Talks and abstracts - alphabet order (authors)

Tomáš Blažek

High-Energy Physics News 2022

Latest News from High-Energy Physics will be presented in a colloquial-type of talk.

Benedek Bukor

Simple systems in 3D noncommutative quantum mechanics

In this presentation, we examine energy spectra of two well-known quantum systems in standard quantum mechanics (QM) affected by introducing a noncommutative (NC) structure into the systems' configuration space. NC structure blurs the configuration space at short distances and the parameter in charge of describing the extent of this blur is λ. In the present case, we investigate the bound states of electron in the NC Coulomb potential and NC 3D isotropic harmonic oscillator. Since complete analytic result for the latter potential is unattainable, the radial WKB approximation is adopted. We calculate the energy of electron in the NC Coulomb potential of arbitrary-order and energy of the NC 3D isotropic harmonic oscillator of the second order in λ.

Frederik Ďalak

Lie derivative of linear connection

As we all know, one of the fundamental tools used in mathematical physics is the Lie derivative. Perhaps a less known fact is that, except for tensor fields, one can also compute the Lie derivative of a structure of linear connection ∇ on a manifold *M*. To introduce this concept we first show how to use a diffeomorphism *f* to create the pullback connection $(f^*\nabla)$ based on the connection ∇. Then we establish a tensor which carries the information about the difference of two connections. That will enable us to formulate the definition of the Lie derivative of linear connection. Finally we go trough some of its basic properties and outline its possible applications.

Tomáš Faikl

Spectral asymptotics of curved metamaterials

In this talk, we will examine essential spectrum of operators associated with negative-index metamaterial transitions. We will describe spectral behaviour of an indefinite Laplacian on a rectangle embedded into a Riemannian 2-manifold with constant curvature. This will be done using construction of singular sequences on this rectangle and also by examining limit form of the eigenequation given in terms of associated Legendre functions.

Marián Fecko

Galilean and Carrollian invariant Hodge star operators

Standard Hodge star operator is naturally associated with metric tensor. It is therefore invariant, on Minkowski spacetime, with respect to Poincaré transformations and is routinely used to succintly write down Poincaré invariant physics equations. In Galilean (Carrollian) spacetime, there is no Galilean (Carrollian) invariant metric tensor available.So usual construction of Galilean (Carrollian) invariant Hodge star does not work. One can, however, introduce an analog of the Hodge star operator which is Galilean (Carrollian) invariant. It may be used to write down Galilean (Carrollian) invariant physics equations, e.g. equations of Galilean (Carrollian) electrodynamics.

Marek Horňák

Gödel universe

In 1949 the Austrian mathematician Kurt Gödel discovered a remarkable special solution to the Einstein field equations of general relativity. A spacetime with the Gödel metric features several counter-intuitive effects. The aim of this lecture is to describe the sources in the Gödel universe, derive the optical effect of double image of a small object and demonstrate the existence of closed timelike curves. These curves may be perceived as worldlines of particles travelling in such a manner that at the end of the travel they return to the moment when they started, therefore these worldlines correspond to travelling back in time.

Goce Chadzitaskos

Space proper time manifold

Interchanging the function of time and proper time in space-time leads to interesting consequences. The flow of proper time is understood as the distance traveled by the spatial component of space-time, and the time is the distance traveled by a particle in a four-dimensional space. Some of the implications are discussed.

Juraj Kováč

Dissipation in the Boltzmann equation and beyond

How fast do dissipating systems approach (Maxwellian) equilibrium? Classical analysis of the Boltzmann equation uses advanced methods to argue that this occurs as $\mathcal{O}(t^{-\infty})$. This means that energy dissipation and entropy production in (certain) gases take place at a rate faster than any polynomial. We summarize this result, including its assumptions and applicability, and suggest a possible generalization to chemical kinetics.

Samuel Kováčik

The Fuzzy Onion

The fuzzy sphere model has been studied in great detail and it serves as a very simple example of a quantized space. A proposal how to connect various fuzzy spheres to form a 3D-space-filling object dubbed the fuzzy onion will be introduced.

Vladimír Kráľovič

Infrared finiteness of the NLO corrections to leptogenesis

Infrared divergences appear in quantum theories involving massless particles and complicate evaluation of the reaction rates. Therefore, it is crucial to somehow remove these divergences from our calculations. In this thesis we explore how we can use the S-matrix unitarity constraints for the cancelation of infrared divergences. Then we will use this approach to evaluate some reaction rates for the type-I seesaw model. This model involves only one type of massive particles at the relevant energetic scale (the right-handed Majorana neutrinos) and all standard model particles are considered massless.

Ondřej Kubů

Quadratic integrable systems in magnetic fields: the extended cylindrical and spherical cases

Integrable systems are special due to their high amount of first integrals and the subsequent exact solvability. Despite its relevance e.g. in plasma physics or the physics of charged particle beams, the magnetic field has been so far mostly omitted from these systems. In its presence, the pairs of quadratic integrals can have a more complicated form [Marchesiello and Šnobl 2022 J Phys A]. Here we present the classification of integrable systems for 2 physically relevant nonstandard pairs, namely the extended cylindrical and spherical ones.

Tereza Lehečková

(Super)integrability in Minkowski - classification and characterization

In this talk, we will focus on single-particle systems with electromagnetic field in Minkowski spacetime with polynomial integrals of motion. We will explore their structure and show how to systematically find and classify integrable systems (subalgebras of the Poincaré algebra, separation of variables). Finally, we will give examples of special superintegrable cases in these classes of integrable systems in 2+1 Minkowski with their solutions and properties.

Martin Malachov

Analogue of Mandelbrot set for chaotic purification protocols.

Purification protocols form an important part of quantum information and communication theories because they can help sustain and reliably perform calculations and communication within quantum computers. One of protocols was shown to exhibit chaotic behaviour in sense of exponential sensitiveness to initial conditions. We propose and study wider class of protocols and show how the chaotic features of the particular physical protocols connect to the theory of chaos, including famous Mandelbrot set, and discuss the practical potential of the protocols.

Filip Moučka

Courant algebroids and Palatini formalism

Standard Palatini formalism is a way how to justify the use of the Levi-Civita affine connection for general relativity. We have developed the “generalized” Palatini formalism, which justifies the concept of Levi-Civita Courant algebroid connections. For the case of exact Courant algebroids, the corresponding equations of motion precisely coincides with the bosonic part of type IIB Supergravity equations.

Petr Novotný

How to distinguish Lie algebras

Classification and identification of Lie algebras is still open question. Complete classification is known only for simple Lie algebras. Other types are completely classified up to dimension six. We present overview of invariant characteristics of Lie algebras usually used during classification process and demonstrate how they distinguish non--isomorphic Lie algebras.

Magdalena Parýzková

Percolated two-walker discreet-time quantum walks

Dynamically percolated graphs are graphs where at every time step of the quantum walk some of the edges can get randomly broken. Dynamical percolations then can be used to simulate systems with possible imperfections. There is an existing formalism that allows us to analytically investigate the asymptotic evolution of such systems. Using this, some of the interesting properties of several of these systems for single-walker quantum walks have already been revealed. Namely, for some graphs, the possibility of broken edges causes improvement of the systems' transport properties. The first part of this talk will introduce the aforementioned formalism and the second will then continue with an investigation of the special case of Hadamard walk of two walkers in one dimension.

Václav Potoček

Quantum local time

The trajectory of a quantum particle during unitary evolution between its preparation and a later measurement can not be studied without measuring the particle, but measurement disturbs the state and the statistics of the measurement outcomes no longer pertain to the original evolution. We show how using path integral methods and a generalized weak measurement scheme a sensible quasi-probability can be assigned to the event of passing multiple points along a path, or to entire trajectories, in a position- and time-discrete system. We use the quasi-probability to define a quantum version of local time, a random variable studied in random processes. Taking this approach, a broad range of statistical properties of quantum local time can be studied. We illustrate the theory on a discrete-time quantum walk on a line, where we introduce the notions of weak recurrence and weak Pólya number.

Stanislav Skoupý:

Search and state transfer by means of quantum walk in a graph with fully connected vertices

We present search and state transfer algorithms based on discrete and continuous time quantum walks on general graph. Then we present results from Razzoli, Bordone and Paris for search and state transfer for fully connected vertices using continuous-time quantum walk. Using analogous methods in discrete-time algorithms we show that perfect state transfer is achieved between fully connected vertices, but the search algorithm does not find fully connected marked vertex with unit probability.

We show that by modifying the weight of the loop at marked vertex we can improve success probability of the search close to one on d-regular graphs.

Matyáš Staněk

Fano diagonalization applied to surface plasmon polaritons

Fano diagonalization is a technique used to treat systems with discrete and continuous energy levels. As an example, we introduce a surface plasmon polariton - a surface electron density coupled to an electromagnetic wave. The method can be used simplify the corresponding Hamiltonian to a simple harmonic oscillator.

Rudolf Šmolka

Algebraic Phylogenetics

The advent of high-throughput techniques in biology at the turn of the millennium resulted in a huge increase in the amount of quantifiable biological data. The interpretation of this data, in turn, presents many new and interesting challenges in mathematics. The aim of this talk is to illustrate the use of algebraic geometry in phylogenetics — the study of the evolutionary history of species. In particular, after recalling some relevant background, we will see that evolutionary models can be regarded as (the points of) certain algebraic varieties.

Daniel Štěrba

Asymptotic dynamics of open quantum systems

A quantum system in contact with the environment typically represents a system too complex to be properly analyzed using the traditional framework of closed systems quantum mechanics. Fortunately, reasonable simplifications exist which at least make it feasible to study the asymptotic limit. The talk aims to introduce a suitable model of Markovian time evolution of open quantum systems and discuss some of its relevant properties.

Karel Tesař

Incomplete phase transition and anisotropy in titanium

In terms of our imperfect world, the phase transitions often do not manifest in the entire specimen volume at once. Rather, the nucleation sites of a new phase, stable at current external and internal conditions, are connected with lattice imperfections, strain localization or sites with different impurity content. The procedure of such a transformation is to form nucleation centres and then the new, thermodynamically more favourable phase, is to grow until the entire specimen is transformed. This process is very fast for some materials and quite slow for others. If the process is interrupted before it is completed a so-called volumetrically incomplete phase transition is achieved. In metals, such processes are often detrimental to the properties. The question arises, whether this phenomenon can be utilized for materials, where the presence of localized sites of different chemistry or crystal structure would be highly beneficial. This type of phase transition, together with the study of external and internal anisotropy of highly deformed titanium, will be presented.

Lukáš Vácha

The Klein paradox

The talk deals with scattering problem for the Dirac equation. In particular, reflection and transmission coefficient for the step-like, rectangle, and delta potentials are calculated. An unexpected dependence of these coefficients on energies, known as the Klein paradox, is discussed. Finally, we compare the scattering coefficients for the delta interaction and its approximation by scaled rectangular potentials.

Viktor Zaujec

CPT and unitarity constraints for CP asymmetries at finite temperature

This contribution presents a bottom-up approach to quantum thermal effects in higher-order CP asymmetries within the seesaw type-I leptogenesis. It is demonstrated that including perturbative corrections to the zero-temperature description of the interactions inconspicuously induces quantum effects in the Boltzmann equation. Thermal mass and quantum statistics within the top Yukawa corrections to the right-handed neutrino rates are obtained as an example.

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