Programme Talks: Damping at Granada

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Monday 21
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Hugh Jones (Imperial College, London)

Title: The remarkable optical properties of materials with coordinated gain and loss.

Abstract:
In recent years a great deal of work has been done on understanding quantum theories which have a non-Hermitian Hamiltonian, but which nevertheless possess a real energy spectrum, due in many cases to an underlying PT symmetry. In some circumstances, however, this symmetry may be broken, in which case some or all of the eigenvalues coalesce into complex conjugate pairs.

These ideas have now found practical application in the field of classical optics, where the paraxial equation of propagation is formally identical to the Schroedinger equation, with the role of the quantum potential being played by the variations in the refractive index.

Wave guides and optical lattices with the carefully coordinated regions of loss and gain implied by PT symmetry have many remarkable properties, some of which may prove useful in optical devices needed for optical computers.

We review both the original concepts of PT symmetry in quantum mechanics and their application in classical optics.

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Dieter Schuch (Institut für Theoretische Physik, Frankfurt)

Title: Dissipation, Irreversibility and their Interrelations in Classical and Quantum Physics

Abstract:
In the classical theory of open systems, two aspects must be considered: (1) the dissipation of energy and (2) the irreversible time-evolution. The first can be described by a modified Newtonian equation with an additional friction force (Langevin equation), the latter in a probabilistic description via a Fokker-Planck equation with diffusion terms.

In conventional quantum mechanics, similar equations are obtained in Madelung's hydrodynamic version using a modified Hamilton-Jacobi equation for the phase of the wave function and a (reversible) continuity equation for its amplitude. Important is that both these quantities are not independent of each other but coupled via some invariants.

This coupling can be traced back to a complex nonlinear Riccati equation that occurs in time-dependent as well as time-independent quantum mechanics and also has (at the least, formal) similarities with the quantum Arnold transformation. It also becomes important for open quantum systems since the dissipative aspect is essentially reflected by the behaviour of the phase, whereas the irreversibility is related to a kind of Fokker-Planck equation for the amplitude, leading to a non-unitary time-evolution.

In this context, different effective descriptions of open quantum systems leading to nonlinear Schrödinger equations with (possibly complex) friction terms, (linear) time-dependent Hamiltonians (e.g. Caldirola-Kanai approach) etc. and their interrelations (e.g. via non-unitary transformations) will be discussed. Also for open quantum systems, relations can be drawn to complex nonlinear Riccati equations. Similar equations also occur in other fields of physics, like classical and quantum optics, Bose-Einstein condensates or cosmological models, and the modifications in the case of open quantum systems can provide clues for similar modifications in these fields.

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Julio Guerrero (Departamento de Matematica Aplicada, Murcia and IAA-CSIC, Granada)

Titulo: The Quantum Arnold Transformation and its Applications

Abstract:
The Quantum Arnold Transformation relating system with quadratic, time-dependent Hamiltonians with the free particle

is revised, and some of its applications to dissipative
systems, inflationary cosmological models, and
Bose-Einstein Condensates, are shown.

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Tuesday 22
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Beppe Marmo (INFN Napoli)

Title: The observables of a dissipative quantum system

Abstract: A time-dependent product is introduced between the observables of a dissipative quantum system,
that accounts for the effects of dissipation on observables and commutators. In the $t \to \infty$ limit

this yields a contracted algebra. The general ideas are corroborated by a few explicit examples.

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Francisco Lopez-Ruiz (IAA-CSIC, Granada)

Title: Symmetries of the Bateman's dual system

Abstract:
For the Caldirola-Kanai (C-K) system, describing a quantum damped harmonic oscillator, a couple of constant-of-motion operators generating the Heisenberg algebra can be found making use of the Quantum Arnold Transformation. The inclusion of the standard time evolution symmetry in this algebra for
the C-K non-conservative system, in a unitary manner, requires a non-trivial extension of this basic algebra and hence the physical system itself. Surprisingly, this extension leads directly to the so-called Bateman's dual system, which now includes a new particle acting as an energy reservoir.

The group of symmetries of the dual system will be presented, as well as a quantization
that implies, in particular, a first-order Schrödinger equation. Some comments on its physical solutions as well as on its resonant states will be made in order to clarify a frequent misunderstanding spread through the literature.

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Mikel Fernández-Méndez (Instituto de Estructura de la Materia IEM-CSIC, Madrid)

Title: Unitarity and uniqueness in the quantization of cosmological perturbations

Abstract: We study the Fock quantization of the scalar perturbations about the
FLRW model in the 3-sphere with a scalar massive field as matter content. After
expanding the perturbations in modes using the eigenstates of the Laplace-Beltrami
operator, a perturbative analysis is performed up to terms quadratic in these modes.
We fix the gauge almost completely and introduce a canonical transformation in order
to obtain a convenient formulation of the system. We consider Fock quantizations of
the perturbations with the following properties: i) an SO(4)-invariant vacuum state
and ii) unitarily implementable perturbations dynamics. All such representations are
proven to be unitarily equivalent.

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Jose Luis Jaramillo (Albert Einstein Institut, Potsdam)

Title: Probing spacetime dynamics through horizon geometry dissipation

Abstract:
The qualitative and quantitative understanding of near-horizon
gravitational dynamics in the strong-field regime represents
a challenge both at a fundamental level and in astrophysical
applications. We discuss a research methodology in which spacetime
dynamics is probed through the cross-correlation of geometric
quantities constructed on the black hole horizon and on null
infinity. These two hypersurfaces respond to evolving
gravitational fields in the bulk, providing canonical

"test screens" in a "scattering"-like perspective onto
spacetime dynamics. Aiming at fitting the general theme of the workshop,
we will underline here the link between some of the elements in this
analysis framework and the dissipation of the "test screen"
geometry from the perspective of a viscous-fluid analogy of black hole
horizons.

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Guillermo A. Mena Marugán (Instituto de Estructura de la Materia IEM-CSIC, Madrid)

Title: Uniqueness of the Fock quantization in nonstationary spacetimes

Abstract:
A fundamental problem in quantum field theory in curved spacetimes is the ambiguity in the choice of a Fock representation for the canonical commutation relations. There exists an infinite number of choices that lead to inequivalent physical predictions. In stationary scenarios, a common strategy consists in demanding the invariance of the vacuum under the background spacetime symmetries. When stationarity is lost, a possible generalization is to replace time invariance by the requirement of a unitary evolution. In fact, when the spatial sections are compact, the criterion of a unitary dynamics, together with the invariance under the symmetries of the field equation, turn out to select a unique family of Fock quantizations for scalar fields with a time dependent mass. We study in detail the case of the three-sphere, and discuss the applications in cosmology.

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Jaime Julve (Instituto de Fisica Fundamental, IFF-CSIC, Madrid)

Título: Some properties of Gamow states.

Abstract:
The resonant solutions (Gamow states) to the Schrödinger equation, corresponding to complex energies and momenta, lie outside the familiar realm of Hermitian operators in Hilbert spaces. Some results on the norm, inner products, expansions, and contribution to completeness relations of these states are worked out for 1-dimensional systems with quantum barriers.

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Wednesday 23
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Enrico Celeghini - University of Florence, Italy

Title: BROKEN SYMMETRIES

ABSTRACT:
Two objects we classify together cannot be identical as we have to distinguish between them. Thus they can only be almost equal: every symmetry is -by itself- broken.

To describe a broken symmetries, up to few decades ago, the unique possibility was to start from an exact mathematical symmetry and to introduce the breaking at the physical level or in the states (as in spontaneous symmetry breaking) or in the operators (as in mass formulas for hadrons).

Recently a possibility has appeared to consider the breaking directly in the mathematics. This talk is devoted to discuss this new approach where deformations of Lie algebras, called quantum algebras, are introduced.

Unfortunately these objects are infinite dimensional: indeed they are properly called by mathematicians Quantum Universal Enveloping Algebras. They are infinite dimensional deformations of the infinite dimensional algebra of the polynomials constructed on the Lie algebras generators.

We have thus to came back and individuate, among the infinitely many possible bases, the relevant one. In Lie algebras this work has been done by Cartan and

Dinkin one century ago but, for quantum algebras, the choice has been up to now arbitrarily done.

Here we mimic the Cartan-Dinkin approach to individuate the finite dimensional quantum algebra canonical basis. Resorting to analyticity but also to the underlying Hopf algebra a self-consistent perturbative approach has been thus developed and the quantum algebra canonical generators, deformation of the Lie ones, obtained.

The approach is general and consistent extensions to quantum superalgebras as well as to quantum Poisson algebras has been developed.

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Juan Calvo (Departamento de Matematica Aplicada, Universidad de Granada)

Title: Dynamic and dispersion properties in relativistic kinetic systems

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Manuel Calixto (Departamento de Matematica Aplicada, Universidad de Granada and IAA-CSIC, Granada)

Title: Damping Dicke's Maser Model

Abstract: We consider a system of spins coupled to a single mode of the electromagnetic radiation and study the loss effect in the quantum phase transition from ``normal'' to ``superradiant'' through a coupling to phonons.

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Fernando Barbero (Instituto de Estructura de la Materia IEM-CSIC, Madrid)

Title: Black hole entropy and the thermodynamic limit

Abstract: The stastistical entropy in thermodynamics is usually a staircase function of the energy that cannot be used directly to derive other quantities by differentiation. The standard remedy to this problem is to define a suitable thermodynamic limit in which the entropy is smooth and well behaved. I will discuss in the talk how this can be explicitly done in the case of black holes in loop quantum gravity and show in several examples how the subdominant corrections to the asymptotic behavior of the entropy as a function of the area change in the large area limit.

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Daniel Martín-de Blas (Instituto de Estructura de la Materia IEM-CSIC, Madrid)

Title: The hybrid Gowdy model: Solvable Hamiltonian constraint and inhomogeneous quantum cosmologies

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Mercedes Martín-Benito (Instituto de Estructura de la Materia IEM-CSIC, Madrid)

Title: First steps to bring spin foams closer to statistical physics

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Javier Olmedo (Instituto de Estructura de la Materia IEM-CSIC, Madrid)

Title: Inhomogeneities and inflation in LQC: A hybrid approach

Abstrac: We quantize to completion a homogeneous and isotropic spacetime with positive spatial curvature coupled to a massive scalar field in the framework of Loop Quantum Cosmology. We provide the physical Hilbert space constructed out of the space of initial data on the minimum volume section. By means of a perturbative treatment we introduce inhomogeneities adopting a hybrid quantum approach, i.e., assuming that these degrees of freedom can be

suitably described by a standard Fock quantization. For the considered case of compact spatial topology, the requirements of: i) invariance of the vacuum state under the spatial isometries, and ii) unitary implementation of the quantum dynamics, pick up a privileged set of gauge invariant potentials and a unique Fock representation (up to unitary equivalence).

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Carlos Barcelo (IAA-CSIC, Granada) (Only if weather allows for it)

Title: In search of a solution for the trans-Planckian catastrophe

Abstract:
We use the avoidance of the trans-Planckian problem of Hawking radiation as a guiding principle in searching for a compelling scenario for the evaporation of black holes or black-hole-like objects. We argue that there exist only three possible scenarios, depending on whether the classical notion of long-lived horizon is preserved by high-energy physics and on whether the dark and compact astrophysical objects that we observe have long-lived horizons in the first place. Along the way, we find that i) a theory with high-energy superluminal signaling and a long-lived trapping horizon would be extremely unstable in astrophysical terms and that ii) stellar pulsations of objects hovering right outside but extremely close to their gravitational radius can result in a mechanism for Hawking emission.

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Victor Aldaya (IAA-CSIC, Granada) (Only if weather allows for it)

Titulo: Where are all singularities gone?

Abstract:
In order to clarify the nature of the solution manifold of static and isitropic solutions of Einstein equations in the vacuum, and particularly, the symplectic structure and dynamical symmetries, we investigate the analogous problem in the simpler case of massless Klein-Gordon equation.