi$; because of the finite range of the junction (comparable to $\ell$) we may assume that this interaction continues to a smooth function $x \mapsto \Delta(x)e^{i\phi(x)}$, which vanishes rapidly inside $[-L, L]$. BdG Hamiltonian then takes the form

$$\mathcal{P}(x,\xi) = \begin{pmatrix} \xi^2 - \mu(x) & \Delta(x)e^{i\phi(x)/2} \\ \Delta(x)e^{-i\phi(x)/2} & -\xi^2 + \mu(x) \end{pmatrix} \tag{1}$$

We consider dynamics of the quasi-particle described semi-classically by the operator $\mathcal{P}(x, hD_x)$ on $L^2(\mathbb{R}) \otimes \mathbb{C}^2$. To simplify the model we have continued $\mu(x)$ to a constant $\mu_0$ for $|x| \geq L + \ell/2$, which makes sense if $\ell$ is sufficiently large with respect to the typical wave-length $h$. We assume potentials $x \mapsto \mu(x)$ and $x \mapsto \Delta(x)$ to be smooth and even functions on the real line, so that $\mathcal{P}(x, hD_x)$ enjoys time-reversal and PT symmetries. Electrons ($e^-$) and holes ($e^+$) with energy $E < \inf_{\mathbb{R}} \mu(x)$, $E < \Delta_0$ form so-called Andreev states sensitive to the variation of phase parameter $\phi$ between the superconducting banks. We are interested in resonances for the scattering processes $e^- \to e^+$ and $e^+ \to e^-$ where the wave functions of $e^\pm$ are purely outgoing at infinity (within the approximation above). We compute the first order asymptotics of the real parts of resonances, as solutions of generalized Bohr-Sommerfeld quantization rules, by constructing "relative monodromy operators" in the "classically allowed region" defined by $\Delta(x) \leq E$. These operators belong to U(1,1) the unitary group associated to the "flux norm" (in fact, a Lorenzian metric) generalizing a concept introduced by Helffer and Sjöstrand.

*Rutten, Nina J.*

## The defining properties of the Kontsevich unoriented graph complex Gra

Consider the real vector space of formal sums of non-empty, finite, unoriented graphs without multiple edges and loops. Endow every graph $\gamma$ in such sum with an ordering of edges $\mathsf{E}(\gamma)$ and introduce the relation $(\gamma_1, \mathsf{E}(\gamma_1)) - \text{sign}(\sigma)(\gamma_2, \mathsf{E}(\gamma_2)) = 0$ for topologically equal graphs $\gamma_1$ and $\gamma_2$ whose edge orderings differ by a permutation $\sigma$. The vector space of formal sums of graphs modulo this relation is the unoriented graph complex and is denoted by Gra.

Any representative of the zero element in Gra is a formal sum of graphs that cancel via the above relation, i.e. a graph in such sum cancels with another graph in the sum or it cancels with itself under a symmetry that permutes edges. We use symmetry groups that act on zero graphs to establish several identities for the differential and the Lie bracket defined on Gra. These identities show that Gra is a well-defined differential graded Lie algebra.

Using the calculus of the unoriented graph complex, we found the explicit form of the heptagon-wheel cocycle in [**1**]. M. Kontsevich related the unoriented graph complex to Poisson geometry. Namely, cocycles in this complex correspond to cocycles in the oriented graph complex; in turn, those cocycles induce universal infinitesimal deformations of Poisson structures on affine manifolds. In [**2**] we found an explicit form of the Poisson structure deformation which corresponds to the pentagon-wheel cocycle.

*Sabido, M.*

## On Deformed Phase Space Deformations in Cosmology.

We discuss the physical consequences of phase space deformations on scalar field FRW cosmology. The deformation is introduced by modifying the symplectic structure of the minisuperspace variables. In the deformed space models, we find that the deformation parameters can modified the value of the cosmological. Furthermore in some cases we find accelerating scale factor and infer that the deformation parameter gives an effective cosmological constant.

*Sadeghi, Jafar*

## The equivalence between Finsler and non-commutative geometries by massive gravity black hole

In the present work, we are interested to find the possible way in order to make equivalence between non-commutative and Finsler geometries as two useful mathematical tools. According to this purpose, we are concerned to search this possibility by investigating the massive gravity black holes. Firstly, the Lagrangian of system is introduced and then it is rewritten in the non-commutative regime by definition of the new variables. On the other hand, we focus on the Finsler geometry in order to find a Finslerian function which is equivalent with the mentioned non-commutative Lagrangian under special conditions. Also, the effective potential of system is calculated as a part of the corresponding conditions.

*Sahoo, P.K.*

**Traversable wormholes in $f(R,T)$ gravity**

We propose, as a novelty in the literature, the modelling of wormholes within the particular case of the $f(R,T)$ gravity, namely $f(R,T) = R + \lambda T$, with $R$ and $T$ being the Ricci scalar and trace of the energy-momentum tensor, respectively, while $\alpha$ and $\lambda$ are constants. Although such a functional form application can be found in the literature, those concern to compact astrophysical objects, such that no wormhole analysis has been done so far. The linear geometric and material corrections of this theory make the matter content of the wormhole to remarkably be able to obey the energy conditions.

*Sako, Akifumi*

**Hermitian-Einstein metrics from noncommutative U(1) instantons**

Hermitian-Einstein metrics are locally constructed by using self-dual two forms. As the self-dual two forms, $U(1)$ instantons on a noncommutative $\mathbb{C}^2$ are used in this article. To construct this non-commutative $\mathbb{C}^2$ we chose the deformation quantization with separation variables which is given by Karabegov to make noncommutative Kähler manifolds. Noncommutative Kähler manifolds given by Karabegov's deformation quantization have (twisted) Fock representations. There is a dictionary between the basis of the Fock representations and ordinary functions on the Kähler manifolds. Using the dictionary we construct concrete examples of Hermitian-Einstein metrics. This correspondence between the Hermitian-Einstein metrics and the noncommutative U(1) instantons is deeply related to the Seiberg-Witten map. Kähler conditions are concerned with the Bianchi identities for $U(1)$ gauge curvatures.

*Saksida, Pavle*

**Nonlinear Fourier transform and nonlinear superposition**

I shall consider the nonlinear Fourier transform associated with the ZS-AKNS systems with periodic boundary conditions. In general, the linear Fourier theory and its linear generalizations provide solutions of linear initial problems as linear superpositions of the Fourier modes. To some extent, the integrable nonlinear partial differential equations can be analyzed in an analogous way. In the talk I will present a perturbation theoretic approach to the construction of the nonlinear Fourier modes and of their nonlinear superposition. The key element of this approach is a convergent iterative scheme for the evaluation of the inverse nonlinear Fourier transform of the ZS-AKNS type.

*Salehi, Nasrin*

**A New Model for Calculating the Mass Spectrum of Hyperons under the Modified killingbeck Potentioal via Heun Method**

In recent years, the baryon spectroscopy is investigated by various phenomenological constituent quark models and many experimental studies. The baryons are combinations of three quarks. Baryons containing u and d quarks are called nucleons and combinations of u, d and s quarks are called hyperons.In this article, we have calculated the masses of $\Lambda$ ,$\Sigma$,$\Xi$,and,$\Omega$ hyperons by using the hypercentral constituent quark model (hCQM). For this goal we have solved the hyperradial Schrödinger equation analytically for three particles under the modified Killingbeck potential. Wave function and energy eigen values for our proposed potential are obtained by in terms of Heun function. To produce the splitting within the SU(6) multiplets mass, we have also considered the spin – spin, isospin – isospin and spin – isospin interactions, which have been treated as perturbative terms. Our obtained masses are in good agreement with experimental predictions. For the hyperons masses the minimum and maximum percentage of relative error values are 0.5% and 11.13% between our calculations and the experimental masses, which show that our model (the combination of our proposed hypercentral potential and the Heun method to solve the Schrödinger equation) has been useful to description of the hyperons spectrum.

*Sarkissian, Gor*

**On mini-superspace limit of boundary three-point function in Liouville field theory**

We study the mini-superspace semiclassical limit of the boundary three-point function in the Liouville field theory. We compute also matrix elements for the Morse potential quantum mechanics. An exact agreement between the former and the latter is found. We show that both of them are given by the generalized hypergeometric functions.

*Sato, Naoki*

**Hamiltonian and non-Hamiltonian reductions of conservative dynamics: structures created by degenerate, singular, and finite helicity field tensors**

Topological constraints on a dynamical system often manifest themselves as a degenerate or broken Hamiltonian structure. Examples are integrable and non-integrable constraints on Lagrangian mechanics. The statistical mechanics under such topological constraints is the subject of the present study. Integrable constraints foliate the phase space into Casimir leaves, each of them representing a symplectic submanifold where the standard methods of statistical mechanics are applicable. For such non-canonical Hamiltonian systems, the sources of heterogeneity in the distribution function are the Casimir invariants. In the case of non-integrable constraints conventional arguments based on phase spaces, Jacobi identity, invariant measure, or the H theorem are no longer applicable, since all these notions stem from the symplectic geometry underlying canonical Hamiltonian systems. Remembering that Hamiltonian systems are endowed with field tensors that have zero helicity, our mission is to extend the scope toward finite-helicity field tensors. Here we introduce a new class of field tensors that are characterized by Beltrami vectors. We prove an H theorem for this Beltrami class. The most general class of energy-conserving systems are non-Beltrami, for which we identify the “field charge” that prevents the entropy to maximize, resulting in creation of heterogeneous distributions.

*Sawado, Nobuyuki*

**Spectral flow and the index analysis for the skyrmions of the $CP^N$ and the $F_N$**

Soliton solutions of the non-linear sigma model (with some stabilizers) of two or three dimensions have been extensively studied in several physics like effective models of QCD or, some continuous limits of Heisenberg model. Recently we have found novel vortex solutions of the models of the $CP^N := SU(N+1)/U(N)$ and also of the $F_N := SU(N+1)/U(1)^N$. In this presentation we would like to discuss normalizable modes of the spinor in two or three spatial dimensions coupled with such solitons especially of the simplest case, the $CP^2$ and the $F_2$. We also mention behavior of the fermions coupled with the known Skyrme-Faddeev Hopfions bacause they may share some basic features with the vortices in three dimensions.

*Sawicki, Adam*

**Asymptotic properties of entanglement polytopes for large number of qubits**

Entanglement polytopes have been recently proposed as a way of witnessing the SLOCC multipartite entanglement classes using single particle information. We present first asymptotic results concerning feasibility of this approach for large number of qubits. In particular, we show that entanglement polytopes of $L$-qubit system accumulate in the distance $O(\frac{1}{\sqrt{L}})$ from the point corresponding to the maximally mixed reduced one-qubit density matrices. This implies existence of a region where many entanglement polytopes overlap, i.e where the witnessing power of entanglement polytopes is weak. Moreover, we argue that the witnessing power cannot be strengthened by any entanglement distillation protocol, as for large $L$ the required purity is above current capability.

*Schroeck, Franklin E.*

**Theory and Examples of Quantum Mechanics on Phase Space**

I will give a brief exposition of quantum mechanics on phase space (q.m. on p.s.) and then present some examples where q.m. on p.s. is required whereas ordinary quantum mechanics will not do.

*Sciarappa, Antonio*

**Gauge theory approach to quantum relativistic integrable systems**

It is usually quite complicated to study relativistic quantum integrable systems analytically, due to the finite-difference nature of their Hamiltonians. Recently however it has been understood that supersymmetric gauge theories in five dimensions can be thought of as an alternative, powerful framework for solving these systems. In this talk we will review these new developments, mostly focussing on the case of systems with elliptic potential (aka Ruijsenaars-Schneider).

*Sechin, Ivan*

**Anisotropic long-range spin chains and their Hamiltonians**

The talk is dedicated to one special type of the quantum integrable systems — long-range spin chains, and provides a new method of constructing of the Hamiltonians of such spin chains via the connection with the classical Calogero-Moser (CM) system of particles. The classical Lax pairs for CM system appear to have R-matrix-valued generalizations, where the rational, trigonometric or elliptic functions in the matrix elements are replaced by the quantum R-matrices of the appropriate type. Additional terms in this generalization can be considered as the Hamiltonians of the quantum spin chains with long-range interaction. This correspondence works properly for known types of the long-range spin chains — for the trigonometric Haldane-Shastry and the elliptic Inozemtsev ones, where known Hamiltonians are obtained. Moreover, one can consider the anisotropic analogues of the Haldane-Shastry and Inozemtsev chains respectively. Numerical calculations shows that the Hamiltonians provided by correspondence commute in the anisotropic case as well.

*Sergyeyev, Artur*

**Plethora of integrable (3+1)-dimensional systems via contact geometry**

Finding an effective construction for integrable nonlinear partial differential systems in four independent variables is a longstanding problem in modern mathematical physics. In this talk we address the problem in question by introducing a novel construction for a large class of such systems using nonisospectral Lax pairs that involve contact vector fields. Please refer to the article A. Sergyeyev, New integrable (3+1)-dimensional systems and contact geometry, *Lett. Math. Phys.* **108** (2018), no. 2, 359–376 for further details.

*Shalaby, Abouzeid M.*

**PT-symmetry**
**breaking as a signature of Young-Lee Edge singularity in Quantum field Theory**

Phase transitions are always associated with Symmetry breaking. Young-Lee singularity is a kind of critical phenomena and in magnetic systems it occurs at imaginary external magnetic field. In view of our recent work in PRD 96, 025015 (2017) we shed light on PT-symmetry breaking in non-Hermitian field theory and show that PT-symmetry breaking is associated with Yang-Lee singularity. Although Yang-Lee singularities are known long time ago but the PT-symmetric studies offers a concrete description of the theory regarding Metric implementation, stability and unitarity.

*Sharapov, Alexey*

**Variational Tricomplex, Global Symmetries and Conservation Laws of Gauge Systems**

Using the concept of variational tricomplex endowed with a presymplectic structure, we formulate the general notion of symmetry. We show that each generalized symmetry of a gauge system gives rise to a sequence of conservation laws that are represented by on-shell closed forms of various degrees. This extends the usual Noether's correspondence between global symmetries and conservation laws to the case of lower-degree conservation laws and not necessarily variational equations of motion. Finally, we equip the space of conservation laws of a given degree with a Lie bracket and establish a homomorphism of the resulting Lie algebra to the Lie algebra of global symmetries.

*Sheinman, Oleg*

**Lax operator algebras and integrable systems**

Lax operator algebras emerged in the joint work by Krichever and the author (2007) where it was observed that the space of Lax operators with the spectral parameter on a Riemann surface invented by Krichever in 2001, possesses a structure of a Lie algebra. The class of the corresponding integrable systems includes Hitchin systems as well as several classes of classical integrable systems like giroscopes, integrable cases of flow around a solid body, etc. In 2013 a fundamental relation between Lax operator algebras and gradings of semi-simple Lie algebras had been found out. Later a unifying approach to commuting hierarchies and Hamilton theory of integrable systems of the above mentioned class has been developed on this base. In the talk we are planning to give an overview of those results. If the time permits, I'll comment on quantization of the Lax integrable systems in question, and on the interrelation between Lax operator algebras and holomorphic G-bundles via matrix divisors (2016).

*Shen, Yibing*

**Ground-state energies of the open and closed $p+ip$-pairing models from the Bethe Ansatz**

We first study the $p+ip$ Hamiltonian isolated from its environment (closed model) through the Bethe Ansatz solution and consider the case of a large particle number. A continuum limit approximation is applied to compute the ground-state energy. We discuss the evolution of the solution curve, and the limitations of this approach. We then consider an alternative approach that transforms the Bethe Ansatz equations to an equivalent form in terms of the real-valued conserved operator eigenvalues. This approach also generalizes to accommodate interaction with the environment (open model).

*Sheppeard, Marni D.*

**Masses and mixing matrices in motivic quantum gravity**

Category theoretic combinatorics for motivic amplitudes in the Standard Model suggest an infinite dimensional perspective on motives, taking into account the quantization of rest mass for gravity under the new cosmological Higgs mechanism. Here the Hopf algebras of the cosmic Galois group constrain parameters for rest masses and for the PMNS and CKM mixing matrices. Solomon's descent algebra and the associated permutohedra define canonical coordinates, from which classical continua are generated, starting with Jordan algebras for octonionic quantum mechanics. An underlying abstract Stone duality motivates the construction.

*Shnir, Yakov*

**Gauged Baby Skyrme Model with and without Chern-Simons Term**

The properties of the multisoliton solutions of the U(1) gauged modification of the 2+1 dimensional planar Skyrme model with and without Chern-Simons term are investigated numerically. Coupling to the Chern-Simons term allows for existence of the electrically charged solitons which may also carry magnetic fluxes. It is found that, generically, the coupling to the Chern-Simons term strongly affects the usual pattern of interaction between the skyrmions, in particular the electric repulsion between the solitons may break the multisoliton configuration into partons. In the strong coupling limit the coupling to the gauge field results in effective recovering of the rotational invariance of the configuration and both the magnetic flux and the electric charge of the solutions become quantized, although they are not topological numbers. We construct new class of regular soliton solutions with fractional topological charges in the scalar sector. These field configurations represent Skyrmed vortices, they have finite energy and carry topologically quantized magnetic flux. We show that, unlike the vortices in the Abelian Higgs model, the gauged merons may combine short range repulsion and long range attraction.

*Sidorov, Stepan*

**Deformed $\mathcal{N}=8$ mechanics of $(\mathbf{8},\mathbf{8},\mathbf{0})$ multiplets**

We construct new models of $SU(4|1)$ supersymmetric mechanics corresponding to two versions of the multiplet $(\mathbf{8},\mathbf{8},\mathbf{0})$. The worldline realizations of the supergroup $SU(4|1)$ is treated as a deformation of the flat $\mathcal{N}=8$, $d=1$ supersymmetry. Introducing $SU(4|1)$ chiral superfields, we construct invariant actions where complex coordinates correspond to the Special Kähler manifold. The general construction of $SU(4|1)$ invariant actions is given in the framework of $SU(2|1)$ superfields. Also, we find actions invariant under the superconformal group $OSp(8|2)$.

*Simulik, Volodimir*

**On the bosonic symmetries of the Dirac equation with nonzero mass**

Bosonic symmetries of the Dirac equation with nonzero mass, which existence is under consideration after our publications in the years 2011–2015, are proved here on the basis of two different methods. The first one appeals to the 64-dimensional gamma matrix representation of the Clifford algebra $\mathcal{C}\ell^{\mathbb{R}}(0,6)$ over the field of real numbers and the 28-dimensional gamma matrix representation of the algebra SO(8) (over the field of real numbers as well). The second way of proof is based on the start from the relativistic canonical quantum mechanics of spin (1,0) particle multiplet and its relationship with the Dirac equation, which is given by the extended Foldy-Wouthuysen transformation suggested by us in 2014–2017. Both the Lorentz and Poincaré bosonic symmetries are considered. The 32-dimensional algebra of invariance is found. The bosonic solutions and conservation laws are found as well. The considered phenomenon is called the Fermion-Boson duality of the Dirac equation according to P. Garbaczewski's titles suggested in 1986.

*Smaldone, Luca*

**Patterns of chiral symmetry breaking and dynamical generation of fermion mixing**

A careful non perturbative study of flavor mixing reveals an interesting structure of the flavor vacuum. This is deeply related to the existence of unitarily inequivalent representations of field algebra in Quantum Field Theory. The particle-antiparticle condensate structure of the flavor vacuum suggests the idea of fermion mixing as an emergent dynamical phenomenon. An attempt in this direction, using operator formalism, was recently formulated, and gap equations were obtained both for the masses and mixing angles. We studied chiral symmetry breaking, in connection with the problem of dynamical generation of fermion masses and mixing. For simplicity's sake we consider the case of $SU(2)_A \times SU(2)_V \times U(1)_V$ chiral group. Basing our analysis just on algebraic methods, we analyze the structure of vacuum at different steps of symmetry breaking and we show that a non-trivial condensate structure of vacuum characterizes the phenomenon of dynamical generation of field mixing. We also show, thanks to Ward-Takahashi identities, how Nambu–Goldstone modes appear in the physical spectrum, finding that anomalous propagators play a role when mixing is dynamically generated. An explicit algebraic analysis is performed in the mean-field approximation.

*Smilga, Walter*

**Orbital angular momentum in relativistic multi-particle systems**

Linear and angular momenta are well-known examples of conserved quantities. Therefore, it seems strange that the perturbation algorithm of quantum electrodynamics, on the one hand, explicitly ensures the conservation of the linear momentum at each vertex by appropriate delta functions but, on the other hand, does not make similar provisions for the angular momentum. I address the specific role of the orbital angular momentum in relativistic multi-particle systems and explain how the conserved angular momentum determines the basic structures of quantum electrodynamics and quantum gravity.

*Son, Dam Thanh*

**Algebraic approach to fractional quantum Hall effect**

We construct an algebraic description for the ground state and for the static response of the quantum Hall plateaux with filling factor $\nu = N/(2N+1)$ in the large $N$ limit. By analyzing the algebra of the fluctuations of the shape of the Fermi surface of the composite fermions, we find the explicit form of the projected static structure factor at large $N$ and fixed $z = (2N+1)q\ell_B \sim 1$. When $z < 3.8$, the result does not depend on the particular form of the Hamiltonian. Reference: arXiv:1805.00945.

*Sontz, Stephen B.*

**Co-Toeplitz Operators and their Associated Quantization**

Dual to the theory of Toeplitz operators with symbols in an algebra we introduce a theory of co-Toeplitz operators with symbols in a co-algebra. This gives a corresponding quantization scheme, including creation and annihilation operators. For example, we can take the symbol space to be a Hopf algebra (quantum group), and therefore, a co-algebra. One such example is given by using the quantum group $SU_q(2)$ as symbol space.

*Sorokin, Dmitri*

**3-form gauge fields, (super)gravity and membranes**

We will review physical effects that rank-3 antisymmetric (three-form) gauge fields may produce in four-dimensional field theories and gravity, as well as a possible origin of these fields from the dimensional reduction of higher-dimensional supergravity theories. In particular, we will discuss how non-zero expectation values of these fields dynamically generate a cosmological constant term in Einstein equations and break supersymmetry spontaneously. We will also consider couplings of the three-form fields to membranes within $N = 1, D = 4$ supergravity and give examples of BPS domain wall solutions that separate supersymmetric vacua with different values of the cosmological constant.

*Souček, Jiří*

**The quantization of the Higgs' condensate and the "physical randomness" hypothesis imply the invalidity of quantum mechanics at short distances**

In this Letter we give a completely general formulation of the argument that quantum mechanics (QM) is invalid at short distances. The proof is based on the use of two reasonable "physical" hypotheses: (i) the particle structure of the Higgs' condensate, (ii) the origin of the randomness in quantum mechanics rests in the interaction with particles from the Higgs' condensate.

*Souček, Vladimír*

**On BGG complexes in singular infinitesimal character**

It is well known how to construct the BGG complexes on a general flag manifold in the case of regular infinitesimal character. In the lecture, I will review results showing how the methods of the Penrose transform developed by R. Baston and M. Eastwood are used to construct the BGG complexes on certain types of flag manifolds in singular infinitesimal character.

*Srisukson, Saksilpa*

**Hamiltonian Zoo for the harmonic oscillator**

We present alternative forms of the standard Hamiltonian called Newton-equivalent Hamiltonian Zoo for the harmonic oscillator giving the same equation of motion. These Hamiltonians are solved directly from the Hamilton's equations and come with extra-parameters which are interpreted as time scaling factors. The Hamiltonian Zoo can be treated as a generator, producing infinite hierarchy of Hamiltonians, and the Hamiltonian hierarchy processes also the Pascal triangle structure. Moreover, it is discovered that the Hamiltonian hierarchy forms an Abelian Lie group.

*Sternheimer, Daniel*

**Segal's contractions, Anti de Sitter and conformal groups**

Symmetries and their applications have always played an important role in I.E. Segal's work. I shall exemplify this, starting with his incidental 1951 introduction of the (1953) Inönü-Wigner contractions, of which the passage from AdS SO(2,3) to Poincaré is an important example, all the way to his interest in conformal groups in the latter part of last century. Since the 60s Flato and I had many fruitful interactions with him around these topics, which I shall briefly sketch.

*Stoilova, N.I.*

**Odd Gel'fand-Zetlin basis and Clebsch-Gordan Coefficients for Covariant Representations of the Lie superalgebra $\mathfrak{gl}(n|n)$**

A Gel'fand-Zetlin basis is given for the irreducible covariant tensor representations of the Lie superalgebra $\mathfrak{gl}(n|n)$. The basis follows the $\mathfrak{gl}(n|n)$ decomposition according to a chain of only Lie superalgebras of type $\mathfrak{gl}(k|l)$ with $k$ and $l$ nonzero (apart from the final element of the chain which is $\mathfrak{gl}(1|0) \equiv \mathfrak{gl}(1)$). Explicit expressions for a set of odd generators of the algebra on this Gel'fand-Zetlin basis are given. Clebsch-Gordan coefficients corresponding to the tensor product of the natural representation $V([1,0,\ldots,0])$ of $\mathfrak{gl}(n|n)$ with highest weight (1,0,. . . ,0) with any covariant tensor representation of $\mathfrak{gl}(n|n)$ are computed. Both results are intermediate steps for the explicit construction of the parastatistics Fock space with an infinite number of parabosons and parafermions.

*Strasburger, Aleksander*

**Coherent states, $CP^N$-sigma models and Jacobi polynomials**

We investigate further relations between $CP^N$-sigma models and coherent states of the $\mathbf{SU}(2)$ group, studied recently in collaboration with A. M. Grundland and D. Dziewa-Dawidczyk. In particular, using an explicit parametrization of the solutions of $CP^N$-sigma models by means of Jacobi polynomials, we connect the invariant recurrence relations between surfaces arising from solutions of the models, as studied by P. Goldstein and A. M. Grundland, with recurrence relations of the Jacobi polynomials.

*Studziński, Michał*

**Optimal Port-based Teleportation in Arbitrary Dimension**

Port-based teleportation (PBT), introduced in 2008, is a type of quantum teleportation protocol which transmits the state to the receiver without requiring any corrections on the receiver's side. Evaluating the performance of PBT was computationally intractable and previous attempts succeeded only with small systems. We study PBT protocols and fully characterize their performance for arbitrary dimensions and number of ports. We develop new mathematical tools to study the symmetries of the measurement operators that arise in these protocols and belong to the algebra of partially transposed permutation operators. First, we develop the representation theory of the mentioned algebra which provides an elegant way of understanding the properties of subsystems of a large system with general symmetries. In particular, we introduce the theory of the partially reduced irreducible representations which we use to obtain a simpler representation of the algebra of partially transposed permutation operators and thus explicitly determine the properties of any port-based teleportation scheme for fixed dimension in polynomial time. We present optimal solutions for two kinds of PBT protocols, probabilistic and deterministic one. Later on we also discuss possible further applications of developed mathematical tools.

*Stukopin, Vladimir*

**Isomorphism between super Yangian and quantum loop superalgebra**

Following V. Toledano-Laredo and S. Gautam approach we construct isomorphism between super $\hbar$-Yangian of special linear superalgebra and quantum loop superalgebra. We also obtain a classification of finite dimensional representations of quantum loop superalgebra.

*Subag, Eyal*

**Contractions, Algebraic Families and the Hydrogen Atom**

I will explain how contractions of Lie groups and their representations can be studied using algebraic families of Harish-Chandra pairs and their modules. I will focus on the example of the two dimensional hydrogen atom and show that in that case, the Schrödinger equation gives rise to an algebraic family of Harish-Chandra pairs that codifies the hidden symmetries. The talk is based on joint work, in parts, with Joseph Bernstein and Nigel Higson.

*Sutulin, Anton*

**Supersymmetric $n$-particles Euler-Calogero-Moser model**

We construct the supersymmetric extension of the $n$-particles Euler-Calogero-Moser model within the Hamiltonian approach. The main feature of the proposed supersymmetrization method is that it is automatically adapted for a model of the type under consideration with an arbitrary even number of supersymmetries. It is shown that the number of fermions that must be used in this construction is $Mn(n+1)$. We demonstrate that the resulting $\mathcal{N} = 2M$ supersymmetric system is dynamically invariant with respect to the superconformal group $Osp(2M|2)$ and give the explicit realization of generators of the latter as conserved currents. For the simplest case of the $\mathcal{N} = 2$ supersymmetric $n$-particles Euler-Calogero-Moser model we provide its description in superspace by using the corresponding constraint superfields.

*Szajewska, Marzena*

**Reduction of orbits of finite Coxeter gorup of noncrystallographic type**

We present a reduction of orbits of finite reflection groups to their reflection subgroups which is produced by means of projection matrices, which transform points of the orbit of the group to the points of orbits of the subgroup.

*Šilhan, Josef*

**Higher supersymmetries**

Higher symmetries of the (conformal version) of the Laplace operator $\Delta$ are controlled by conformal Killing tensors and higher symmetries of the (conformal version) of the Dirac operator $\not{D}$ are controlled by conformal Killing forms. These can be completely classified on conformally flat manifolds. We shall study the algebra of higher symmetries of the $(\Delta, \not{D})$–pair. It turns out twistor spinors play an additional role of "mixing" symmetries or rather supersymmetries. In particular, we shall show when this algebra is generated by first order (super)symmetries and how it can be expressed as a quotient of the universal enveloping algebra of a suitable Lie superalgebra.

*Šnobl, Libor*

**Spherical type integrable classical systems in a magnetic field**

We show that four classes of second order spherical type integrable classical systems in a magnetic field exist in the Euclidean space $E_3$, and construct the Hamiltonian and two second order integrals of motion in involution for each of them. For one of the classes the Hamiltonian depends on four arbitrary functions of one variable. This class contains the magnetic monopole as a special case. Two further classes have Hamiltonians depending on one arbitrary function of one variable and four or six constants, respectively. The magnetic field in these cases is radial. The remaining system corresponds to a constant magnetic field and the Hamiltonian depends on two constants. Questions of superintegrability – i.e. the existence of further integrals – are discussed.

*Tan, Si-Hui*

**A quantum approach to homomorphic encryption**

Homomorphic encryption is a cryptographic scheme that allows evaluations to be performed on ciphertext without giving the key to the evaluator. It comprises of four algorithms: random key generation, encryption, evaluation, and decryption. We present a quantum approach to use evaluation operators that commute with the encryption operators. Then, applying the inverse of the encryption operation decrypts the evaluated state, and the decryption key depends only on the encryption key. We will present various quantum homomorphic encryption schemes, some of which admit an interpretation with quantum optical systems. For example we can compute on coherent-state qubits, and with identical bosons with internal degrees of freedom. Another relies on random quantum codes and random permutations to allow computations of Clifford circuits and a constant number of T-gates. It is not always clear what the group of allowed evaluations would be, as is the case with the scheme for identical bosons with internal degrees of freedom, and will be discussed here.

*Tao, Jim*

**The Gauss–Bonnet Theorem for Cyclic Projective Modules over the Noncommutative Two-Torus**

In this paper, we generalize Connes and Tretkoff's calculation of the value at zero of the spectral zeta function of the Laplacian on the noncommutative two-torus to Laplacians on cyclic projective modules over the noncommutative two-torus. We introduce a self-adjoint idempotent $e$ that does not commute with the other variables and appears in denominators as part of the ratio of a geometric series, analytically continued. As it turns out, improper integrals of rational functions with $e$ appearing in the denominator are not straightforward to evaluate, especially in the nontrivial case where $e \neq 1$. Also, if $e$ appears in the denominator and doesn't commute with other variables in the denominator, it becomes a challenge to adapt techniques that work in the case $e = 1$. This is where the fun begins; by pioneering a combinatorial way of evaluating noncommutative integrals, we are able to prove a generalization of Connes and Tretkoff's rearrangement lemma.

*Tempesta, Piergiulio*

**Haantjes Algebras of Classical Integrable Systems**

We propose the notion of Haantjes algebra, which consists of an assignment of a family of fields of operators over a differentiable manifold, with vanishing Haantjes torsion and satisfying suitable compatibility conditions. Haantjes algebras naturally generalize several known interesting geometric structures, arising in Riemannian geometry and in the theory of integrable systems. At the same time, they play a crucial role in the theory of diagonalization of operators on differentiable manifolds: In the semisimple case, there exists a set of local coordinates where all operators can be diagonalized simultaneously. Moreover, in the non-semisimple case, they acquire simultaneously a block-diagonal form. A new approach to classical integrable and superintegrable systems is also proposed, based on the geometry of Haantjes tensors. We introduce the class of symplectic-Haantjes manifolds, as the natural setting where the notion of integrability can be formulated. We prove that the existence of suitable Haantjes algebras is a necessary and sufficient condition for a Hamiltonian system to be integrable in the Liouville-Arnold sense. Furthermore, we propose a novel approach to the theory of separation of variables for integrable and superintegrable systems. The special family of Darboux-Haantjes coordinates will be introduced: They ensure the additive separation of variables of the Hamilton-Jacobi equation. Finally, we present an application of our approach to the study of some models, as the Post-Winternitz model, a stationary reduction of the KdV hierarchy, the Jacobi-Calogero system and a Drach-Holt type system; the separability properties of the latter were not known.

*Teodorescu, Razvan*

**Projective connections and extremal domains for analytic content**

An unexpected outcome of the author's recent proof of the 30 year old conjecture that disks and annuli are the only domains where analytic content - the uniform distance from $\bar{z}$ to analytic functions - achieves its lower bound, is a new insight into projective connections and the classification of quadratic differential spaces. In particular, we reveal a new relation between the symmetry constraints characterizing extremal domains (in the approximation theory sense) and invariance groups for projective connections in the case of finite-genus Riemann surfaces.

*Tombuloglu, Semiha*

**PT Symmetric Floquet Topological Phase in SSH Model**

We study tight binding lattice in one dimension with gain and loss. Our model is periodically modulated Su-Schrieffer-Heeger (SSH) model and it can be realized with current technology in photonics using waveguides. This model allows us to study Floquet topological insulating phase. We find the quasi-energy spectrum of this one dimensional PT symmetric topological insulator by using Floquet theory.We show that stable Floquet topological phase exists in our model provided that oscillation frequency is large and the non-Hermitian degree is below than a critical value.

*Toppan, Francesco*

**Quasi-nonassociativity from an exceptional spectrum-generating superalgebra.**

Exceptional Lie (super)algebras are derived from octonions. I present the Calogero-deformed quantum oscillator induced by the spectrum generating exceptional superalgebra $F(4)$. This system is a unique example of "quasi-nonassociativity". This means, in particular, that the Calogero coupling constants are determined in terms of the octonionic structure constants. The Hilbert space is a 16-ple of square integrable functions.

*Trnka, Jaroslav*

**The Amplituhedron**

In this talk I will review some of the recent developments in the study of scattering amplitudes which show how the physics principles can emerge from intriguing geometric structures. The first example is the Amplituhedron in the context of amplitudes in planar $\mathcal{N} = 4$ SYM theory.

*Truini, Piero*

**The Magic Star of Exceptional Periodicity**

I present a periodic infinite chain of finite generalisations of the exceptional structures, including the exceptional Lie algebra E8, the Exceptional Jordan Algebra (and Pair) and the Octonions.

*Tsiganov, Andrey*

**Superintegrable systems with higher order integrals of motion**

We revisit known two and three dimensional superintegrable Stäckel systems with natural Hamiltonians and addition polynomial integrals of motion of $n$-th order related to Chebyshev's and Euler's rationalizing substitutions. We also plan to discuss some new integrable systems, superintegrable systems with nonstandard metric and quantum counterparts of the corresponding action-angle variables.

*Tuček, Vít*

**Invariant differential operators and unitarizable lowest weight modules**

Laplace and Dirac operators are intrinsically defined on any pseudo-Riemannian manifold $(M, g)$. However, one can add lower order terms so that the resulting operators are naturally defined also on any conformal manifold $(M, [g])$, i.e. a manifold with a chosen class of metrics $[g]$ where two metrics $g_1, g_2$ belong to the same class if there exists everywhere positive smooth function $\varphi \in \mathcal{C}^\infty(M)$ such that $g_1 = \varphi g_2$.

I will present generalization of construction of sequences of naturally defined differential operators due to Čap, Slovák and Souček. For homogeneous spaces one obtains complex of invariant differential operators that calculates cohomology with values in certain auxiliary vector bundle. As a special case, this construction gives the conformally invariant modifications of Laplace and Dirac operators in the Lorentzian signature. For homogeneous manifolds the resulting sequences of invariant differential operators are dual to BGG resolutions of unitarizable lowest weight modules.

*Tumpach, Alice Barbara*

**Bruhat-Poisson structure of the restricted Grassmannian and the KdV hierarchy**

In the first part of this talk, we explore the notion of Poisson structure in the Banach context. We show that the Leibniz rule for a Poisson bracket on a Banach manifold does not imply the existence of a Poisson tensor. The existence of a Hamiltonian vector field on a Banach manifold endowed with a Poisson tensor is also not guaranteed. We propose a definition of a (generalized) Poisson structure on a Banach manifold which includes all weak symplectic Banach manifolds.

The second part of the talk is devoted to the study of particular examples of generalized Poisson manifold, namely Banach Poisson-Lie groups related to the Korteweg-de-Vries hierarchy. We construct a generalized Banach Poisson-Lie group structure on the unitary restricted group, as well as on a Banach Lie group consisting of (a class of) upper triangular bounded operators. We show that the restricted Grassmannian inherite a Bruhat-Poisson structure from the unitary restricted group, and that the action of the triangular Banach Lie group on it by "dressing transformations" is a Poisson map. This action generates the KdV hierarchy, and its orbits are the Schubert cells of the restricted Grassmannian.

*Turner, Peter S.*

**Unitary-unitary duality in quantum photonics**

Recent advances in scaling photonics for universal quantum computation spotlight the need for a thorough understanding of practicalities such as distinguishability in multimode quantum interference. A first quantised formalism arises by observing that Fock states can have natural Schmidt decompositions, corresponding to what has been called unitary-unitary duality in the representation theory of many-body physics. We present results along two lines: (i) generalised Hong-Ou-Mandel interference as unambiguous state discrimination (arXiv:1806.01236, with S. Stanisic); we find interferometers that optimally discriminate between indistinguishable and interesting distinguishable states by projecting onto non-symmetric irreps of the unitary group of interferometers, and (ii) quantum simulation of noisy boson sampling(arXiv:1803.03657, with A. Moylett); we provide a quantum circuit that simulates bosonic sampling with arbitrarily distinguishable particles, based on the quantum Schur-Weyl transform, that makes clear how distinguishabililty leads to decoherence in the standard quantum circuit model.

*Tyc, Tomáš*

**Superintegrability, the Hamilton-Jacobi equation and absolute optical instruments**

Starting from the analogy between mechanics and optics, we will present a comprehensive theory of absolute optical instruments based on the Hamilton-Jacobi equation and action-angle variables. From this theory we derive very general properties of absolute instruments and present a number of examples. We will also show that an absolute optical instrument can be derived from any mechanical potential that gives closed orbits even just for a single energy. This opens an interesting challenge in mechanics, namely to find all potentials that have closed trajectories for one or a discrete set of energies. Despite the knowledge already available in this field, there are also many other open problems to be solved; applying methods of mechanics to optical situations could be invaluable.

*Valenzuela, Mauricio*

**New matrix models from Yang-Mills theories**

We introduce some new matrix models with multivector target spaces, i.e. where the target spaces are described by higher rank multivectors. These models can be obtained from higher dimensional Yang-Mills interaction terms in the large-N limit. The correspondence Matrix-Model–Yang-Mills theory is obtained by means of novel type of dimensional reduction, different than Kaluza-Klein's. We shall also study the formal classical limit of these models and their relation with higher spin gravity.

*van de Vijver, Wouter*

**A discrete higher rank Racah algebra**

The Racah algebra is an algebra encoding interesting properties of the univariate Racah polynomials. Recently it has been shown that this algebra can be generalized to the higher rank Racah algebra by considering the tensor product of $n$ copies of $\mathfrak{su}(1,1)$. It also arises as the symmetry algebra of the $\mathbb{Z}_2^n$ Dunkl-Laplacian. Remarkably, the connection coefficients between bases of Dunkl-harmonics diagonalized by labelling Abelian subalgebras are multivariate Racah polynomials as defined by M. V. Tratnik. One wonders if an action of the generalized Racah algebra can be realized on the multivariate Racah polynomials encoding their properties. We propose such a realization by making use of the bispectral shift operators defined by J.S. Geronimo and P. Iliev.

*Van der Jeugt, Joris*

**Parabosons, parafermions and representations of $(\mathbb{Z}_2 \times \mathbb{Z}_2)$ graded Lie superalgebras**

When a system of $m$ parafermions and $n$ parabosons are combined, there are two choices for the relative commutation relations. One choice (of relative parafermion type) gives rise to the classical orthosymplectic Lie superalgebra $\mathfrak{osp}(2m+1/2n)$. For the other choice (of relative paraboson type), the underlying algebraic structure is no longer an ordinary Lie superalgebra, but a $(\mathbb{Z}_2 \times \mathbb{Z}_2)$ graded superalgebra, denoted by $\mathfrak{pso}(2m+1/2n)$. Analysing the subalgebra structure of $\mathfrak{pso}(2m+1/2n)$ allows the investigation of the parastatistics Fock spaces for this new set of $m+n$ para-operators, as they correspond to lowest weight representations of $\mathfrak{pso}(2m+1/2n)$. Our main result is the construction of these Fock spaces, with a complete labeling of the basis vectors and an explicit action of the para-operators on these basis vectors. This is the first example of a complete class of representations for a $(\mathbb{Z}_2 \times \mathbb{Z}_2)$ graded Lie superalgebra.

*Vasak, David*

**Dark Energy is a geometry effect in the Covariant Canonical Gauge Gravity**

The Covariant Canonical Gauge Gravity (CCGG) is a first-order theory based on a rigorous mathematical framework rooted in a minimal set of postulates. It results in a Hamiltonian with a term quadratic in the momentum field – the conjugate to the connection field – added to the Einstein-Hilbert action. Due to that term the stress tensor of matter is not covariantly conserved, and the dynamics of matter and space-time are modified. In what we call the "Einstein view" all modifications are recast as contributing to the stress tensor on the r.h.s. of the Einstein-Hilbert equation and interpreted as Dark Energy (DE). This DE is driven by the presence of dust and of a non-vanishing cosmological constant. No ad hoc "quintessence"-like scalar fields are needed. In the Friedman model of the universe we show that the CCGG theory leads to a running cosmological constant. The scale dependence of that function is determined and shown to give rise to a "geometrical fluid". A single dimensionless parameter, $f_0$, standing for the presence and strength of the quadratic non-Hilbert term, is accessible to standard cosmological observations. We solve the Friedman equations and discuss the resulting cosmology.

*Vieira, Nelson*

**On the fundamental solution of the time-fractional telegraph Dirac operator**

In this talk we present the first fundamental solution of the multidimensional time-fractional telegraph Dirac operator where the two time-fractional derivatives of orders $\alpha \in ]0,1]$ and $\beta \in ]1,2]$ are in the Caputo sense. Explicit integral and series representation of the fundamental solution are obtained for any dimension. We remark that the series representation depends on the parity of the space dimension. We present and discuss some plots of the fundamental solution for some particular values of the dimension and of the fractional parameters $\alpha$ and $\beta$. Finally, using the fundamental solution we study some Poisson and Cauchy problems.

*Vinet, Luc*

**The Racah algebra as a finite W algebra and superintegrable models**

The Racah algebra which encodes the bispectrality of the Racah polynomials is known to be the symmetry algebra of the generic superintegrable model on the 2-sphere. The finite W algebra structure of this algebra will be identified by observing that it is the commutant of the $\mathfrak{o}(2)\oplus\mathfrak{o}(2)\oplus\mathfrak{o}(2)$ subalgebra of $\mathfrak{so}(6)$ in the universal algebra of the latter. The connection with the $\mathfrak{su}(1,1)$ Racah problem and the superintegrable model on the 2-sphere will be discussed on the basis of the Howe duality associated to the pair $(O(6),\, \mathfrak{su}(1,1))$.

*Vinitsky, Sergue*

**On generation of the Bargmann-Moshinsky basis of SU(3) group**

Generation procedures of the non-canonical Bargmann and Moshinsky (BM) basis with the highest weight vectors of SO(3) irreps is reviewed. An efficient procedure of orthonormalisation of the basis is examined using the known analytical formula of overlap integrals. Calculations of components the quadrupole operator between orthonormalised basis vectors needed for construction of nuclear models are tested.

*Visinescu, Mihai*

**Integrability of the geodesic flow on the resolved cones over Sasaki-Einstein space $T^{1,1}$**

We investigate the integrability of geodesics in the five-dimensional Sasaki-Einstein space $T^{1,1}$ and its Calabi-Yau metric cone. We construct explicitly the constants of motion and prove the complete integrability of geodesic motions. This property is also valid for geodesic motions on its Calabi-Yau metric cone. Having in mind that the metric cone is singular at the apex of the cone, we extend the analysis of integrability for resolved conifolds. It is shown that in the case of the *small resolution* the integrability is preserved, while in the case of the *deformation* of the conifold it is lost.

*Vourdas, A.*

**Phase space methods: independence of subspaces**

Quantum systems with finite-dimensional Hilbert space, are considered. The concepts of independence and totalness of subspaces are introduced in the context of quasi-probability distributions in phase space. It is shown that there are various levels of independence, from pairwise independence up to (full) independence. This is related to the non-distributivity of the lattice of subspaces. Pairwise totalness, totalness and other intermediate concepts are also introduced, which roughly express that the subspaces overlap strongly among themselves, and they cover the full Hilbert space. Applications of the formalism are discussed.

*Wang, Yupeng*

**Exact spectrum of the relativistic quantum Toda chain**

With the off-diagonal Bethe Ansatz method, the spectral problem of the relativistic quantum Toda chain is exactly solved. By taking the classical limit, we show that the spectrum of the classical Toda chain can also be obtained naturally.

*Wojciechowicz, karolina*

**Deformation of algebroid bracket of differential forms and Poisson manifold**

We construct the family of algebroid brackets $[\cdot,\cdot]_{c,v}$ on the tangent bundle $T^*M$ to a Poisson manifold $(M,\pi)$ starting from an algebroid bracket of differential forms. We use these brackets to generate Poisson structures on the tangent bundle $TM$. Next, in the case when $M$ is equipped with a bi-Hamiltonian structure $(M,\pi_1,\pi_2)$ we show how to construct another family of Poisson structures. Moreover we present how to find Casimir functions for those structures and we discuss some particular examples.

*Xenitidis, Pavlos*

**Deautonomization of integrable difference equations**

Integrability conditions for difference equations can be used not only to check the integrability of a given equation but also to compute its generalised symmetries and derive conservation laws. In this talk we explore one more application of these conditions: the construction of integrable non-autonomous equations. We demonstrate how the integrability conditions can be used to deautonomize a given autonomous equation and apply this procedure to a certain family of equations defined on an elementary quadrilateral of the $\mathbb{Z}^2$ lattice. In particular we show that all the non-autonomous equations we find are related via Miura transformations to the same integrable two-quad autonomous equation. Finally we prove the integrability of the latter equation by generating an infinite hierarchy of its symmetries using a local master symmetry.

*Yahalom, Asher*

**Metage Symmetry Group of Non Barotropic Magnetohydrodynamics and the Conservation of Cross Helicity**

Standard cross helicity is not conserved in non-barotropic magnetohydrodynamics (MHD) (as opposed to barotropic or incompressible MHD). It was shown that a new kind of cross helicity which is conserved in the non barotropic case can be introduced. The non barotropic cross helicity reduces to the standard cross helicity under barotropic assumptions. Here we show that the new cross helicity can be deduced from a variational principle using the Noether's theorem. The symmetry group associated with the new cross helicity is related to translation in a labelling of the flow elements connected to the magnetic field lines known as magnetic metage.

*Yanai, Shota*

**New harbor-type black hole solutions of a compact $Q$-shell model**

No-hair theorem is supposed to be a most elementary nature of black hole. Of course, there are several counterexamples such as the skyrmion hair. Another interesting example is so-called *a harbor* ; of which the black hole is surrounded by compact boson shells. We consider the configuration for compact $Q$-balls and $Q$-shells coupled to gravity in a $CP^{2n+1}$, $n \in \mathbb{Z}$ non-linear sigma model. The solutions are obtained within the Schwarzschild metric. We have found the harbor-type black holes which almost look like scalar hair solutions. Especially, for $n \to \infty$ the shell becomes large and thin which may involve a larger black hole.

*Yao, Ruoxia*

**Lump solution and bilinear Bäcklund transformation for the (4+1)-dimensional Fokas equation**

In this paper, we first obtain a bilinear form with small perturbation $u_0$ for the (4+1)-dimensional Fokas equation by an appropriate transformation. By using the Hirota bilinear operator, we construct the bilinear Bäcklund transformation which consists of three bilinear equations and involves four arbitrary parameters and then obtain a new class of lump solution including some free parameters for the (4+1)-dimensional Fokas equation based on the bilinear form. By choosing different values of the parameters, the dynamic properties of two different cases of lump solutions are shown graphically. From the graphs, we see some interesting nonlinear phenomena which might provide us with useful information on the dynamics of relevant fields in nonlinear science. Finally, the mathematical reason of lump solutions is analyzed by using the extreme value theory.

*Yates, Luke*

**Hidden supersymmetry and quadratic deformations of the space-time conformal superalgebra**

The non-appearance of predicted superparticles in high-energy particle experiments has placed severe constraints on candidate models of supersymmetry; in particular on the masses of the superpartners of known particles. Drawing on our earlier work investigating quadratic deformations of Lie superalgebras we present in this talk our recent findings that for certain extensions of space-time supersymmetries, namely the conformal superalgebra, there are representations without any superpartners (see J. Phys. A: Math. Theor. 51 (2018) 145203). This possibility arises due to a remarkable coincidence between the admissible quadratic extensions of the algebra, wherein a generalisation of the PBW theorem holds, and the minimal polynomial identity satisfied by generators of the even subalgebra.

*Yau, Hou-Ying*

**Time and Space Symmetry in a Quantum Field**

Despite nature's preference for symmetries, the treatment of time and space in quantum theory is not symmetrical. To restore the symmetry, we introduce an additional degree of freedom allowing matter to vibrate in the temporal direction. We find that a system with matters vibrating in time obeys the Klein-Gordon equation and Schrödinger equation. The energy in this system must be quantized under the constraint that a particle's mass is on shell. There is only a probability of finding a particle at a given location. In the non-relativistic limit, the vibrations in time can be related to the wave function in quantum mechanics but with an arbitrary phase difference. The emerged quantum wave can have physical vibrations despite the overall phase for the wave function is unobservable. The system can also be transformed to a quantum field via canonical quantization. This real scalar field has the same basic properties of a zero-spin bosonic field. Furthermore, the internal time of this system can be represented by a self-adjoint operator. The spectrum of this operator spans the entire real line despite the Hamiltonian of the system is bounded from below without contradicting the Pauli's theorem. By restoring the symmetry between time and space, we reconcile the quantum properties of a bosonic field.

*Yurduşen, İsmet*

**Higher-order superintegrable systems separating in polar coordinates**

Classical and Quantum mechanical superintegrable systems that are separating in polar coordinates are analyzed. The motion is restricted to a Euclidean plane $E_2$ and the additional integral is assumed to be a polynomial of degree $N \geq 3$ in momenta. Cases $N = 3, 4$ and 5 are investigated in detail. This leads to a general and unified description of higher-order superintegrability in the case of potentials allowing separation in polar coordinates.

*Zhang, Hechun*

**Generic representations of quantized coordinate algebras**

We classify all of the Laurent type irreducible representations of quantum coordinate algebras with generic parameter $q$. The irreducible modules are parametrized by the double Bruhat cells which are the so-called symplectic loaves of the Poisson algebraic group $G$.

*Zhdanovskiy, Ilya*

**Self-associated set of points and commutators.**

My talk is based on joint work with Kocherova A. (MIPT). Set of configurations of n points in projective space $P^k$ is a GIT-quotient $(P^k)^{\times n}/PLG_{k+1}$. Recall that there is a Gail involution on the set of configurations. Gale involution-fixed configurations are called *self-associated*. Self-associated configuration consists of 2k+2 points in $P^k$ with some geometric condition. Consider complete set of orthogonal projectors of rank 1, acting in $k+1$-dimensional vector space. It is easy that complete set of orthogonal projectors is given by $k+1$ points in $P^k$. Consider two complete sets of projectors of rank 1. In this case we get $2k+2$ points in $P^k$. We prove that configuration of $2k+2$ points is self-associated iff dimension of commutator space $[p_i, q_j]$ is less or equal $k(k+1)/2$. Also, I will say about connection of this result with flat connections, character varieties, representation theory.

*Zheng-Johansson, J.*

**Gravitational Radiation – A Solution based on Quantum Electromagnetism**

We represent a (large) mass $M$ as composed of IED particles whose total (internal) electromagnetic potentials sum to $\Phi, \mathbf{A}$, and fields to $\mathbf{E} = \mathbf{B} \times \mathbf{c}$, $\mathbf{B} = \boldsymbol{\nabla} \times \mathbf{A}$. Their depolarisation radiation fields can propagate freely and produce gravity. For a stationary $M$, we obtained earlier in a vacuum of a normalised susceptibility $\bar{\chi}_0$ the gravitational potentials $\Phi_g = -\frac{GM}{r} = -\frac{e}{m_p}\bar{\chi}_0^2\Phi$, $\mathbf{A}_g = -\frac{e}{m_p}\bar{\chi}_0^2\mathbf{A}$ and force fields $\boldsymbol{g}_0 = \boldsymbol{g}_0^\dagger \times \mathbf{c}$, $\boldsymbol{g}_0^\dagger = -\boldsymbol{\nabla} \times \mathbf{A}_g$. We consider now an accelerating $M$ of mass current density $\mathbf{j}_m$, and further obtain under Lorenz gauge the Poisson (field) equations, $\nabla^2 \mathbf{A}_g = 8\pi G \mathbf{j}_m / c^2$ for $\mathbf{A}_g$. The solutions contain transverse dipole, quadrupole radiative fields, $\boldsymbol{g}_1, \boldsymbol{g}_1^\dagger$, $\boldsymbol{g}_2, \boldsymbol{g}_2^\dagger$, etc. $\boldsymbol{g}_2$ say tensile deforms (polarises) by $u_{p2} = \delta D_2 \Psi_{p2}(t - \frac{r}{c})$ the vacuum about $r$ of a specific dimension $D_0 = ct_0$. Combining with the eom of a perturbed vacuum, we obtain the Lagrangian-Green's strain tensor $h_2 = \frac{2\delta D_2}{D_0} = \frac{2g_2}{\ddot{\Psi}_{p2} c t_0} = \frac{2G(\hat{r} \times \ddot{\mathbf{I\!I}} \times \hat{r}) \times \hat{r}}{\ddot{\Psi}_{p2} c^4 t_0 r}$, where $\mathbf{I\!I}$ is the second mass moment. The resultant $h_2$

and radiation energy are directly comparable with GR and the recent LIGO experimental results. The dipole term $h_1 = \frac{2g_1}{\ddot{\Psi}_{p1}ct_0}$ could account for the "glitch" observed in the LIGO experiment. The harmonic, quantum nature of dipole radiation can yet restrict a coincidence detection between interferometers too far apart, and even its general presence. This work has been motivated by Professor G 't Hooft.

*Zloshchastiev G., Komstantin*

**Master equation approach for non-Hermitian Hamiltonians: Original and phase-space formulations**

We consider evolution of dynamical systems described by non-Hermitian Hamiltonians, using the density operator approach. The latter is formulated both at the level of the Hilbert space and the phase space, with emphasis on applications to open quantum systems. We illustrate the formalism using a non-Hermitian Hamiltonian system, which is quadratic with respect to a momentum and position. Despite the initial simplicity of a Hamiltonian, the structure of its solutions and spectral characteristics are nontrivial, and they can drastically change depending on parameters of the model and its symmetry in phase space.

*Znojil, Miloslav*

**PT symmetry and perturbation theory**

In PT symmetric formulation of quantum theory [also known as the Dyson's three-Hilbert-space (3HS) formalism], unitary evolution is described via a simultaneous representation of a state $\psi(t)$ in an *ad hoc* triplet of Hilbert spaces $\mathcal{H}^{(1,2,3)}$. All equations are solved in the auxiliary, unphysical but user-friendliest Hilbert space $\mathcal{H}^{(1)} = \mathcal{H}^{(false)}$. The probabilistic predictions require a hermitization of the operators of observables, realized in the second, physical, sophisticated Hilbert space $\mathcal{H}^{(2)} = \mathcal{H}^{(standard)}$. Finally, a return to textbooks is mediated by the unitary equivalence between conventional $\mathcal{H}^{(textbook)} = \mathcal{H}^{(3)}$ and innovative $\mathcal{H}^{(2)}$. We will show that the study of influence of perturbations becomes an intrinsically nonlinear problem in this language. Making the conventional linear perturbation theory inapplicable, and invalidating also the recent claims of an intrinsic instability of certain generic PT-symmetric quantum systems.

*Zohrabi, Arezoo*

**Locally Conformally Cocalibrated $G_2$-Structure**

We study the condition in which $G_2$-structures are introduced by a non closed four-form, although they are satisfying locally conformal conditions.All solutions are found in the case when the Lee form of $G_2$-structures is non-zero and $\mathfrak{g}$ introduces seven-dimensional Lie algebras.A $G_2$-structure $(M^7, \varphi)$ on a seven-dimensional manifold $M^7$ can be characterized by the existence of globally 3-form $\varphi$ called fundamental 3-form. the classes of $G_2$-structures can be described in the terms of the exterior derivatives of fundamental 3-form $\varphi$ and the 4-form $\phi = *\varphi$ , where $*$ is the Hodge operator defined from metric and the derivative of $V_{g_\varphi}$, here we focus our attention on The class of locally conformally cocalibrated $G_2$-structures (usually denoted by L.C.CC $G_2$-structures), which are characterized by the condition $d\phi = -\theta \wedge \phi$ for a closed non vanishing 1-form $\theta$ also known as the Lee form of the $G_2$-structures.

*Zuevsky, A.*

**Foliations associated to vertex algebras**

For a smooth manifold we construct a foliation of associated to a grading-restricted vertex algebra. Such foliation is defined by means of the space of matrix elements for a vertex algebra. We study differential equations for the transition functions defining a foliation associated to a grading-restricted vertex algebra. We use the cohomology theory of grading-restricted vertex algebras in order to introduce the cohomology of corresponding foliation.

*Zusmanovich, Pasha*

**Hom-Lie and post-Lie structures on current and Kac-Moody algebras**

Hom-Lie algebras (under different names, notably "q-deformed Witt or Virasoro") started to appear long time ago in the physical literature, in a constant quest for deformed, in that or another sense, Lie algebra structures bearing a physical significance. The last decade has witnessed a surge of interest in them.
Post-Lie algebras is another kind of algebraic structures which was studied recently, and appear naturally in differential geometry and mathematical physics (Yang-Baxter equations).
We will describe Hom-Lie and commutative post-Lie structures on the following classes of Lie algebras: current algebras, and, more general, tensor products of algebras over Koszul dual operads, and affine Kac-Moody algebras. We will also discuss a question when Hom-Lie structures form a Jordan algebra.