Problemi Attuali di Fisica Teorica

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Meccanica Quantistica e Computazione Quantistica
(giornate a cura di G. Casati – Como, S. Pascazio – Bari)

31 Marzo 2007

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Vietri sul Mare (Italy)

Ferdinando de Pasquale (Roma I)
con Gian Luca Giorgi, Simone Paganelli

Squeezing and entanglement of two macroscopic photon systems

Bose-Einstein condenstates in restricted geometries are currently considered as macroscopic quantum systems suitable for quantum information processing. We show that two coupled photon systems exhibit, under realistic conditions, the same properties of BEC systems. The amplitude of the coupling should be greater than the energy of the isolated systems and an even small non linearity is taken into account. Under these condition the vacuum state is unstable with respect to an perturbation (symmetry-breaking field) which can be associated to a fixed classical current. The new ground state exhibits BEC and squeezing. A large condensate amplitude is associated to a small non-linearity strength. In the new ground state, as a result of squeezing, the systems are entangled. We study the statistical correlation of the two system both in the steady state and in the quantum oscillation regime as a function of the symmetry-breaking field. Peculiarities of a vanishing small symmetry-breaking field limit (Goldstone theorem) are discussed. A comparison with a different model of photon superfluid is carried out.

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Carlo Di Castro (Roma I)

Quantum criticality in Cuprates

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P. Facchi (Bari)
with M. Asorey, V.I. Man'ko, G. Marmo, S. Pascazio, E.G.C. Sudarshan

Quantum and classical tomography

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Domenico Finco (Univ. Bonn)

Coupling in the singular limit of thin quantum waveguides

We analyze the problem of approximating a smooth quantum waveguide with a quantum graph. We consider a planar curve with compactly supported curvature and a strip of constant width around the curve. We rescale the curvature and the width in such a way that the strip can be approximated by a singular limit curve, consisting of one vertex and two infinite, straight edges, i.e. a broken line. We discuss the convergence of the Laplacian, with Dirichlet boundary conditions on the strip, in a suitable sense and we obtain two possible limits: the Laplacian on the line with Dirichlet boundary conditions in the origin and a non trivial family of point perturbations of the Laplacian on the line. The first case generically occurs and corresponds to the decoupling of the two components of the limit curve, while in the second case a coupling takes place. We present also two families of curves which give rise to coupling.

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Andrea Fubini (Firenze)
with Giuseppe Falci and Andreas Osterloh

Robustness of adiabatic passage trough a quantum critical point

Adiabatic passages are a fascinating and important tools in modern physics, since they allow to manipulate quantum states in a controlled manner via tunable parameters of a physical model system. We analyze the dynamical crossing of the quantum critical point in the XY model in transverse field, analytically for an ideal clean system and numerically in the presence of white noise. Our focus is to determine the robustness of the adiabatic passage trough a (quasi) degeneracy point of a many-body system when one considers the effects of finite sweeping period, mesoscopic and noise fluctuations. The vanishing gap makes the notion of slow change rates of the driving field obsolete, and strictly speaking no adiabatic passage exists across a quantum critical point. This topic is also related to the Kibble-Zurek theory, where critical scaling laws have been employed to obtain predictions for the density of defects after the crossing of a phase transition[1,2]. We find a surprisingly high predictive power of the Landau-Zener formula for the final excitation density, when several modes are taken into account and we reproduce the scaling laws predicted by the Kibble-Zurek theory. In addition huge fluctuations around the average excitation density dominate the state during the sweep, in particular for not too large systems. The presence of noise corrupts the success of a possible adiabatic passage for low sweep velocities due to the opening of a non-hermitian degeneracy leading to a ``critical region'' rather than just a singular point.

[1] W.H. Zurek, Phys. Rep. {\bf 276}, 177 (1996);
[2] W.H. Zurek, U. Dorner, and P. Zoller, Phys. Rev. Lett. {\bf 95}, 105701 (2005);
[3] A. Fubini, G. Falci, and A. Osterloh, cond-mat/0702014.

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Ennio Gozzi (Trieste)

Interplay Between Classical and Quantum Mechanics Via a Metric in Time

After a quick review of the Koopman-von-Neumann formalism for Classical Mechanics and its path-integral counterpart, we compare it with the path-integral for Quantum Mechanics. Next we show how the two path-integrals can be interpolated by a family of metrics in an extension of time.

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Cosmo Lupo (Napoli)

On the Realignment Criterion and Beyond

I discuss and comment the separability criterion known as the Realignment Criterion. Some consequences of this criterion are described, which yield to a geometrical characterization of entanglement breaking channels. Finally, the question is posed whether is possible to extrapolate new independent criteria.

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Chiara Molinelli (Laboratoire Kastler Brossel, Parigi)
with O. Arcizet, T. Briant, P.-F. Cohadon, A. Heidmann, M. Pinard

Radiation pressure effects upon a micromirror in a high finesse optical cavity

We present an experiment where the motion of a silicon micro{mechanical resonator is optically measured with a highfinesse cavity (F = 30000). We have observed the thermal noise of our MEMS over a wide frequency range with a limited sensitivity at the 10^-19m/sqrt(Hz) level and we have characterized its eigenmodes. We have cooled the resonator with a cold damping technique, which consist in applying to the MEMS an electrostatic viscous force; moreover we have demonstrated a new cooling mechanism due to a direct effect of radiation pressure in a detuned cavity. These active cooling system, combined with the passive cryogenic technique, may lead to a cooling of the resonator suffcient for observing its quantum ground state.

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Elisabetta Paladino (Catania)

Impurities induced dephasing in solid state qubits

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Orlando Panella (INFN Perugia)

Casimir-Polder intermolecular interactions in minimal length theories

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Matteo Paris (Milano)

Optimal quantum estimation of loss in bosonic channels

We address the estimation of the loss parameter of a bosonic channel probed by Gaussian signals. We derive the ultimate quantum bound on precision and show that no improvement may be obtained by having access to the environment degrees of freedom. We found that, for small losses, the variance of the optimal estimator is proportional to the loss parameter itself, a result that represents a qualitative improvement over the shot noise limit. An observable based on the symmetric logarithmic derivative is derived, which attains the ultimate bound and may be in principle implemented using Gaussian operations and photon counting.

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Luca Pezze' (Trento)

Phase estimation and Heisenberg limit in Quantum Interferometry

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Francesco Plastina (Calabria)

Critical properties of Entanglement and Berry phase in the Dicke model

By employing the adiabatic approximation, we discuss the thermodynamic-limit and finite-size scaling properties of both quantum correlations (entanglement) and of the geometric (Berry's) phase in the Dicke model. In the thermodynamic limit, we entanglement shows a non-analytic behavior at the super-radiant transition point and at the same time a nonzero Berry phase is obtained only if a path in parameter space is followed that encircles this critical point. Precursors of the critical behavior are present for a system with finite size. To show this, we evaluate the leading orders in the 1/N expansion to obtain analytically various bipartite entanglement measures and the Berry phase, together with their critical exponents.

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Mario Pulvirenti (Roma I)

Weak-Coupling for Quantum Systems and Boltzmann equation

In this talk I want to review some recent results concerning the transition from the quantum dynamics of a large quantum systems to a mesoscopic picture (Boltzmann equation) in the so called weak-coupling limit.

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Gaetano Senatore (Trieste)

**Effetti di dispositivo sulle proprieta di spin di elettroni confinati in 2 dimensioni:
la finitezza trasversa, la degenerazione di valle, il disordine e l' anisotropia di massa.**