2025 Talks and abstracts - alphabet order (authors)

Tomáš Blažek

Recent results on New Physics searches in High-Energy Experiments

A review will be given with emphasis on results from the NA62 Experiment. No clear signal of New Physics has been found yet despite a great effort to discover, e.g. a laboratory evidence of dark matter. The data acquisition and analyses are ongoing.

Sebastian Brezina

Classical gauge theories and gravity

It belongs to folklore that electromagnetic, electroweak, and strong interactions are understood as gauge theories. In contrast, the situation regarding gravitational interaction is often considered more complex. Since the 1960s, this complexity has led to extensive research on the question: Can gravity be understood as a gauge theory?

In this talk, we explore a framework for describing classical gauge theories developed by Andrzej Trautman in the 1970s. This framework utilizes the theory of Ehresmann connections on principal G-bundles. Within the framework, gravity can be understood as a classical gauge theory, where the metric tensor field is treated as a classical Higgs field. One significant advantage of this framework is that it enables the description of gravity and gauge theories of internal symmetries using the same mathematical formalism. This unification leads to a deeper understanding of the crucial geometrical differences between these two distinct classes of classical gauge theories, which have non-trivial physical implications.

Marián Fecko

Space-time formulations of Galilean and Carrollian electrodynamics

As was shown in 1973, there are two Galilean limits of standard (Lorentzian) electrodynamics, the so-called electric and magnetic. Similar fact holds for Carrollian electrodynamics (2014). In the language of space-time differential forms, Galilean magnetic and Carrollian electric versions can be treated if we introduce the corresponding analogues of the Hodge star operator. All four versions may be described in terms of Galilean and Carrollian linear connections. Specific features of variational formulations are also discussed.

Goce Chadzitaskos

Parabolic cylinder functions as orthonormal bases on L^2(R^+) and L^2(R)

In addition to orthogonal polynomials, orthogonal functions also play an important role and have a wide range of uses. They are related to the solution of differential equations. In this contribution we present the explicit form of one parameter families of orthonormal bases on spaces L^2(R^+) and L^2(R). The bases are formed by eigenvectors of the self-adjoint extension of Schrödinger operator of the asymmetric harmonic oscillator. For each parameter the set of eigenvectors form an orthonormal basis on L^2(R^+) or L^2(R). The Hermite polynomials are done by special parameters.

Martin Kováč

Hamiltonian Formulation of Teleparallel Gravity

The standard approach to obtaining the Hamiltonian formulation of general relativity is through the ADM formalism, which involves splitting the spacetime metric into a lapse function, shift vector, and spatial metric. It turns out that only the spatial metric appears in the Lagrangian with time derivatives, while the lapse and shift do not. This indicates that they are not dynamical variables and leads to the emergence of constraints. In this talk, we introduce the ADM formalism and then we explore the Hamiltonian formulation of teleparallel gravity.

Martin Krššák

Gravitational Instantons

Instantons are solutions of the classical field equations with finite Euclidean action, playing an important role in path integral quantization and in understanding the non-perturbative aspects of the corresponding theories. Examples include the self-dual BPST instantons in the Yang–Mills theories and the Gibbons–Hawking instanton in general relativity. In this talk, I will present new instanton solutions in the teleparallel formulation of general relativity, which enable the construction not only of the Gibbons–Hawking instantons but also of gravitational analogues of self-dual BPST instantons.

Peter Mészáros

Schwarzschild spacetime with extra compact dimensions

There are two branches of 1+(3+n)-dimensional spacetimes with (1+3)-dimensional part corresponding to spherically symmetric spacetime and with Euclidean symmetry in n extra dimensions which satisfy vacuum Einstein field equations. One branch is a trivial extension of the Schwarzschild spacetime, while the second branch is nontrivial. The extra dimensions may be compactified, so that, in principle, these solutions may be relevant in our (1+3)-dimensional Universe. We will discuss some unusual features of the nontrivial case, based on tests through Newtonian limit, Kretschmann scalar invariant, and conserved energy defined through Landau-Lifshitz stress-energy pseudotensor.

Jan Masák

Emergent gravity

I will review several approaches to the emergence of general relativity. The talk will begin with a brief overview of the four laws of black hole dynamics and how the generalized second law of thermodynamics motivates entropy bounds. I will then discuss different types of entropy bounds, focusing in particular on Bousso's bound, which is widely regarded as the most successful. This will lead to the holographic principle and its realization in the AdS/CFT correspondence. The main part of the talk will focus on Jacobson's and Verlinde's approaches to emergent gravity. I will conclude by discussing the role of generalized entropies in this context and how they can lead to modifications of the Friedmann equation.

Filip Moučka

Symmetric Poisson structures and where to find them

I will introduce symmetric Poisson structures: symmetric bivector fields satisfying a specific integrability condition. I will explain how this new framework extends (pseudo-)Riemannian geometry and show the geometric interpretation of symmetric Poisson structures. I will illustrate the theory on several interesting examples.

Petr Novotný

Classification of standard Manin triples and corresponding Drinfeld doubles in dimension 4+4

Drinfeld doubles and Manin triples have been systematically used in Poisson-Lie T-plurality, integrable systems, string backgrounds, and generalized geometry. The classification of these structures is known up to dimension 3+3. In higher dimensions, there are only isolated examples in the literature. We present a classification of a certain class of so-called standard Manin triples in dimension 4+4.

Magdalena Parýzková

Measures of Non-Classicality for Quantum Optical States

Non-classical states of light, such as Fock states or squeezed states, play a central role in quantum optics and are essential resources for quantum technologies, including quantum computation, secure communication, and metrology. Traditionally, they are defined as states of light that cannot be described by classical electromagnetic theory. However, this description is often impractical for determining non-classicality in real situations. Consequently, many different definitions and quantifiers of non-classicality and quantumness have been suggested in the literature over the years. This talk aims to first introduce key concepts and then give an overview of various theoretical approaches to defining and quantifying the non-classicality of quantum states of light.

Ján Pulmann

Quantum observables and topology

In some quantum field theories, one can study Wilson lines and other observables with extended support. Such observable is called topological if its expectation value is independent of small deformations. By considering collisions, interfaces etc., the set of topological observables acquires an interesting mathematical structure of an E_n algebra. In this talk, I will review these notions, focusing on the example of Wilson lines of Chern-Simons theories. If time permits, I will also comment on semiclassical side of this story and quantization.

Daniel Račko

Cosmological perturbations in universe with anisotropy

We present a cosmological model in which a so-called anisotropic solid remnant is present in the early post-inflationary Universe dominated by radiation. This model is inspired by a multifield inflation model called solid inflation and its generalizations with matter described through a triplet of fields. In our model, the internal full global Euclidean symmetry of this triplet is broken, which leads to an anisotropic expansion of the Universe. We study the effect of the anisotropic solid remnant on superhorizon scalar, vector, and tensor perturbations.

Dominik Rist

Connections at Higher Altitudes

Ordinary gauge theory describes fields as connections on principal bundles, with field strengths represented by their curvatures. Higher gauge theory extends this framework to incorporate higher-form fields, which arise naturally in various contexts of mathematical physics. Geometrically, these correspond to connections on higher, or categorified, principal bundles. However, climbing higher than gauge theory is a demanding task and requires the appropriate equipment.
In this talk, I will give a pedagogical introduction to higher gauge theory, outlining both the known challenges and recent advances in its formulation.

Stanislav Skoupý:

Simulation of a quantum walk on hypercube using a quantum computer

Quantum walks are quantum analogues of classical random walks, where the evolution of a quantum particle is influenced by interference and superposition, leading to different probability distributions compared to its classical counterpart. We introduce a model of discrete-time quantum walk with coins and present its implementation on a hypercube graph. The hypercube is a graph with a natural mapping of vertices to binary register. We use this to implement the simulation of a quantum walk on the hypercube on an IBM quantum computer. We show that current IBM quantum hardware is not yet suitable to simulate quantum walk properly and it starts to deviate from expected results after very few steps of the walk for hypercube dimension 4.

Rudolf Šmolka

Frobenius Theorem for Graded Manifolds

One of the fundamental theorems in differential geometry, the Frobenius theorem is often stated in two parts. The so-called local Frobenius theorem states that a smooth distribution is involutive if and only if it is integrable. The so-called global Frobenius theorem then states that every integrable distribution is given by a unique regular foliation. In this talk we revisit the theorem in the category of Z-graded manifolds, though the discussion applies to other gradings as well. We will see that one needs to be careful with the definition of integrable distribution and integral sumbanifold. These can be given in several ways that are equivalent in non-graded geometry, but not so in graded geometry.

Martin Štefaňák

Recurrence of unitary and stochastic quantum walks

Recurrence means a return of the dynamical system to its initial state. Classical result of Polya [1] from 1920's shows that a random walk on a line and a 2D grid returns to the origin with certainty, while it is transient on higher-dimensional lattices. For quantum walks, detection of recurrence requires partial measurement after each step, yielding a conditional quantum dynamics. We review the method to study quantum recurrence based on generating functions [2], focusing on the quantum walk on a line. Combination of measurement induced effects and faster spreading implies that a quantum walk on a line can escape to infinity without ever returning to the origin. Finally, we present a recent extension of the study of recurrence to quantum stochastic walks [3], which interpolates between quantum and classical walk dynamics [4]. Surprisingly, we find that introducing classical randomness can reduce the recurrence probability --- despite the fact that the classical random walk returns with certainty --- and we identify the conditions under which this intriguing phenomenon occurs.

[1] G. Pólya, Math. Ann. 84, 149 (1921)

[2] F. A. Grünbaum, et al., Commun. Math. Phys. 320, 543 (2013)

[3] F. A. Grünbaum and L. Velázquez, Advances Math. 326, 352 (2018)

[4] M. Štefaňák, et al., arXiv:2501.08674

Vojtěch Vanc:

Knotted classical fields

We present special configurations of electromagnetic fields and fluids whose streamlines exhibit non-trivial topology. The degree of entanglement of the field lines, quantified by the helicity, is closely related to the Gauss linking integral and linking number. Finally, we investigate a possible connection between these configurations and their spinor representations via conformal transformations.