The 27th Student Conference "Winter School on Mathematical Physics"

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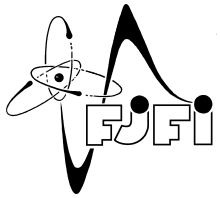
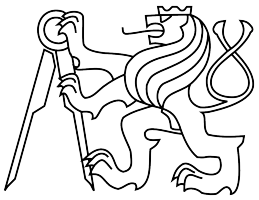
Book of Abstracts





Krzysztof Bardadyn
Characterisations of Amenable Groups

The idea of an amenable group appeared first in von Neumann dissertation from 1929 in response to the Banach-Tarski paradox. Amenable groups occur and play an important role in many areas of mathematics such as ergodic theory, harmonic analysis, representation theory, dynamical systems, geometric group theory, probability theory and statistics. In contrast to non-amenable groups, they can be viewed as well behaved, non-pathological objects. The amenability property has a large number of equivalent formulations. In my lecture I will prove equivalence of some important descriptions of this notion for discrete groups.

Adam Brus
Multivariate Chebyshev-like polynomials of second and fourth kind

With use of multivariate trigonometric functions the classical Chebyshev polynomials of second and fourt kind are generalized to orthogonal polynomials of several variables. Furthemore the general recurence relations are obtained. In dimension three some of the first polynomials are shown.

Tomasz Czyżycki
Tau method and its applications to differential equations

The tau method called also Lanczos approximation method is the method of searching for approximate solutions of e.g. differential equations in the form of finite sum of functions from a given family (basis). A main idea is to approximate the solution of a given problem by solving exactly an approximate problem. We discuss tau method in one-dimensional case and also present two-dimensional examples.

Magdalena Dąbrowska
Copulas - basic properties and examples

Copulas are functions that join multivariate distribution functions to their one-dimensional marginal distribution functions. They have many applications, for example in finance, insurance and random vector generation. In my presentation I will say about some properties of copulas and quote Sklar's theorem, which is central to this theory.

Marián Fecko
Vector analysis in 3 and 2 dimensions

3-dimensional vector analysis, which is a standard tool for huge amount of physics, is pretty well-known to be expressible, with a profit, in the language of differential forms. When trying to repeat the same steps in 2-dimensional case, one encounters perhaps a bit richer situation than naively expected.

Marie Fialová
Spectrum of Dirac operator with a translationally invariant potential

The direct integral decomposition is a convenient tool for spectral analysis of differential operators with a translationally invariant potential. Using this tool the spectrum in the case

of Hamiltonian of a relativistic particle moving in the field of parallel magnetisation will be described. The result will be then interpreted in the connection with a simplified classical model.

Jaroslav Kňap
Weyl gravity and its comparison with General Relativity

Weyl's theory of gravity, also known as conformal theory of gravity, is a conformally invariant analogy of the general theory of relativity in four dimensions. Recently it has emerged as the centerpiece of interest because it is can be considered to be an appropriate extension of the conventional Einstein-Hilbert action. We show the basic features of Weyl gravity with emphasis on its differences from the general theory of relativity.

Jan Kotrbatý
Octonions and physics

Generalizing further the idea of complex numbers, the octonions are octets of a real and seven independent imaginary parts. They form the largest of the only four normed division algebras. Despite lack of commutativity and even associativity, they embody numerous interesting connections not only to various areas of mathematics but also to mathematical physics. Within the talk, the octonions are introduced at first and then their role in the Hopf fibrations, Lie theory, and the Standard Model, respectively, is discussed.

Tereza Kurimaiová
The first Robin eigenvalue with negative boundary parameter

We introduce the self-adjoint Robin Laplacian with negative boundary parameter and some of the properties of its spectrum. Of our main interest will be the isoperimetric spectral inequality for the first eigenvalue which is the only known example where the ball is not an optimiser. Finally, we will present an attempt to prove that the annulus is the optimiser using the so called parallel coordinates.

Pavel Lokvenc
Continuous contractions and invariants of Lie algebras

A Rigorous definition of an one-parametric continuous contraction will be given. A number of invariants will be proposed and there will be show how this invariants behave under contraction. Lists of all possible proper and nontrivial continuous one-parametric contractions of complex Lie algebras up to a dimension four will be clearly illustrated.

Martin Malachov
Box-counting and chaos in quantum distillation

Entanglement distillation is a key process to successful quantum computation and communication. One of protocols aiming on entanglement distillation has been shown to exhibit chaotic features when acting on certain physical states. Since this type of inherent chaos is new to quantum theory we focus on studying and describing the protocol action on wider set

of states, namely mixed two-qubit states. To do so we implement numerical methods including box-counting concept in order to characterise asymptotic dynamics. We present concept of box counting-dimension in detail as a useful numerical tool, later we use it to manage and understand chaotic dynamics of mixed states in terms of phase transitions.

Jan Mazáč
On the self-similarities of cut-and-project sets

Among the commonly used mathematical models of quasicrystals are Delone sets constructed using a cut-and-project scheme, the so-called cut-and-project sets. A cut-and-project scheme $(\mathcal{L}, \pi_1, \pi_2)$ is given by a lattice $\mathcal{L}$ in $\mathbb{R}^s$ and projections π_1, π_2 to suitable subspaces V_1, V_2. In this paper we derive several statements describing the connection between self-similarity transformations of the lattice and transformations of its projections $\pi_1(\mathcal{L})$, $\pi_2(\mathcal{L})$. For a self-similarity of a set Σ we take any linear mapping A such that $A\Sigma \subset \Sigma$, which generalizes the notion of self-similarity usually restricted to scaled rotations. We describe a method of construction of cut-and-project schemes with required self-similarities and apply it to produce a cut-and-project scheme such that $\pi_1() \subset \mathbb{R}^2$ is invariant under an isometry of order 5. We describe all linear self-similarities of this scheme and show that they form an 8-dimensional associative algebra over the ring $\mathbb{Z}$. We perform an example of a cut-and-project set with linear self-similarity which is not a scaled rotation.

Josef Navrátil
Skew-symmetric reaction-diffusion systems

Skew-symmetric reaction-diffusion systems satisfying assumptions guaranteeing Turing's instability and supplemented by unilateral terms of a type v^- and v^+ will be introduced. The presence of unilateral terms induces an existence of critical points and sometimes also bifurcation of stationary spatially non-homogeneous solution for rates of diffusion for which it is excluded without any unilateral term. The main tool in an analysis of these systems is a variational characterization of the largest eigenvalues of positively homogeneous operators and consequently a proof the bifurcation from these eigenvalues.

Radek Novák
Kramers-Fokker-Planck equation with a short-range potential

In this talk we study the equation describing the Brownian motion, the Kramers-Fokker-Planck equation, with a potential whose gradient tends polynomially fast to zero at the infinity. For this class of short-range potentials in one position variable, we obtain the low-energy resolvent asymptotics, which gives us the large-time asymptotics of solutions to the KFP equation in appropriate spaces. These are expressed in terms of the equilibrium state, the Maxwellian.

Ivo Petr
Secret sharing schemes

Let a natural number S represent a secret information. A secret sharing scheme is a scheme that allows to derive and distribute pieces of information about S to n parties, such that

knowledge of k or more pieces makes uniquely S computable, while knowledge of $(k-1)$ or less pieces leaves S completely undetermined. In the talk we introduce the secret sharing problem, describe schemes that allow to solve this problem and emphasize their security and effectiveness.

Nina Jeanine Rutten
Calculus of the Kontsevich unoriented graph complex

The unoriented graph complex Gra is a particular example of a differential complex. Consider the set of finite graphs without multiple edges and without loops, each on an unlabeled set of vertices and with a wedge-ordered set of edges. Vector space Gra is the vector space of formal sums of such unoriented graphs. This vector space Gra inherits a bi-grading corresponding to the number of vertices and the number of edges in the graphs. With respect to this bi-grading there is a differential defined on this vector space so that Gra forms a differential complex. Kontsevich related this unoriented graph complex Gra to Poisson geometry. Namely, cocycles in this complex induce universal infinitesimal deformations of Poisson structures on affine manifolds.

In this talk we prove the defining property for the differential: dd=0, and we illustrate with an example that d(zero graph)=0 (a necessary condition for d to be well defined). Here a zero graph is a graph equal to minus itself due to a symmetry that matches the wedge-ordered sets of edges in such a way that the ordering of matched edges differs from the initial one with a parity odd permutation. There is also a Lie bracket defined on this space Gra and we shall make one or two remarks about that. We shall conclude with an overview of our results, concerning this graph complex Gra and the (related) oriented graph complex, presented in the papers arxiv: 1710.00658, 1710.02405 and 1712.05259 (written by R. Buring, A. V. Kiselev and N. J. Rutten).

Bernard Rybołowicz
On group objects in a monoidal category

In my talk I will introduce the notion of a monoidal category. Next I will try to convince the audience that one cannot speak about a group without introducing the definition of a comonoid.

Iveta Semorádová
Quantum square well with logarithmic central spike

Singular repulsive barrier $V(x) = -gln(|x|)$ inside a square well is considered. Rayleigh-Schroedinger perturbation theory is shown to provide a closed-from spectrum at the sufficiently small g or after and amendment of the unperturbed Hamiltonian. Further, numerical solvability and analytic regularization of the singularity of this model are discussed.

Stanislav Skoupý
Szegedy's quantum walk search algorithm on regular graphs

We introduce the quantum search algorithms and describe the scheme of the search algorithm based on Szegedy's quantum walk. We present the results for the search to be optimal

on regular graphs proved by Szegedy. Then we show new theorem for the optimality of the Szegedy's quantum walk search algorithm and we brie y describe the proof.

Jan Šmejkal
Bending and twisting of quantum waveguides

We discuss the effects that shape perturbation, namely bending and twisting, has on the spectrum of an infinite quantum waveguide, which is modelled by a time-independent Schrödinger equation with a Dirichlet boundary condition. Next, we propose a model a of a finite waveguide with Dirichlet and Neumann boundary conditions and using the minimax principle show that any twisted waveguide has a higher ground state energy than a straight waveguide.

Vojtěch Šmíd
Analytic aspects of domain perturbations due to twisting

In this talk, we will introduce the method of multipliers which represents a valuable tool in the theory of elliptic partial differential equations. We will apply this technique to derive the conditions which guarantee emptiness of point spectrum of a Schrödinger operator in three dimensions and higher.

Tereza Štefková
Quantum walks on directed lattices

Quantum walks represent a quantum-mechanical counterpart of classical random walks. In this lecture we focus mainly on two special cases of two-dimensional quatum walks on the so-called Manhattan lattice and L-lattice that represent Cartesian lattices with directed edges. We deal with homogeneous quantum walks for which we derive conditions on the coins that lead to the effect of trapping.

Daniel Štěrba
ADM formalism in general relativity

Arnowitt-Deser-Misner formalism is a designation for hamiltonian formulation of general relativity. It describes the dynamics of gravitational field as a hamiltonian system using techniques of classical field theories. The ADM approach is based on foliation of spacetime into a family of spacelike hypersurfaces and description of its geometry in terms of suitably chosen variables of the resulting 3+1 setup. Interesting in its own right, ADM formulation also plays an important role in numerous modern theories of quantum gravity and in numerical relativity.

Zlata Tabachová
Transfer entropies

A central task in analyzing complex dynamics is to determine the location of information storage and information flows within a system. In recent decade the concept of transfer entropy was developed and frequently discussed. In my talk I will derive classical transfer entropy from the Shannon entropy and conclude with its generalization obtained from a

one-parametr family of information measures currently known as Rényi entropies. The Rényi entropy selectively emphasizes only certain sectors of the underlying empirical distribution while strongly suppressing others. Therefore it provides a powerfull tool for analyzing nonlinear information flows and interactions in complex systems.

Michal Tichý
Diffusion equation and symmetries of differential equations
There are many models of diffusion. The equation of Fick's diffusion having the same form as the heat equation is not a physically correct model. The non-linear diffusion equation is more difficult partial differential equation but using symmetry methods it can be easily solved. One of the symmetries of this equation is the scale symmetry and invariant solution corresponding to this symmetry has better physical interpretation.

Patrik Urban
Effective action in field theories
Firstly a brief introduction to a path integral formulation of quantum theory will be given. Afterwards, a concept of effective action as an analogue of the classical least action principle will be introduced. After discussing some basic properties, an effective action of a linear harmonic oscillator will be calculated.

Kateřina Zahradová
Spectral analysis of quantum nanoribbons
Quantum nano-ribbons represent a fine example of quantum waveguides and find many applications in modern physics. In this lecture, we will focus on defining the concept of quantum nano-strips in any dimension, the correct introduction of a quantum Hamiltonian and several known spectral results for three-dimensional quantum nano-ribbons. Additionally, some of those results will be generalized to higher dimensions.

Václav Zatloukal
Shape tensor and geometry of embedded manifolds
The shape tensor is a convenient tool for description of both intrinsic and extrinsic properties of embedded manifolds. I provide its definition, using the language of geometric algebra, and show how it gives rise to familiar differential-geometric notions, such as parallel transport, covariant derivative, and curvature. The relevance of combining intrinsic and extrinsic geometry will be briefly discussed in connection with attempts to unify gravity and the Yang-Mills theories.

Karolina Żukowska
Combining intrinsic and extrinsic geometry with the shape tensor
In the beginning I will recall some basic definitions from differential geometry such as Poisson manifold $(M, \{\cdot,\cdot\})$, Lie-Poison bracket, Casimir function and bi-Hamiltonian structure. I will also present some theorems about tangent lifts of the Poisson structure and apply them to the example of the bi-Hamiltonian structure related to the Lie algebra $\mathfrak{so}(3)$.

Monday 22.1.	Tuesday 23.1.	Thursday 25.1.	Friday 26.1
9:00 Novák 30	9:00 Fecko 50	9:00 Zatloukal 30	9:00 Malachov 30
9:35 Kotrbatý 30	10:00 Żukowska 30	9:35 Czyżycki 30	9:35 Semorádová 30
10:10 Navrátil 30	10:35 Rybołowicz 25	10:10 Petr 30	10:10 Skoupý 30
11:00 Zahradová 25	11:20 Dąbrowska 25	11:00 Fialová 25	11:00 Urban 25
11:30 Šmíd 25	11:50 Bardadyn 25	11:30 Kňap 25	11:30 Kurimaiová 25
12:00 Štefková 25		12:00 Tabachová 25	12:00 Šmejkal 25
	15:20 Rutten 30		
	16:00 Mazáč 25		
	16:30 Tichý 25		
	17:00 Štěrba 25		
	17:30 Lokvenc 25		