Abstracts and Programme

6th International Workshop on New Challenges in Quantum Mechanics: Integrability and Supersymmetry

A conference in honor of

Prof. Véronique Hussin

Universidad de Valladolid

June 27–30, 2017

Facultad de Ciencias, Sala de Grados II

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Foreword

The *"6th International Workshop on New Challenges in Quantum Mechanics: Integrability and Supersymmetry"* will be organized in Valladolid (Spain) on June 27-30, 2017 in honor of Prof. Véronique Hussin. Prof. Hussin is an internationally recognized expert in many branches of mathematical physics. She has made remarkable contributions in coherent and squeezed states, supersymmetry, sigma models, nonlinear equations and other topics that show her wide range of interest.

The workshop programme takes an special attention on the topics in which Prof. Véronique Hussin has been working for many years. It is a pleasure for all of us to dedicate this special scientific event to her.

The Organizing Committee

Valladolid, June 26th, 2017

Contents

Abstracts

Kink dynamics in a system of two coupled scalar fields in two space-time dimensions

Alberto Alonso Izquierdo
University of Salamanca (Spain)

The scattering processes between the members of a rich plethora of kinks which arise in a $(1 + 1)$-relativistic two-coupled scalar field theory model is analyzed. These kinks carry two different topological charges, which determine the mutual interactions between the basic energy lumps (particles) described by these topological defects. Topological charge interchanging processes, kink-antikink bound state formation or kink repulsion are examples of events present in the kink dynamics of this model. A second order energy conservative numerical scheme adapted to the field theory framework has been employed to simulate these events.

Squeezed and coherent states of anharmonic oscillators

Maia Angelova
Deakin University (Australia)

The motivation of this work is the Lie-algebraic approach to anharmonic quantum oscillators and in particular the Morse oscillator. I will consider constructions of ladder operators, quantum bosons, coherent and squeezed states related to the discrete spectrum of the anharmonic quantum system. Properties of diatomic molecules and molecular complexes will be presented in the context of the models.

Controlling the states of Light in a Mach-Zehnder interferometer

Zurika I. Blanco-Garcia
CINVESTAV (México)

The experiment proposed by Elitzur and Vaidman is modified by replacing the fully absorbing obstacle (the 'bomb') with a non-linear optical medium. In this form the involved Mach-Zehnder interferometer works as a quantum beam splitter that produces NOON states which can be controlled if the input is the appropriate linear combination of two-mode Fock states.

Integrable Hénon–Heiles systems on curved spaces: The Sawada–Kotera case

Alfonso Blasco Sanz
University of Burgos (Spain)

Amongst the three (Liouville) integrable Hénon–Heiles systems on the two-dimensional Euclidean plane, we consider the Sawada–Kotera Hamiltonian given by

$$\mathcal{H} = \frac{1}{2}(p_1^2 + p_2^2) + \delta(q_1^2 + q_2^2) + \gamma\left(q_1^2 q_2 + \frac{1}{3}q_2^3\right),$$

where δ and γ are two arbitrary real parameters. This system corresponds to the superposition of an isotropic oscillator (whenever $\delta > 0$) and a cubic potential. It is well-known that the corresponding integral of motion $\mathcal{I}$ is quadratic in the momenta and $\mathcal{H}$ becomes separated in rotated Cartesian coordinates: $u = q_1 + q_2$ and $v = q_1 - q_2$. In this contribution, we present the constant curvature analogue of $\mathcal{H}$, denoted $\mathcal{H}_\kappa$, on the two-dimensional sphere and the hyperbolic plane, where the real parameter κ is just the (Gaussian) curvature of the underlying Riemannian space. In our approach, the curvature κ can be regarded as a deformation/contraction parameter, in such a manner that the Euclidean Hénon–Heiles system $\mathcal{H}$ is recovered when the flat limit $\kappa \to 0$ is performed. In particular, we explicitly obtain the curved constant of motion $\mathcal{I}_\kappa$ (which remains as a quadratic one in the momenta) and, furthermore, we solve the Hamilton–Jacobi separability of the curved system on an appropriate curved counterpart of the rotated Cartesian coordinates (u, v). We stress that the separability of $\mathcal{H}_\kappa$ leads to a new series of integrable (curved) homogeneous potentials, similarly to what happens with the Ramani–Dorizzi–Grammaticos homogeneous potentials which are related to the Hénon–Heiles KdV Hamiltonian.

Casimir energies of fractal configurations

Inés Cavero-Peláez
University of Zaragoza (Spain)

In this talk we will be dealing with simple self-similar configurations where the interactions are mediated by a scalar field subject to boundary conditions from delta-function potentials. We show that the idea of self-similarity alone leads to an interaction vacuum energy that agrees with the more elaborate calculation based on Green functions. We give a general method to calculate the Green?s functions for an N-body system where N can extend to infinity. We will be using different configurations of parallel delta-function plates to illustrate our method but it can be employed with total generality. Among others, we particularly calculate the Casimir energy of a stack of delta-function plates whose positions constitute the Cantor set.

A SWITCH test for the discrimination of quantum operators

Pedro Chamorro Posada
University of Valladolid (Spain)

We propose a scheme for discriminating two arbitrary quantum systems in the context of quantum information. It permits to test the equality of two quantum systems and it can also be used to estimate a fidelity measure of evolution operators. The relation of the proposal to the SWAP test for discriminating two quantum states is analyzed. We also discuss potential applications for the discrimation of quantum channels and possible laboratory implementations along the same lines of recent experimental realizations of quantum superpositions of causal orders exploiting additional degrees of freedom of photons. A preliminar version of this work will be available from arxiv.org in the following days.

Construction of solvable time dependent potentials through confluent SUSY QM

Alonso Contreras-Astorga
Indiana University Northwest (US)

Supersymmetric quantum mechanics (SUSY QM) is a technique that allows us to produce new solvable stationary Schrödinger equations. The constructed potentials are written in terms of a given one and some known solutions of the initial problem called transformation functions. There are different versions of SUSY QM and in each one the number of transformation functions involved as well as the requirements they need to fulfill are different. The confluent version needs only one transformation function to generate a family of solvable systems. To construct new time dependent potentials and solutions of the corresponding Schrödinger equation the confluent SUSY QM will be adapted using two different methods: first, by a direct intertwining relationship between Schrödinger operators and secondly, by using a point transformation mapping from stationary to time dependent Schrödinger equations.

Group approach to the propagation of paraxial modes in a parabolic medium

Sara Cruz y Cruz
IPN (México)

A group-theoretical approach to the propagation of paraxial modes based on the factorization method is presented. It is shown that the su(1,1) and the su(2) algebras generate the spectrum of propagation constants at any fixed transversal plane. The complete set of modes is decomposed into hierarchies that are used to establish the representation spaces of SU(1,1) and SU(2). The corresponding families of generalized coherent states are constructed and the variances of the quadratures and canonical variables are determined.

Coherence and nonclassicality for noncommutative models with minimal length

Sanjib Dey
University of Paris-Sud (France)

The existence of space-time noncommutativity is very promising in almost all approaches towards quantum theory of gravity. Several different types of noncommutative structure have been suggested depending on their significance in different contexts. We discuss about the construction of one such noncommutative framework originating from the generalised Robertson-Schrodinger uncertainty relation. It is important to understand the consequences of such theories in lower dimensions, which have not been studied considerably in the literature. We study coherent states and some interesting nonclassical states based on these models and discuss their behaviour in comparison with those arising from the ordinary harmonic oscillator.

Casimir-like interactions of Dirac fields under external boundary conditions: a model for graphene

Manuel Donaire
University of Valladolid (Spain)

I compute the energy associated to the vacuum fluctuations of a massive Dirac field in d spatial dimensions, subject to the most general boundary conditions compatible with self-adjoint extensions of the Dirac Hamiltonian in the so-called Casimir geometry. In particular, I calculate the Casimir interaction between d-1 dimensional fermionic plates and the Casimir. The Dirac field in d=2 is intended to model the low-lying excitations of graphene. I also investigate the presence of localized states in the aforementioned structures. They are the so-called edge states whose energy lies within the mass gap. One finds that the fermionic Casimir interaction presents, generally, spatial dispersion along the infinite dimensions of the plates. In addition, certain boundary conditions generate unstable vacuum states. Finally, I sketch the computation of the Casimir force due to the electromagnetic fluctuations with the Casimir force due to fermionic fluctuations in a partially opened carbon nanotube.

Variational method for position-dependent mass problems

Elso Drigo Filho
Sao Paulo State University (Brazil)

We present the general outline of an analytic method based on an adaptation of the variational method to determine the solutions of a Schrödinger-like equation with position-dependent mass of a specific case. The result shows that the adapted variational method is successful in determining the lowest energy of these kind of system. The proposed methodology was tested in two particular cases, one trivial that brought confidence to the approach and another which does not have an exact/analytic solution. From the results obtained, it is possible to conclude that the variational method can be used in the adapted form and it is a good alternative to study quantum problems with position-dependent mass.

PIV solutions from systems with harmonic oscillator gapped spectrum

Mario Ivan Estrada Delgado
CINVESTAV (México)

Supersymmetric transformations of order k are applied to the harmonic oscillator to generate potentials V whose spectra have a gap of thickness $k + 1$ with respect to the initial spectrum. The system's extremal states are identified and, since the reduction theorem conditions are satisfied, which ensures that the system has third order ladder operators and hence it is connected with the PIV equation, solutions to this equation can be found. Then, an alternative supersymmetric transformation is applied to the harmonic oscillator, by adding the levels needed to reproduce the spectrum of V , up to a displacement by a constant factor. The extremal states are identified and, as the reduction theorem is met again, we can get also solutions to the PIV equation. Finally, the PIV solutions found through both transformations are analysed.

Harmonic versus conical confinement perturbed by a central $|\delta'\rangle\langle\delta'|$-interaction in one-dimensional quantum mechanics

Silvestro Fassari
University of Valladolid (Spain)

The remarkable modifications induced by a central $|\delta'\rangle\langle\delta'|$-perturbation, discontinuity of the antisymmetric eigenfunctions and level crossing of eigenvalues, are shown for two confining potentials, namely the harmonic potential and the conical one.

Coherent states for SUSY partner Hamiltonians

David J. Fernández C.
CINVESTAV (México)

In this talk I will review a general approach for constructing coherent states for a class of one-dimensional exactly solvable Schrödinger Hamiltonians generated through supersymmetric quantum mechanics from a given initial one. I will tell how I gave my first steps on the subject, together with Luismi Nieto during the first collaboration with our dear Véronique.

The Lippmann-Schwinger formula and one dimensional models with Dirac delta interactions

Manuel Gadella
University of Valladolid (Spain)

We show the powerfulness of the Lippmann-Schwinger equation in order to obtain bound states and metastable states like resonances (unstable quantum systems) and virtual states for non-relativistic systems, among other applications. Our model is a one dimensional system with a Schrödinger type free Hamiltonian decorated with a sequence of N Dirac delta interactions.

The effective Hamiltonian for multiple photon evolution in linear quantum optical networks

Juan Carlos García Escartín
University of Valladolid (Spain)

We give an explicit formula for the effective Hamiltonian describing the evolution of the quantum state of any number of photons entering a linear optics multiport. The description is based on the effective Hamiltonian of the optical system for a single photon and comes from relating the evolution in the Lie group that describes the unitary evolution matrices in the Hilbert space of the photon states to the evolution in the Lie algebra of the Hamiltonians for one and multiple photons. We use this description in the corresponding Lie algebras to show that for an even number of photons n, half entering each port of a two-port linear optical system, the expected number of photons at each output is also $n/2$. Preliminary version available from: https://arxiv.org/abs/1605.02653 (soon to be replaced by an updated version).

From classical to quantum models: the regularising role of integrals, symmetry and probabilities

Jean-Pierre Gazeau
Paris-Diderot University (France)

In physics, one is often misled in thinking that the mathematical model of a system is part or is that system itself. Think to expressions like "point particle", motion "on the line", "smooth" observables, wave function.... On the other hand, when a mathematical model becomes really inoperative in regard with correct predictions, one is forced to replace it with a new one. It is precisely what happened with the emergence of quantum physics. Classical models were (progressively) replaced by quantum ones through quantization prescriptions. These procedures appear often as ad hoc recipes. In the present paper, well defined quantizations, based on integral calculus and symmetry, are described in simple terms through one of the most basic examples of Mechanics. Starting from probability distribution(s) on the Euclidean plane viewed as the phase space for the motion of a point particle on the line, i.e. its classical model, we will show how to build corresponding quantum model(s) and associated probability (e.g. Husimi) or quasi-probability (e.g. Wigner) distributions. We highlight the regularizing role of such procedures with examples like motions with variable mass, quantum angle or phase, smoothing of classical singular potentials.

An exactly solvable model for quantum resonances: The Friedrichs model

Alex Glickfield
Butler University (US)

The Friedrichs model consists in an interaction between the bound state of a quantum system (say, an atom) and an external field, interaction which produces a resonance. This interaction intertwines the bound state with the eigen-vectors of the continuous spectrum of the field Hamiltonian and depends on a coupling parameter. The resonance appears as a pole of the analytic continuation of the reduced resolvent corresponding to the interacting Hamiltonian. This model admits generalizations like, for instance, adding bound states and/or degeneracy to the field Hamiltonian. We examine what happens as the imaginary component of the eigenvalue associated with a resonant energy approaches zero.

Discrete frame systems and LC groups

Fernando Gómez-Cubillo
University of Valladolid (Spain)

Frame systems generalize the concept of Riesz basis and, in particular, of orthonormal basis in Hilbert space. We present some results on discrete wavelet frames and frame systems which arise from the action of unitary representations of LC discrete groups on a single element of a Hilbert space. Connections with the theory of coherent states are explored.

The orbits of the two fixed center problem on the sphere S^2

Miguel Ángel González León
University of Salamanca (Spain)

An isomorphism between the two Newtonian fixed center problem in the sphere and two associated planar two fixed center problems is constructed by performing two simultaneous gnomonic projections in S^2. This isomorphism converts the original quadratures into elliptic integrals and allows to describe the bifurcation diagram of the spherical problem by means of a superposition of the corresponding ones to the planar systems. The complete set of orbits in the different regimes for the problem in S^2 is calculated in terms of Jacobi elliptic functions. Closed orbits are obtained for the case of commensurability of the involved periods, otherwise orbits are dense.

Families of coherent states of Laguerre-Gaussian modes in a medium with quadratic refractive index profile

Zulema Gress-Mendoza
IPN (México)

The factorization method is applied in the solution of the paraxial Helmholtz equation in order to construct, by means of the corresponding operator algebra, the Laguerre-Gaussian modes in a medium with quadratic refractive index profile. The paraxial optics analogue of some families of coherent states is also presented.

Non-Hermitian coherent states for finite-dimensional systems

Julio Guerrero
University of Murcia (Spain)

Since the introduction of non-Hermitian Hamiltonians [1] in Quantum Mechanics, only a few papers have been devoted to coherent states (CS) for non-Hermitian systems (see, for instance, [2], where Gazeau-Klauder CS are constructed using the definition of scalar product in terms of the CPT norm, or [3]). Here we shall introduce Gilmore-Perelomov CS for finite-dimensional non-unitary representations of non-compact groups, and discuss the main similitudes and differences with respect to ordinary Gilmore-Perelomov CS. The example of CS for the non-unitary finite dimensional representations of $SO(2,1)$ is considered and use them to describe the propagation of light in coupled PT-symmetric optical devices [4,5]. The case of non-hermitian CS for non-unitary finite dimensional representations of $SO(3,1)$ will also be commented. [1] C.M. Bender, Phys. Rev. Lett. 80, 5243-5246 (1988) [2] B. Roy and P. Roy, Physics Letters A 359 (2006) 110-113 [3] F. Bagarello, in Geometric Methods in Physics, series Trends in Mathematics, pp 15-23 (2016) [4] B.M.Rodríguez-Lara and J. Guerrero, Opt. Lett. 40, No. 23, 5682-5685, (2015) [5] J. D. Huerta Morales, J. Guerrero, S. López-Aguayo, and B.M. Rodríguez-Lara, Symmetry 8, 83 (2016)

On Hamiltonians with position-dependent mass from Kaluza-Klein compactifications

Iván Gutiérrez Sagredo
University of Burgos (Spain)

In a recent paper (J.R. Morris, Quant. Stud. Math. Found. 2 (2015) 359), an inhomogeneous compactification of the extra dimension of a five-dimensional Kaluza-Klein metric has been shown to generate a position-dependent mass (PDM) in the corresponding four-dimensional system. As an application of this dimensional reduction mechanism, a specific static dilatonic scalar field has been connected with a PDM Lagrangian describing a well-known nonlinear PDM oscillator. Here we present more instances of this construction that lead to PDM systems with radial symmetry, and the properties of their corresponding inhomogeneous extra dimensions are compared with the ones in the nonlinear oscillator model. Moreover, it is also shown how the compactification introduced in this type of models can alternatively be interpreted as a novel mechanism for the dynamical generation of curvature.

Exact Richardson solutions with continuum real and complex energies

Rodolfo Id Betan
Physics Institute of Rosario (Argentina)

The constant pairing Hamiltonian holds exact solutions worked out by Richardson in the early Sixties [1]. The exact solution of the pairing Hamiltonian regained interest at the end of the Nineties [2]. For loosely-bound systems, the correlations with the continuum spectrum of energy must be considered explicitly. The resonant states with complex energy had been included in the Richardson solutions in Ref. [3]. In this presentation I reformulate the problem of determining the exact eigenenergies of the pairing Hamiltonian with continuum spectrum. The continuum is included through the continuum single particle level density [4]. The solutions of Ref. [3] is recovered by analytic continuation of the equations to the complex energy plane. Applications in Tin and Carbon isotopes are shown. [1] R. W. Richardson, Phys. Lett. 3, 277 (1963). [2] J. von Delft and F. Braun, arXiv:cond-mat/9911058. [3] M. Hasegawa and K. Kaneko, Phys. Rev. C 67, 024304 (2003). [4] R. Id Betan, Phys. Rev. C 85, 064309 (2012).

Comments on Chern-Simons supergravity

José M. Izquierdo
University of Valladolid (Spain)

Three dimensional gravity and supergravity are Chern-Simons theories, but this is not the case for higher dimension. However, it has been conjectured by several authors that there is a connection between higher Chern-Simons theories and certain (super) gravities in odd dimensions. In this talk it is argued that while the connection seems to work for pure gravity and for the bosonic sector of some supergraviries, it does not work when fermions are included.

Confluent Crum-Darboux transformations in Dirac Hamiltonians and optical systems with PT-symmetric refractive index

Vit Jakubsky
Nuclear Physics Institute of ASCR (Czech Republic)

We consider optical systems where propagation of light can be described by a Dirac-like equation with PT-symmetric Hamiltonian. In order to construct exactly solvable configurations, we extend the confluent Crum-Darboux transformation for the one-dimensional Dirac equation. The properties of the associated intertwining operators are discussed and the explicit form for higher-order transformations is presented. We utilize the results to derive a multi-parametric class of exactly solvable systems where the balanced gain and loss are represented by the PT-symmetric refractive index.

The polynomial associated with the BFK-gluing formula of the zeta-determinant

Klaus Kirsten
Baylor University (US)

Let M_1 and M_2 be two Riemannian manifolds each of which have the boundary N. Consider the Laplacian on M_1 and M_2 augmented with Dirichlet boundary conditions on N. A natural question to ask is if there is any relation between spectral properties of the Laplacian on M_1, M_2, and the Laplacian on the manifold (without boundary) $M = M_1 \cup_N M_2$. A partial answer is given by the Burghelea-Friedlander-Kappeler-gluing formula for zeta-determinants. This formula contains an (in general) unknown polynomial which is completely determined by some data on a collar neighborhood of the hypersurface N. In this talk I present results for the polynomial in terms of suitable geometric tensors on N. Choosing M_1, M_2 and M suitably, a gluing formula for Casimir energies results.

Conditionally invariant equations

Decio Levi
Roma Tre University (Italy)

We show how one can construct classes of equations invariant under a conditional symmetry. We present in a few examples how the Boussinesq equation appears in terms of the invariants but provide also some KdV like conditionally invariant equations.

Poisson-Hopf algebra deformations of Lie-Hamilton systems

Javier de Lucas Araujo
University of Warsaw (Poland)

A Lie-Hamilton system is a Hamiltonian system of ordinary differential equations describing the integral curves of a t-dependent vector field taking values in a finite-dimensional Lie algebra of vector fields V, a so-called Vessiot-Guldberg Lie algebra. The latter structure is useful to obtain the constants of motion, symmetries and general properties of the Lie-Hamilton system through the universal enveloping algebra of V. This talk employs the deformation theory of Poisson-Hopf algebras so as to deform a Lie-Hamilton system giving rise to a z-parametric family of non-autonomous Hamiltonian systems which are not of Lie-Hamilton type. Although I will focus upon Lie-Hamilton systems related to $V \simeq sl(2)$ and the deformation will be accomplished via the non-standard deformation $U_z(sl(2))$ of the universal enveloping algebra U(sl(2)), our method is extendable to a general setting. The properties of the deformed Lie-Hamilton system are encoded in the associated Poisson-Hopf algebra structure $U_z(sl(2))$, which leads to obtaining, in an explicit way, the t-independent constants of motion and symmetries of the deformed Lie-Hamilton systems from quantum deformed Casimir invariants. Our findings are applied to Milne-Pinney equation and several types of Riccati equations.

Exceptional orthogonal polynomials in quantum mechanics

Ian Marquette
University of Queensland (Australia)

I will review some recent results on exceptionnal orthogonal polynomials and exactly, quasi exactly and superintegrable systems in quantum mechanics. I wil discuss various interesting properties and some connection with Painleve transcendents

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Resonances in the fractional driven damped oscillator

Fernando Olivar Romero
CINVESTAV (México)

The resonances associated with a fractional damped oscillator which is driven by an oscillatory external force are studied. It is shown that such resonances can be manipulated by tuning up either the coefficient of the fractional damping or the order of the corresponding fractional derivatives.

Special functions, Lie algebras and rigged Hilbert spaces

Mariano A. del Olmo
University of Valladolid (Spain)

In this communication we show that discrete and continuous basis connected with special functions supporting representations of certain Lie algebras of physical interest coexist on Rigged Hilbert spaces that we describe.

Casimir effect for Dirac lattices

Irina Pirozhenko
Joint Institute for Nuclear Research (Rusia)

We consider polarizable sheets, which recently received some attention, especially in the context of the dispersion interaction of thin sheets like graphene. These sheets are modeled by a collection of delta function potentials and resemble zero-range potentials, which are known in quantum mechanics. We develop a theoretical description and apply the so-called TGTG formula to calculate the interaction of two such lattices. Thereby, we make use of the formulation of the scattering of waves off such sheets provided earlier. We consider all limiting cases, providing a link to earlier results. Also, we discuss the relation to the pairwise summation method.

Ladder operators for rationally extended quantum harmonic oscillator systems

Mikhail Plyushchay
University of Santiago de Chile (Chile)

We discuss the construction of the ladder operators for rationally extended quantum harmonic oscillator systems by employing Darboux-Crum-Krein-Adler transformations and exploiting the analogy with reflectionless (finite-gap) systems. The peculiar spectral properties of the rationally extended quantum harmonic oscillator systems are shown to be detected and reflected by three pairs of the ladder operators. A special role in the construction belongs to generalized Jordan states.

Equivalence between monopartite and bipartite systems

Claudia Quintana
CINVESTAV (México)

The quantum state of a bipartite system composed by two qubits is studied and compared with the state of a qudit of four levels. Both kinds of states can be analyzed by using the same mathematical picture, so that concepts as the Von-Neumann entropy and the mutual information can be attained to each one of them, although such concepts have a physical meaning for the bipartite system only. What kind of information can be obtained from these concepts in the monopartite case? In the talk we shall report some of the advances that we have obtained on the matter.

Thermodynamics of supersymmetric spin chains

Miguel A. Rodríguez
Complutense University of Madrid (Spain)

The thermodynamics of supersymmetric Haldane-Shastry spin chains is studied via their relation with one-dimensional vertex models. The use of the partition function of these models and its expression in terms of transfer matrices allows to study the thermodynamical properties of the chain and its behaviour when the number of spins tends to infinity. Joint work with F. Finkel, A. Gonzalez-Lopez and I. Leon.

Singular potentials in a D-dimensional system and Casimir energy with polar symmetry

César Romaniega
Complutense University of Madrid (Spain)

We provide a general framework to obtain the relevant quantities in a D-dimensional quantum system whose potential has singular support. Basically, this potential is a sum of Dirac delta and its derivative placed in concentric $D-1$ spheres. Within the TGTG approach, we also compute the Casimir energy between two disk in a two dimensional system using scattering data of $\delta - \delta'$ quantum system.

A Bi-orthogonal approach to non-Hermitian Hamiltonians with real spectrum

Óscar Rosas-Ortiz
CINVESTAV (México)

In ordinary quantum mechanics the dynamical variables that are susceptible to measurement are called observables, these are represented by self-adjoint operators whose eigenvectors form a complete set (i.e., by Hermitian operators). The latter means that the superposition principle holds since any linear combination of the eigenvectors also represents a state of the system. The self-adjointness of an operator that represents any observable is the simplest form to associate its eigenvalues with the result of a measurement, which must always give a real number as result. However, the reality of the eigenvalues does not imply that the observables must be represented by self-adjoint operators. In this talk we shall discuss about the validity of the superposition principle for non-Hermitian Hamiltonians with real spectrum. Such Hamiltonians are not required to be PT-invariant. We shall show that the bi-orthogonality of the related eigenvectors permits the construction of states with specific properties. As examples we shall present diverse families of generalized coherent states and optimized binomial states.

Singular Schrödinger operators in 3D and its application to QFT

Lucía Santamaría
University of Valladolid (Spain)

Schrödinger operators with singular potentials in three-dimensional space are shown to be of great importance to describe effective theories in relativistic quantum field theories. In particular we investigate the use of Dirac-delta function potentials to describe conductors and other materials in interaction with a quantum scalar field.

Thermal corrections to the Casimir effect of a massless scalar field under general boundary conditions

Marcos Tello-Fraile
University of Valladolid (Spain)

We compute the free energy of a massless scalar field in thermal equilibrium by means of the Matsubara formalism. The domain in which the field is defined is the empty space between two homogeneous parallel plates with the most general type of boundary conditions. We can split the free energy into two parts: the first one is temperature-independent and corresponds to the vacuum energy of the field at zero temperature, whereas the second part is the thermal correction. In order to obtain a physically meaningful thermal correction, we need to regularize the ultraviolet divergent terms. Finally, we compute the resulting physical thermal correction in the limit of low temperatures. The result is a temperature exponential decay which relies on the lower part of the spectrum of the field.

Entropies, groups and information theory

Piergiulio Tempesta
Complutense University of Madrid (Spain)

Entropy is a fundamental notion, at the heart of modern science. In the second half of the twentieth century, its range of applicability has been extended from the traditional context of classical thermodynamics to new areas such social sciences, economics, biology, quantum information theory, linguistics, etc. We will show that there exists an intrinsic group-theoretical structure behind the notion of generalized entropy. It comes from the requirement of composability of an entropy with respect to the union of two statistically independent systems. In this new perspective, we shall propose a formulation of the celebrated Shannon-Khinchin axioms, in which a new composability axiom replaces the traditional additivity axiom. In particular, the theory of formal groups of algebraic topology offers a natural language for defining a novel class of generalized entropies, called group entropies. Their role in information geometry will be elucidated.

Painlevé functions as superintegrable potentials

Pavel Winternitz
University of Montreal (Canada)

A review is given of ”exotic potentials” in 2 dimensions that allow the separation of variables in Cartesian or Polar coordinates and have an additional integral of motion of order larger or equal 3. By definition these potentials do not satisfy any linear differential equation. The satisfy nonlinear ODEs with the Painlevé property.

Quasi-integrability and some aspects of $SU(3)$ Toda field theories

Wojtek Zakrzewski
University of Durham (UK)

In this talk I will mention some ideas that Luiz Ferreira and I have had on how to define the concept of quasi-integrability. This is due to the observation that many field theory models are 'almost' integrable; *ie* they possess a large number of 'almost' conserved quantities.My discussion will be based on a class of models which generalise the $SU(3)$ Affine Toda model in $(1+1)$ dimensions and its deformations.

First I will recall various aspects of the $SU(3)$ Toda model (its classical solutions and their properties) and then perform some deformations of the model and look at the changes these deformations make and what aspects of integrability are still preserved. I will show that for some deformations the solitons repel and for the others they form a quasi-bound state. When we send solitons towards each other they can repel when they come close together with or without 'flipping' the fields of the model. The solitons radiate very little and appear to be stable.

I will also show that a simple collective coordinate approximation to the solitons does explain some properties of their scattering.

Time-dependent exactly solvable potentials generated by Darboux transformations

Kevin D. Zelaya Mendoza
CINVESTAV (México)

The Darboux transformation is a powerful tool to construct solvable potentials in quantum mechanics. In 1995 Bagrov, Samsonov and Shekoyan (BSS) carried out an extended version to construct solvable time?dependent potentials. The present work is addressed to the application of the BSS method to construct new solvable time-dependent potentials with the profile of the harmonic oscillator.

The challenges of using non-Hermitian Hamiltonians in quantum mechanics

Miloslav Znojil
Nuclear Physics Institute of ASCR (Czech Republic)

In the conventional textbooks one finds several alternative formulations of quantum mechanics. In applications the use prevails of the most common items in the menu: Depending on the purpose of the study people prefer the use of the so called Schroedinger representation of the systems (working, mostly, with the operators of observables which are time-independent) or of the so called interaction representation of the systems (in which both the wave-functions and operators vary with time). Recently, mathematical physics encountered a true challenge with the emergence of the so called pseudo-Hermitian representation of quantum systems. A concise presentation of the idea will be provided and illustrated by examples.

Programme

June 27

Morning Session

9:30- 10:00	**Opening Session**	
Chairman: W. Zakrzewski		
10:00 - 10:30	D.J. Fernández C.	*Coherent states for SUSY partner Hamiltonians*
10:30 - 11:00	M. Angelova	*Squeezed and coherent states of anharmonic oscillators*
11:00 - 11:30	J. Guerrero	*Non-Hermitian coherent states for finite-dimensional systems*
11:30- 12:15	**Coffee Break**	
Chairman: J.P. Gazeau		
12:15 - 12:45	M. Znojil	*The challenges of using non-Hermitian Hamiltonians in quantum mechanics*
12:45 - 13:15	O. Rosas-Ortiz	*A bi-orthogonal approach to non-Hermitian Hamiltonians with real spectrum*
13:15 - 13:45	M.A. González-León	*The orbits of the two fixed center problem on the sphere* S^2
13:45- 16:00	**Lunch**	

June 27

Afternoon Session

Chairman: M. Angelova		
16:00 - 16:20	F. Gómez-Cubillo	*Discrete frame systems and LC groups*
16:20 - 16:40	A. Contreras-Astorga	*Construction of solvable time dependent potentials through confluent SUSY QM*
16:40 - 17:00	K.D. Zelaya Mendoza	*Time-dependent exactly solvable potentials generated by Darboux transformations*
17:00 - 17:20	J.C. García-Escartín	*The effective Hamiltonian for multiple photon evolution in linear quantum optical networks*
17:20- 18:00	**Coffee Break**	
Chairman: M.A. del Olmo		
18:00 - 18:20	Z. Blanco-García	*Controlling the states of light in a Mach-Zehnder interferometer*
18:20 - 18:40	C. Quintana	*Equivalence between monopartite and bipartite systems*
18:40 - 19:00	F. Olivar Romero	*Resonances in the fractional driven damped oscillator*
19:00 - 19:20	A. Glickfield	*An exactly solvable model for quantum resonances: The Friedrichs model*

June 28

Morning Session

Chairman: M. Santander		
09:30 - 10:00	W. Zakrzewski	*Quasi-integrability and some aspects of* $SU(3)$ *Toda field theories*
10:00 - 10:30	M. Donaire	*Casimir-like interactions of Dirac fields under external boundary conditions: a model for graphene*
10:30 - 11:00	I. Pirozhenko	*Casimir effect for Dirac lattices*
11:00 - 11:30	I. Cavero-Peláez	*Casimir energies of fractal configurations*
11:30- 12:15	**Coffee Break**	
Chairman: J. Mateos-Guilarte		
12:15 - 12:45	K. Kirsten	*The polynomial associated with the BFK-gluing formula of the zeta-determinant*
12:45 - 13:15	J.M. Izquierdo	*Comments on Chern-Simons supergravity*
13:15 - 13:45	P. Chamorro Posada	*A SWITCH test for the discrimination of quantum operators*
13:45- 16:00	**Lunch**	

June 28

Afternoon Session

Chairman: M.F. Rañada		
16:00 - 16:20	J. de Lucas Araujo	*Poisson-Hopf algebra deformations of Lie-Hamilton systems*
16:20 - 16:40	A. Blasco-Sanz	*Integrable Hénon-Heiles systems on curved spaces: The Sawada-Kotera case*
16:40 - 17:00	D. Sanjib	*Coherence and nonclassicality for noncommutative models with minimal length*
17:00 - 17:20	Z. Gress-Mendoza	*Families of coherent states of Laguerre-Gaussian modes in a medium with quadratic refractive index profile*
17:20- 18:00	**Coffee Break**	
Chairman: M.A. Rodríguez		
18:00 - 18:20	M.I. Estrada Delgado	*PIV solutions from systems with harmonic oscillator gapped spectrum*
18:20 - 18:40	M. Tello-Fraile	*Thermal corrections to the Casimir effect of a massless scalar field under general boundary conditions*
18:40 - 19:00	C. Romaniega	*Singular potentials in a D-dimensional system and Casimir energy with polar symmetry*
19:00 - 19:20	L. Santamaría	*Singular Schrödinger operators in 3D and its application to QFT*

June 29

Morning Session

Chairman: O. Rosas-Ortiz		
09:00 - 09:30	M. Plyushchay	*Ladder operators for rationally extended quantum harmonic oscillator systems*
09:30 - 10:00	R. Id Betan	*Exact Richardson solutions with continuum real and complex energies*
10:00 - 10:30	S. Fassari	*Harmonic versus conical confinement perturbed by a central $\|\delta'\rangle\langle\delta'\|$-interaction in one-dimensional quantum mechanics*
10:30 - 11:00	M. Gadella	*The Lippmann-Schwinger formula and one dimensional models with Dirac delta interactions*
11:00- 11:45	**Coffee Break**	
Chairman: A. Ballesteros		
11:45 - 12:15	P. Tempesta	*Entropies, groups and information theory*
12:15 - 12:45	A. Alonso Izquierdo	*Kink dynamics in a system of two coupled scalar fields in two space-time dimensions*
12:45 - 13:15	E. Drigo-Filho	*Variational method for position-dependent mass problems*
13:15 - 13:45	I. Gutiérrez Sagredo	*On Hamiltonians with position-dependent mass from Kaluza-Klein compactifications*
14:30	**Banquet**	

June 30

Morning Session

Chairman: D.J. Fernández C.		
09:00 - 09:30	J.P. Gazeau	*From classical to quantum models: the regularising role of integrals, symmetry and probabilities*
09:30 - 10:00	M.A. del Olmo	*Special functions, Lie algebras and rigged Hilbert spaces*
10:00 - 10:30	S. Cruz y Cruz	*Group approach to the propagation of paraxial modes in a parabolic medium*
10:30 - 11:00	V. Jakubsky	*Confluent Crum-Darboux transformations in Dirac Hamiltonians and optical systems with PT-symmetric refractive index*
11:00- 11:45	**Coffee Break**	
Chairman: J.F. Cariñena		
11:45 - 12:15	D. Levi	*Conditionally invariant equations*
12:15 - 12:45	M.A. Rodríguez	*Thermodynamics of supersymmetric spin chains*
12:45 - 13:15	I. Marquette	*Exceptional orthogonal polynomials in quantum mechanics*
13:15 - 13:45	P. Winternitz	*Painlevé functions as superintegrable potentials*
13:45- 14:00	**Closing Session**	
14:00- 16:00	**Lunch**	

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