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The 14th international conference

Analytic and algebraic methods in physics

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→ THE BOOK OF ABSTRACTS ←

(the version of May 23, 2017)

(alphabetical ordering)

Anna Allilueva

Waves on geometric graphs

We describe certain properties of wave equations on geometric graphs. In particular, we study equations corresponding to different types of Laplacians and corresponding reflections on the vertices. We discuss the distribution of wave energy; in particular we show that in certain cases this distribution is governed by the location of eigenspaces of the corresponding unitary operator. For strongly localized solutions, this operator reduced to reflection from a subspace.

Fabio Bagarello

kq-representation for non-Hermitian position and momentum operators, and bi-coherent states

We show how the Zak kq-representation, originally used in many-body theory, can be adapted to deal with pseudo-bosons, and under which conditions this can be done. By means of this representation we prove completeness of a discrete set of bi-coherent states constructed out of pseudo-bosonic operators. The case of Riesz bi-coherent states is analyzed in detail.

Holger Cartarius

Open many-body quantum systems with topologically nontrivial phases

Non-Hermitian systems with PT symmetry can possess purely real eigenvalue spectra if the eigenstates are PT symmetric as well. At the edges of multi-site many-body systems topologically protected states can appear, which lead to complex relations with PT-symmetric potentials. We study one-dimensional bosonic and fermionic systems, in which topologically nontrivial edge states appear, and investigate their behaviour in relation to balanced gain and loss of the probability amplitude modelled by complex PT-symmetric potentials. Typically the edge states are not PT symmetric since their probability amplitude is localised only on one side of the system, however, a particle-hole symmetry can ensure their PT symmetry. For a many-particle system a dynamical approach with a master equation provides a more direct modelling of the in- and outcoupling of particles. Thus, we investigate our models with a master equation in Lindblad form. It is shown that the dynamics of the density matrix follows the predictions of stationary calculations using PT-symmetric potentials. In particular it is found that there is a clear distinction in the dynamics between the topologically different cases known form the stationary eigenstates.

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Work done together with Marcel Klett, Felix Dangel, Marcel Wagner, Dennis Dast and Guenter Wunner

Francisco M. Fernández and Javier Garcia

Highly accurate calculation of the real and complex eigenvalues of one-dimensional anharmonic oscillators

We draw attention on the fact that the Riccati-Padé method developed some time ago enables the accurate calculation of bound-state eigenvalues as well as of resonances embedded either in the continuum or in the discrete spectrum. We apply the approach to several one-dimensional models that exhibit different kind of spectra. In particular we test a WKB formula for the imaginary part of the resonance in the discrete spectrum of a three-well potential.

Daniel Hook

Behavior of eigenvalues in a region of broken PT symmetry

PT-symmetric quantum mechanics began with a study of the Hamiltonian $H = p^2 + x^2(ix)^\epsilon$. When $\epsilon \geq 0$, the eigenvalues of this non-Hermitian Hamiltonian are discrete, real, and positive. This portion of parameter space is known as the region of unbroken PT symmetry. In the region of broken PT symmetry, $\epsilon < 0$, only a finite number of eigenvalues are real and the remaining eigenvalues appear as complex-conjugate pairs. The region of unbroken PT symmetry has been studied but the region of broken PT symmetry has thus far been unexplored. This paper presents a detailed numerical and analytical examination of the behavior of the eigenvalues for $-4 < \epsilon < 0$. In particular, it reports the discovery of an infinite-order exceptional point at $\epsilon = -1$, a transition from a discrete spectrum to a partially continuous spectrum at $\epsilon = -2$, a transition at the Coulomb value $\epsilon = -3$, and the behavior of the eigenvalues as ? approaches the conformal limit $\epsilon = -4$.

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Results of collaboration with

Carl M. Bender, Nima Hassanpour, S. P. Klevansky, Christoph Snderhauf and Zichao Wen, published, on May 15th, 2017, in Phys. Rev. A 95, 052113.

A.M. Ishkhanyan

Bi-confluent Heun solutions of the Schrödinger equation

We present the five six-parametric Lamieux-Bose potentials for which the general solution of the one-dimensional Schrdinger equation is written in terms of the bi-confluent Heun functions [1,2]. To derive the confluent hypergeometric reductions of this family of potentials, we construct an expansion of the solutions of the bi-confluent Heun equation in terms of the Hermite functions. The series is governed by a three-term recurrence relation between successive coefficients of the expansion. We examine the restrictions that are imposed on the involved parameters in order that the series terminates thus resulting in closed-form finite-sum solutions of the bi-confluent Heun equation. We further identify a particular conditionally integrable potential for which the involved bi-confluent Heun function admits a four-term finite-sum expansion in terms of the Hermite functions [3]. This is an infinite well defined on a half-axis. We present the explicit solution of the one-dimensional Schrdinger equation for this potential and discuss the bound states supported by the potential. We derive the exact equation for the energy spectrum and construct a highly accurate approximation for the bound-state energy levels.

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Results of collaboration with T. A. Ishkhanyan

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[1] A. Lamieux and A.K. Bose, "Construction de potentiels pour lesquels l'quation de Schrödinger est soluble", Ann. Inst. Henri Poincaré A 10, 259-270 (1969).

[2] A.M. Ishkhanyan and V.P. Krainov, "Discretization of Natanzon potentials".

[3] T.A. Ishkhanyan and A.M. Ishkhanyan, "Solutions of the bi-confluent Heun equation in terms of the Hermite functions", Ann. of Phys. (2017),

DOI: https://doi.org/10.1016/j.aop.2017.04.015, arXiv:1608.02245 [quant-ph].

Vladimir V. Konotop

CPT-symmetric coupled nonlinear Schrdinger equations

There will be considered two models of the coupled nonlinear Schrödinger equation which are symmetric with respect to simultaneous time-reversal (T), spatial-inversion (P), and field exchange (C). The first model describes the spin-orbit coupled Bose-Einstein condensate with loading of atoms in one hyperfine state and removing from the other one. The second model describes two optical waveguides, one with gain and another with loss, whose coupling is highly dispersive. For both models there will be discussed features of the (CPT)-symmetry breaking, the existence of nonlinear modes (the first model) and solitons (the second model), as well as their stability. Both works are done in collaboration with Y. V. Kartashov and D. A. Zezyulin.

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[1] Kartashov, Y. V, Konotop, V. V, & Zezyulin, D. A. (2014). CPT -symmetric spin-orbit - coupled condensate. EPL (Europhysics Letters), 107, 50002.

[2] Zezyulin, D. A., Kartashov, Y. V., & Konotop, V. V. (2017). CPT-symmetric coupler with intermodal dispersion, 42(7), 1273-1276.

Ali Mostafazadeh

Nonlinear Generalization of Spectral Singularity and Transfer Matrix

We introduce nonlinear extensions of the notions of spectral singularity and transfer matrix for nonlinearities with a compact support. We discuss how some basic relations of laser physics can be obtained from the condition of the presence of a linear or nonlinear spectral singularity. In particular we obtain the laser threshold condition and output intensity for the TE and TM modes of a slab laser and predict that the lasing is forbidden for TM modes with an incident angle exceeding the Brewster's angle. We also discuss applications of our nonlinear transfer matrix in the investigation of spectral singularities and unidirectional invisibility in the presence of confined nonlinearities.

Satoshi Ohya

Exactly Solvable Bound-State Problems and Lie Algebras so(2,1), so(3), and iso(2)

I shall revisit very old bound-state problems in quantum mechanics. I shall focus on five specific examples: Coulomb, trigonometric Rosen-Morse, Manning-Rosen, hyperbolic Rosen-Morse, and attractive Liouville potentials, all of whose bound state problems are known to be exactly solvable. I show that in these problems the energy eigenfunctions as well as energy eigenvalues are all obtained by means of the unitary representations of the Lie algebras so(2,1), so(3), or iso(2).

Etsuo Segawa

Discrete-time quantum walks induced by quantum graphs

I introduce discrete-time quantum walks induced by quantum graphs with some boundary conditions. In this talk, we discuss on a resonance of the quantum walks.

Andrei Shafarevich

Laplacians and wave equations on polyhedral surfaces

We study properties of Laplacialns and wave equations on polyhedral surfaces. These equations appear, particularly in the problem of long waves' scattering on point obstacles. We describe different types of Laplacians, their kernels (spaces of harmonic functions), trace formulas and wave fronts for localized solutions of wave equations.