The VA^2MP meeting

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→ Book of Abstracts ←

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Integrable vortices on a plane: the utility of non-canonical theories.

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Abstract: We explore the BPS vortices+walls on a plane in Abelian-Higgs models with field-dependent kinetic terms. We argue that such theories provide the most natural playground for solitonic solutions as they accommodate multiple phases. As a case study, we present the so-called Bradlow models where domain walls, anti-walls and vortices exist simultaneously as BPS integrable solutions to the equations of motion.

Soft quantum waveguides

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Abstract: The topic of this talk are soft quantum waveguides described by a two-dimensional Schrödinger operators with an attractive potential in the form of a channel of a fixed profile built along an infinite smooth curve which is not straight but it is asymptotically straight in a suitable sense. Using Birman-Schwinger principle we show that the discrete spectrum of such an operator is nonempty if the potential well defining the channel profile is deep and narrow enough. Some related results and questions to be addressed are also mentioned.

Classical and quantum coherences in photonic quantum networks

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Abstract: Discerning quantum and classical features in a real-world scenario is an intriguing task, especially when the system under scrutiny has many degrees of freedom. In optics the notion of coherence is of central importance, and it also comes in two flavours: classical and quantum. In this talk I will present a simple yet powerful technique to study and discern classical and quantum coherences in a photonic quantum network, an object that may encompass a large number of modes, all possibly spatially separated. Finally, I will outline the experimental results from the application of this technique to photonic networks implemented in the time-domain.

The work was done in collaboration with Thomas Nitsche, Sonja Barkhofen, Evan Meyer-Scott, Syamsundar De, Johannes Tiedau, Jan Sperling, Igor Jex, & Christine Silberhorn.

Dirac Materials as playgrounds of high-energy theory

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Abstract: The pioneering work of our group at Charles University, on reproducing scenarios of high energy theoretical physics on Dirac materials, like graphene, will be discussed. The main goal will be to explain how versatile these systems are, and how far and wide into the hep-th territory we can explore with them. I shall review why these materials lend themselves to the emergence of special relativistic-like matter and space. Then the focus will be on the emergence of curvature. I shall show why the low dimensions (2+1), and Weyl symmetry, are crucial to identify the specific arrangements that realize a Unruh-kind of phenomenon. A variety of other interesting scenarios, that include the BTZ black hole and de Sitter spacetime, will be mentioned, including brief comments on how far we went in the direction of experiments. I shall then conclude by just listing some fresh results: from the time-loop to spot torsion (see Pablo Paiss talk), to the generalized uncertainty principle stemming from and underlying (lattice) length; from a model of grain-boundaries and their relation to (A)dS and Poincar spacetime algebras, to Unconventional Supersymmetry and the role of the two Dirac points.

Omnidirectional transmission of Dirac fermions on two-dimensional electrostatic barriers

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Abstract: We use the Wick-rotated time-dependent supersymmetry to construct models of two-dimensional Dirac fermions in presence of an electrostatic grating. We show that there appears omnidirectional perfect transmission through the grating at specific energy. Additionally to being transparent for incoming fermions, the grating hosts strongly localized states.

Opening of spectral gaps for periodic quantum graphs

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Abstract: In the talk we discuss a mechanism of opening of spectral gaps for periodic quantum graphs. Namely, let Γ be an arbitrary Z^n-periodic metric graph, which does not coincide with a line. We consider the Hamiltonian H_ϵ on Γ with the action $-\epsilon^{-1}\frac{d^2}{dx^2}$ on its edges; here ϵ is a small parameter. We show that under a suitable choice of vertex conditions the spectrum of this operator has gaps as ϵ is small enough. We demonstrate that the asymptotic behavior of these gaps and the asymptotic behavior of the bottom of the spectrum as $\epsilon \to 0$ can be completely controlled through a suitable choice of coupling constants standing in those vertex conditions. We also show how to ensure for fixed (small enough) ϵ the precise coincidence of the left endpoints of (finitely many) spectral gaps with predefined numbers.

1. A. Khrabustovskyi, Periodic quantum graphs with predefined spectral gaps, J. Phys. A: Math. Theor. (2020), DOI: 10.1088/1751-8121/aba98b

How to compute functional determinants

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Abstract: In some areas of physics, it might be of interest to consider a generalization of the notion of the matrix determinant to infinite-dimensional operators. We consider two types of operators on the finite interval with Dirichlet boundary conditions – the operator connected with the damped wave equation and the polyharmonic operator. With the use of the result of the paper [1] we evaluate these functional (spectral) determinants and in the case of the polyharmonic operator $(-1)^n(\partial_x)^{2n} + \sum_{j=0}^{m} q_j(x)(\partial_x)^j$, $m \leq n$ we also obtain its asymptotics for large n. We point out some issues connected with the functional determinants.

This is joint work with P. Freitas based on the papers [2, 3].

1. D. Burghelea, L. Friedlander, and T. Kappeler, On the determinant of elliptic boundary value problems on a line segment, *Proc. Amer. Math. Soc.* **123** (1995), 3027–3038.

2. P. Freitas, J. Lipovský, Spectral determinant for the damped wave equation on an interval, *Acta Physica Polonica A* **136** (2019), 817–823 [arXiv: 1908.06862 [math-ph]].

3. P. Freitas, J. Lipovský, The determinant of one-dimensional polyharmonic operators of arbitrary order, preprint [arXiv: 2001.04703 [math-ph]].

Spectral analysis of the multi-dimensional diffusion operator with random jumps from the boundary

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Abstract: We will present a Hilbert-space approach to the diffusion process of the Brow- nian motion in a bounded domain with random jumps from the boundary intro- duced by Ben-Ari and Pinsky in 2007. The generator of the process is given by the Laplace operator in the space of square-integrable functions, subject to non-self- adjoint and non-local boundary conditions expressed through a probability measure on the domain. We will characterise for a large class of measures the numerical range of the operator. For the class of absolutely continuous probability measures with square- integrable densities we will compute the adjoint operator and analyse complete- ness of the system of root vectors. Finally, we will discuss enclosures for the non- real spectrum and provide a sufficient condition for the non-zero eigenvalue with the smallest real part to be real. The latter supports the conjecture of Ben-Ari and Pinsky that this eigenvalue is always real.

This talk is based on a joint work with David Krejčiřík, Konstantin Pankrashkin and Matej Tušek.

Torsion through time-loops on bidimensional Dirac materials

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Abstract: After a brief review of how to describe the electrons of Dirac materials and topligical defects, such as disclinations and dislocations, we propose a scenario where the effects of dislocations, in bidimensional Dirac materials, can be described, at low energies, by a vertex proportional to the totally antisymmetric component of the torsion generated by such dislocations. It is suggested that the two-dimensional geometric obstructions, already known in the literature, can be avoided by including time in the description of electrons. In particular, the emphasis is placed on exotic time-loops, which could be obtained from the hole-particle pair excitations. If torsion/dislocation is present, a net flow of particles-antiparticles (holes) can be inferred and, possibly, be measured.

Approximation of eigenvalues of 1D Schrödinger operators with imaginary potential

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Abstract: Domain truncations for Schrödinger operators with complex potentials are known to be spectrally exact. However, several examples suggest that additional eigenvalues escaping to infinity seem to be a generic feature. We explain the latter by a deeper analysis of truncated operators and proving a generalized norm resolvent convergence of transformed truncated operators.

Location of hot spots in thin curved strips

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Abstract: The maxima and minima of Neumann eigenfunctions of thin tubular neighbourhoods of curves on surfaces are located in terms of the maxima and minima of Neumann eigenfunctions of the underlying curves. In particular, the hot spots conjecture for a new large class of domains (possibly non-convex and non-Euclidean) is proved.

The talk is based on joint work with David Krejčiřík.

Arnold's potentials and quantum catastrophes

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Abstract: In the Thom's classification every classical catastrophe is assigned a Lyapunov function. In the one-dimensional case, due to V. I. Arnold, these functions have polynomial form, $V(k)(x) = x^{k+1} + c_1 x^{k-1} + \ldots$. The natural question is which features of the theory survive when such a function (say, with an even value of asymptotically dominant exponent $k+1$) is used as a confining potential in a $D-$dimensional Schroedinger equation. A few answers will be reviewed in the talk. It will be clarified that due to the tunneling, one of the possible classes of the measurable quantum catastrophes may be sought in a phenomenon of relocalization of the dominant part of the quantum particle density between different local minima. For the sake of definiteness we will consider just the spatially even Arnold's potentials in the limit of the thick barriers and deep valleys. We will arrive at a systematic classification of the corresponding relocalization catastrophes up to $D = 3$.