INFORMATION GEOMETRY, QUANTUM MECHANICS AND APPLICATIONS

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POLICETA-SAN RUFO (SALERNO)

Book of Abstracts

Contents

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Topological QED in 1+1 dimensions

Author: Elisa Ercolessi[1]

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We will discuss a variant of the Schwinger model that describes 1+1 QED which admits symmetry-protected phases. We will show the appearance of such a phase via both bosonization and DMRG calculations.

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Differential calculus on Jordan algebras and Jordan modules

Author: Alessandro Carotenuto[1]

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Jordan algebras provide suitable ground to formalize properties of a finite dimensional quantum geometry.
Recently M. Dubois-Violette proposed an interpretation both of quark-lepton symmetry and of the existence of three generations of particles in terms of rapresentations of the exceptional Jordan algebra.
During this talk I shall review such a theory and then present some recent results in the thoery of connections on Jordan modules.

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A gentle introduction to Schwinger's picture and groupoids in Quantum Mechanics

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An alternative formulation of Quantum Mechanics based on selective measurements due to Schwinger is reviewed. It is argued that the mathematical structure behind Schwinger's "Symbolism of Atomic Measurements"is that of a groupoid. In this framework, both the Hilbert space (Schrödinger picture) and the C*-algebra (Heisenberg picture) of the system turn out to be derived concepts, that is, they are built out of the underlying groupoid structure.

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Lack of thermalization in quantum systems: Localization and glassiness

Author: Antonello Scardicchio[1]

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Abstract: I will review some recent results on ergodicity breaking in many-body systems due to quantum effects. I will underline the similarities and differences with ergodicity breaking in spin glasses, in particular looking at the random energy model, the p-spin model and the Edwards-Anderson spin glass on the Bethe lattice endowed with quantum dynamics.

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Superluminal and Slow Light Propagation in Quantum System

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In this talk, the superluminal and slow light propagation in quantum system will be reviewed theoretically and experimentally. We will show how the medium response to light such as absorption and dispersion could be controlled by the intensity of applied fields. In fact the probe pulse propagation can be switched from subluminal to superluminal by changing the intensity of the coupling field

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The reference frame interpretation

Author: Natalia Sánchez Kuntz[1]

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This talk is around the discussion of the nature of the quantum state: is the quantum state an ontological description of the system or is it just an epistemological tool for prediction?

In this talk I will make a revision of the PBR theorem; through this I will prove that in order to conclude that a certain quantum state is ontological, by carrying out the demonstration of the PBR theorem[1], the precise quantum system whose state is concluded to be ontological must have undergone a measurement. Then, it is shown that what PBR demonstrate is that systems which have been measured are described by states which are ontological. All this implies that through the PBR theorem one cannot conclude the ontology of a quantum state which describes a system that has not been measured.

With this result I will construct an interpretation of the theory that is inspired by Bohr's complementarity principle, which is what we call \emph{the reference frame interpretation} of Quantum Mechanics.

[1] Pusey, M. F., Barrett, J., Rudolph, T.: On the reality of the quantum state. Nature Physics. 8, 475 (2012)

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Localised States in Bounded Chiral Liquid Crystals

Author: Luigi Martina[1]

[1] *Universita' del Salento - Lecce*

Within the framework of Oseen-Frank
theory, we analyse the static configurations for chiral liquid crystals.
In particular, we find numerical solutions for localised axisymmetric
states in confined chiral liquid crystals with weak homeotropic
anchoring at the boundaries. These solutions describe the distortions of
two-dimensional skyrmions, known as either textit{spherulites} or
textit{cholesteric bubbles}, which have been observed experimentally in
these systems. Relations with nonlinear integrable equations have been
outlined and are used to study asymptotic behaviours of the solutions.
By using analytical methods, we build approximated solutions of the
equilibrium equations and we analyse the generation and stabilisation of
these states in relation to the material parameters, the external fields
and the anchoring boundary conditions.

Because of the anisotropic
optical properties of the medium and the peculiar shape of such an
excitation, we quantitatively evaluate the cross section for the
axis-rotation of polarised light, by resorting to the Born
approximation. The analysis suggests the use of the spherulites as
elements of photonics circuits.

On the other hand the same confined
cholesteric liquid crystals admit special nonlinear static elongated
configurations, described by integrable nonlinear equations with
boundary conditions. Thus, confined helicoidal with disclination type
singularities appear. Differently from the well known linear case, we
explicitly find pi or $2pi$ helicoids and analyse their properties
both by analytical and numerical tools.

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A dynamical description of the quantum measurement process

Author: Antonella De Pasquale[1]

Co-authors: Alessandro Cuccoli [1]; Foti Caterina [1]; Paola Verrucchi [2]; Vittorio Giovannetti [3]

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We provide a dynamical description of the quantum measurement process by framing it into the mindset of the theory of open quantum systems. The system and the measurement apparatus are considered as interacting quantum objects, such that the former "steals"information from the latter.

In this formalism, after a given amount of time, the measurement process emerges in the form of an entangled system–apparatus superposition state whose components correspond to the different outcomes of the measurement. In this respect, we have determined a precise form for the system-apparatus Hamiltonian bringing to a dynamical description of both projective and positive-operator valued measures.

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Classical and Quantum Dynamics for a Parametric Oscillator with Analytical Solutions and Comparison with the Damped Harmonic Oscillator

Author: Dieter Schuch[1]

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For quadratic Hamiltonians, the time-dependent Schrödinger equation possesses Gaussian wave packets as exact solutions. They are completely determined by two parameters, the maximum and the width, where both can be time-dependent. The time-dependence of the maximum is determined by the classical Newtonian equation of motion; the width obeys a complex quadratically nonlinear Riccati equation or an equivalent real nonlinear Ermakov equation. All quantum dynamical properties can easily be constructed from the solutions of these equations. In addition, the link to the corresponding classical dynamics is supplied via linearization of the Riccati equation to a complex Newtonian equation. Real and imaginary parts of this equation are not independent of each other but connected via a kind of conservation law in the complex plane. Knowing the solution of one part makes it possible to determine the solution of the other and, thus, the solution of the Ermakov equation. Consequently, explicit expressions can be obtained immediately for all quantum dynamical properties.
Comparing the wave packets with the solutions of the diffusion equation –also Gaussian with time-dependent width –leads to a parametric oscillator with frequency inversely proportional to time. Detailed analysis enables the elimination of certain divergencies and shows similarities with the damped harmonic oscillator for the aperiodic limit. For different choices of a free parameter, similarities with undercritical and overcritical damping can also be shown.

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Derivations based calculi on Lie type non commutative spaces

Author: Alessandro Zampini[1]

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In this talk we shall describe the setting and the main result of a joint recent work with Patrizia Vitale and Giuseppe Marmo. For a class of algebras, whose non commutativity is related to three dimensional Lie algebras, we show how to induce, upon a suitable reduction from a set of derivations for the 4D Moyal space, a four dimensional calculus realised in terms of both inner and outer classical derivations.

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Entanglement generation and bound states in one-dimensional QED

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An excited atom in free space decays towards its ground state through spontaneous emission. Boundary conditions and artificial dimensional reduction drastically modify this picture, enhancing or inhibiting (sometimes hindering) decay.

We investigate the behaviour of two quantum emitters (two-level atoms) embedded in a linear waveguide, in a quasi-one-dimensional configuration. We focus on the single- and two-excitation sector. We explore the relaxation towards bound states for resonant values of the interatomic distance, the stability of such states, the generation of entanglement and the existence of plasmonic modes.

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Positive Hamiltonians can give purely exponential decay

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It is commonly claimed that only Hamiltonians with a spectrum unbounded both above and below can give purely exponential decay. Because such Hamiltonians have no ground state, they are considered unphysical. Here we show that Hamiltonians that are bounded below can give purely exponential decay. This is possible when, instead of looking at the global survival probability, one considers a subsystem only: We show that the reduced state of the subsystem can exhibit a Markovian dynamics, and some (local) observables can decay exponentially. We conclude that purely exponential decay might not be as unphysical as previously thought.

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Qubit-field interactions as singular Hamiltonian perturbations

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We show that the single-excitation interaction of a family of n qubits with a structured boson field can be effectively modeled by a singular finite-rank perturbation Friedrichs-Lee model of a Hamiltonian with n eigenvalues; the resulting perturbation preserves the absolutely continuous spectrum but drastically modifies the singular spectrum. This structure is shown to be universal in the sense that, by fixing n independent states, any self-adjoint operator may be recast as a Friedrichs-Lee model. Some peculiar examples are presented and discussed.

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Correlated photon emission by two excited atoms in a waveguide

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Systems of atoms coupled to a single or few waveguide modes provide the testbed for physically and practically interesting interference effects. We consider the dynamics of a pair of atoms, approximated as two-level quantum emitters, coupled to a linear guided mode. In particular, we analyze the evolution of an initial state in which both atoms are excited, which is expected to decay into an asymptotic two-photon state. We will investigate the lifetime of the initial conguration and the properties of the asymptotic photon correlations, and unveil the dependence on the physical parameters of the relative probability to observe the two photons emitted in the same direction (parallel) or in opposite directions (antiparallel). We discuss the relevance of the bound states in the one-excitation sector, that occur for selected values of the interatomic distance, for the features of photon correlations.

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Continuous and Pulsed Quantum Control

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We show that the evolution of a quantum system can be controlled using two different procedures, one hinging upon a strong continuous coupling with an external control potential and the other consisting in the application of instantaneous unitary kicks to the system with high frequency, yielding a "bang-bang evolution". In both cases the Hilbert space is partitioned in subspaces among which transitions are inhibited by dynamical superselection rules. Using the Trotter product formula the two procedures can be showed to be equivalent up to the order in which a double limit is evaluated. We have also showed that it is still possible to control the evolution of the system in an interpolating situation between the two kind of evolutions, thanks to the validity of a generalized product formula.

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"Why should (and why can) the path integral serve as the basis for quantum theory (and quantum gravity)?"

Author: Rafael D. Sorkin[1]

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Why should (and why can) the path integral serve as the basis for quantum theory (and quantum gravity)

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Two-Level Quantum Systems with Broken Inversion Symmetry

Author: Giovanni Scala[1]

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We discuss the presence of a nontrivial emission at the Rabi frequency in the Jaynes-Cummings model (JC) with broken symmetry in the diagonal terms of dipole moment. JC is a theoretical model which describes the oscillating behavior of a two-level quantum system in a cavity, interacting with one resonant mode of the electromagnetic radiation at an optical frequency. Analytical results for the time-averaged radiation intensity in relevant physical situations are obtained at the first perturbative order in the symmetry violation parameter. Since the Rabi frequency is proportional to the strength of the coupling with the electromagnetic field, the effect can be used for frequency-tuned parametric amplification and generation of electromagnetic waves.

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Anomalous Heisenberg equation and related issues

Author: Fernando Falceto[1]

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We discuss the Heisenberg equation for operators that do not
preserve the boundary conditions for the domain of the Hamiltonian. We show that it acquires an anomalous term that depends only on the boundary values.
We briefly review the theory of selfadjoint extensions of symmetric
operators where the above mentioned anomalous term plays the key role.
We show how the previous results affect to other identities in quantum
mechanics like Hellmann-Feynman or virial theorems.
We finally study some examples of boundary effects in quantum quenching
dynamics.

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Higher derivative field theories: Classical instabilities and positivity problems

Author: Manolo Asorey[1]

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We will review some basic aspects of the covariant approach to
quantum mechanics in a framework free of ultraviolet singularities.
Some higher derivative field theories are also free of ultraviolet
singularities and ghosts. They seem to provide a safe
framework also for quantum field theories.
However, we point out that they undergo hidden pathologies and in spite
of the absence of ghosts most of these theories are not unitary.

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Relative entropies as potential functions of quantum metrics: The q- z family

Author: Marco Laudato[1]

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The so-called q-z-Rényi Relative Entropies provide huge two parameters family of relative entropies which include almost all well-known examples of quantum relative entropies for suitable values of the parameters. In this talk we consider a log-regularized version of this family and use it as a family of potential functions to generate covariant (0,2) symmetric tensors on the space of invertible quantum states in finite dimensions. The geometric formalism developed allows us to obtain the explicit expressions of such tensor fields in terms of a basis of globally defined differential forms on a suitable unfolding space without the need to introduce a specific set of coordinates. We first limit the exposition to the qubit case, and then, we extend the results to a generic n-level system. By suitably varying the parameters q and z, we are able to recover well-known examples of quantum metric tensors that, in our treatment, appear written in terms of globally defined geometrical objects that do not depend on the coordinates system used. In particular, we obtain a coordinate-free expression for the von Neumann-Umegaki metric, for the Bures metric and for the Wigner-Yanase metric in the arbitrary n-level case.

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On divisibility and quantum Markovianity for non-invertible dynamical maps

Author: Dariusz Chru´sci´nski[1]

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We analyze the relation between CP-divisibility and the lack of information back flow for an arbitrary not necessarily invertible dynamical map [1,2,3]. It is well known that CP-divisibility always implies lack of information back flow. Moreover, these two notions are equivalent for invertible maps. We show that for a map which is not invertible the lack of information back flow always implies the existence of completely positive (CP) propagator which, however, needs not be trace-preserving. Interestingly, for a class of image non-increasing dynamical maps [majority of examples studied in the literature do belong to this class] this propagator becomes trace-preserving as well and hence the lack of information back flow implies CP-divisibility. This result sheds new light into the structure of the time-local generators giving rise to CP-divisible evolutions. It is shown that if the map is not invertible then positivity of dissipation/decoherence rates is no longer necessary for CP-divisibility.
[1] D. Chru´sci´nski, A. Kossakowski, and A. Rivas, Phys. Rev. A 83, 052128 (2011).
[2] B. Bylicka, M. Johansson, and A. Ac´ın, Phys. Rev. Lett. 118 , 120501 (2017).
[3] D. Chru´sci´nski, A. Rivas, and E. Størmer, arXiv:1710.06771

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Contact Lagrangian structures and dissipation

Author: Hans Cruz Prado[1]

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We review the concept of dissipation from quantum to classical systems, proving that it does not make sense to say that a system is "conservative" or "dissipative" per se because dissipation is a relational concept. In this spirit, we introduce a "descomposition principle" that allows describe "dissipative"systems in terms of "Contact Lagrangian structures".

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't Hooft quantization scheme and Gupta-Bleuler condition

Author: Massimo Blasone[1]

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In the attempt to find a deterministic description of quantum systems, 't Hooft proposed the idea that deterministic degrees of freedom could operate at very high energy scales (e.g. Planck scale) and ordinary quantum mechanics would appear as a result of an information loss process. This implies the existence of "beables", i.e. ontological (commuting) operators which, after information loss, would give rise to the usual quantum (non-commuting) observables.
I will review some recent developments along this line of research and in particular the possibility of regarding the Gupta-Bleuler condition arising in the quantization of electromagnetic field in Lorenz gauge, as the condition for obtaining a genuine quantum system (QED) out of a deterministic one.

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Multi-symplectic formulation of Lie group thermodynamics for gauge theories: a work in progress

Author: Goffredo Chirco[1]

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I consider the extension of Souriau's formalism of Lie group thermodynamics to the case of constrained hamiltonian systems and gauge theories, in the perspective of a general covariant reformulation of statistical mechanics compatible with the conceptual framework of General Relativity.

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CONCLUSIONS AND PERSPECTIVES

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