Problemi Attuali di Fisica Teorica

XVII Edizione

15 - 20 Aprile 2011

Lloyd's Baia Hotel

Vietri sul Mare (Italy)

Programma

	Venerdi 15
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16:20 - 17:05	R. Savelli - On Flux Quantization in F-theory
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17:40 - 18:25	M. Taronna - String lessons for Higher Spins

	Sabato 16
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10:20 - 11:05	D. Cassani - Lifshitz solutions from consistent truncations with massive modes
11:10 - 11:40	Coffee Break
11:40 - 12:25	F. Nesti - Large distance modified gravity and exact spherically-symmetric solutions
12:30 - 15:00	Lunch Break
15:00 - 16:00	M. Caldarelli (rassegna) - Black holes, fluids and stability
16:10 - 16:40	Coffee Break
16:40 - 17:25	R. Ricci - Cusp anomaly and integrability from string theory
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	Domenica 17
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09:50 - 10:50	M. Trapletti (rassegna) - The MSSM model from compactifications of the heterotic string
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11:30 - 12:30	S. Pasquetti (rassegna) - 2d CFT's, N=2 theories and surface operators

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09:55 -10:20	F. Plastina - Memory-keeping and forgetfulness in the dynamics of a qubit coupled to a spin chain
10:20 -10:45	F. A. Bovino - Quantum representation of a Spiral Phase Plate
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11:10 -11:40	coffee break
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16:15 -16:40	C. Lupo - Quantum communication networking and control
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17:35 -18:00	P. Perinotti - Informational axioms for Quantum Theory

	Martedì 19
09:30 - 09:55	P. Sodano - Long Range Distance Independent Entanglement Generation in Kondo Systems
09:55 -10:20	B. Leggio - Heat capacity versus entanglement in a simple spin model
10:20 -10:45	E. Ercolessi - Entanglement in Luttinger Liquids
10:45 -11:10	F. Troiani - Towards quantum information processing with molecular nanomagnets
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11:40 -12:05	N. Korolkova - Quantum correlations beyond entanglement and Gaussian bound information
12:05 -12:30	F. Sciarrino - New optical technologies for quantum information processing
12:30 -12:55	E. Brambilla - Exploring the spatio-temporal correlation of twin photons via frequency up-conversion
13:00 -15:00	Lunch Break
15:00 -15:25	S. Montangero - Control of Many Body Quantum Systems
15:25 -15:50	D. Ciampini - Testing the quantum speed limit in a BEC experiment
15:50 -16:15	K. Yuasa - Generation of Quantum States by Ergodic Maps
16:15 -16:40	F. Logiurato - On the Born Rule as a Theorem
16:40 -17:10	Coffee Break
17:10 -17:35	P. Aniello - Randomly Generated Semigroups and Quantum Information
17:35 -18:00	G. Palumbo - BF Theory in Quantum Computation
18:00 -20:00	Poster

	Mercoledì 20
09:30-09:55	F. Illuminati - Frustration, entanglement, and factorization in complex quantum systems
09:55-10:20	A. Allevi - Generation of non-Gaussian pulsed states by exploiting quantum and classical correlations
10:20-10:45	A. D'Arrigo - Transmission of classical and quantum information through a memory amplitude damping channel
10:45-11:10	I. Marzoli - A trapped electron quantum computer?
11:10-11:40	Coffee Break
11:40-12:05	G. Adesso - All non-classical correlations can be activated into distillable entanglement
12:05-12:30	M. Barbieri A method for characterising "kittentronics" quantum gates
12:30-12:55	M. Gramegna - Experimental quantum cryptography schemes based on orthogonal states
13:00-15:00	Lunch Break
15:00-15:25	R. Zambrini - Quantum aspects of synchronization
15:25-15:50	M. Bellini - High-fidelity noiseless amplification of light
15:50-16:15	P. Villoresi - Quantum Communications in Free-Space
16:15-16:40	Coffee Break

Abstract

Campi, Gravità e Stringhe

a cura di

L. Bonora - A. Tomasiello

Black holes, fluids and stability

Marco Caldarelli
LPT, Orsay & CPhT, Ecole Polytechnique

In higher than four dimensions, black holes exhibit a much richer dynamics, and qualitatively new phenomena emerge. I will review their properties and show how deviations from the familiar four-dimensional behavior can be traced back to the emergence of widely separated scales in the system. We will see that those are regimes in which instabilities arise and the black hole behaves effectively as a fluid that lives on a dynamical worldvolume. As a result, we gain new insights into the phases of higher dimensional black holes.

Lifshitz solutions from consistent truncations with massive modes

Davide Cassani
Padova University

In the context of the gauge-gravity duality, consistent truncations have proved to be powerful solution-generating tools, their latest application being to the holographic description of condensed matter systems. In this talk, I will discuss a rich class of consistent truncations of type IIB supergravity on squashed Sasaki-Einstein manifolds, leading to N=4 or N=2 gauged supergravity in five dimensions. Building on this, I will illustrate a general result relating AdS backgrounds to non-relativistic Lifshitz solutions in
one dimension less.

Observables from inflation as a probe of high-energy physics and string theory

Diego Chialva
University of Mons

Observations in cosmology have reached a high level of precision. This, together with the sensitivity of the observables generated during inflation to the details of high energy physics, opens the way to the hope that we can test fundamental theories, even constraining, with luck, aspects of string theory. I give an introduction to the formalism and the basic aspects of inflation and its observables, and then discuss how the latter ones can show signatures of very high energy physics, focusing on some examples related both to the CMBR and to observations via (gravitational) interferometers.

Quivers and Noncommutative Donaldson-Thomas Invariants

Michele Cirafici
CAMGSD, Instituto Superior Tecnico, Lisbon

Donaldson-Thomas type invariants of Calabi-Yau threefolds are believed to count BPS states in string theory compactifications. In this talk I will discuss noncommutative Donaldson-Thomas invariants associated with abelian orbifold singularities. Their moduli spaces can be studied via a certain quiver which is associated to the structure of the singularity via the McKaycorrespondence. This quiver can be used to construct a topological quantum mechanics which computes the index of BPS states.

D-brane non-perturbative effects and geometric deformations

Luca Martucci
INFN Roma ``Tor Vergata``

Non-perturbative effects on D-branes play a crucial role in several applications of string theory. In particular, in string compactifications to four-dimensions, they are usually described at the level of the low-energy four-dimensional effective theory. However, it is natural to expect that non-perturbative dynamics on D-branes can have an effect already at the ten-dimensional level. I will address this problem, showing how a gaugino condensate on a stack of D-branes changes the complex and the symplectic structures of the original compactification manifold by deforming the ten-dimensional supersymmetry conditions. I will focus on the cases of D5, D6 and D7-branes. For the latter case, I will discuss the explicit form of the resulting back-reacted background at linear order in the gaugino condensate.

Large distance modified gravity and exact spherically-symmetric solutions

Fabrizio Nesti
L'Aquila University

A massive gravity theory can be obtained by coupling the metric to additional dynamical fields, leading to a well-behaved phase with Lorentz breaking. I discuss the weak field limit and then describe the exact spherically symmetric solutions generalizing the Schwarzschild metric to the case of massive gravity. Besides the usual 1/r term, the main effects are screening/anti-screening of the bare mass of a body, and the presence of a new power-like term. The size of these corrections are determined by the shape (the radius) of the source, and the power-like term may dominate at large distances or even in the ultraviolet. The effect persists also when the fluctuations of the extra field are decoupled. Some results on the propagation in a curved background are presented.

2d CFT's, N=2 theories and surface operators

Sara Pasquetti
Queen Mary University, London

I will review the correspondence recently proposed by Alday, Gaiotto and Tachikawa, relating the new class of four-dimensional N=2 super-conformal gauge theories introduced by Gaiotto to two-dimensional CFT's. I will also report on an interesting extension of the original correspondence addressing the introduction defects in the gauge theory, such as surface operators, and their dual CFT realisation.

Cusp anomaly and integrability from string theory

Riccardo Ricci
Imperial College, London

According to the AdS/CFT duality a remarkable correspondence exists between strings in AdS and operators in N=4 SYM. A particularly important case is that of folded strings and the so called twist-operators in gauge theory. This is a remarkable tool for uncovering and checking the detailed structure of the AdS/CFT correspondence and its integrability. In this talk I will show how to match the expression of the anomalous dimension of twist operators (cusp anomaly) as computed in string theory with the result obtained from the Bethe ansatz of SYM. This agreement resolves a long-standing disagreement between gauge and string sides of the AdS/CFT duality and provides a highly nontrivial strong coupling test of SYM integrability. Using superstring sigma model perturbation theory I will also compute the dispersion relations of the elementary excitations near a folded string. This calculation, which is motivated by the computation of the null polygonal Wilson loops, will be compared with the recent asymptotic Bethe ansatz computation.

On Flux Quantization in F-theory

Raffaele Savelli
MPI, Munich

The problem of the quantization of fluxes in F-theory compactifications is addressed using M/F theory duality and Witten's prescription for the quantization of the M-theory G-flux. In the case of F-theory on smooth Calabi-Yau fourfold no shifted quantization condition arises: any possible half-integral quantization effects must arise from 7-branes, i.e. from singularities of the fourfold. Flux quantization rules for F-theory fourfolds with Sp(N) singularities are then analyzed and the results are connected via Sen's limit to type IIB string theory. The G-flux turns out to be half-integrally quantized whenever the 7-brane stack wraps a non-spin manifold, according to the perturbative Freed-Witten anomaly. General explicit formulae are given for the D7 gauge flux as well as for the curvature and flux-induced D3 tadpoles.

Holographic Superconductors and Negative Refractive Index

Massimo Siani
Leuven University

Using holography, we study a model which exhibits the peculiar features of superconductivity on the strongly coupled field theory side. Beyond this surprising result, we show that the same model predicts the refractive index becoming negative at low frequencies and temperatures.

String lessons for Higher Spins

Massimo Taronna
SNS, Pisa

I will address the issue of consistent higher-spin interactions taking String Theory as a ``theoretical laboratory'', presenting handy expressions for the whole set of bosonic and fermionic (SUSY) higher-spin Noether currents. I will also comment on the issue of introducing explicitly non-local quartic couplings. The extension of these results to the case of mixed-symmetry fields will be also described.

The MSSM model from compactifications of the heterotic string

Michele Trapletti
Bonn University

We present the main constructive and phenomenological features of heterotic string models reproducing, at low energy, the MSSM quantum numbers. In particular, we show how models of this kind can be obtained both from orbifold and smooth manifold compactifications

Meccanica Quantistica

Fourth Italian Quantum Information Science Conference 2011

a cura di

P. Facchi - V. Giovannetti - S. Pascazio

All non-classical correlations can be activated into distillable entanglement

Gerardo Adesso
University of Nottingham

We devise a protocol in which general non-classical multipartite correlations produce a physically relevant effect, leading to the creation of bipartite entanglement. In particular, we show that the relative entropy of quantumness, which measures all non-classical correlations among subsystems of a quantum system, is equivalent to and can be operationally interpreted as the minimum distillable entanglement generated between the system and local ancillae in our protocol. We emphasize the key role of state mixedness in maximizing non-classicality: Mixed entangled states can be arbitrarily more non-classical than separable and pure entangled states.

Generation of non-Gaussian pulsed states by exploiting quantum and classical correlations

Alessia Allevi* & Maria Bondani
*Università dell'Insubria

Photon-number correlations represent an unavoidable requirement for the generation of non-Gaussian conditional states. The nature of the correlations and the conditions posed on the detected-photon numbers, either quantum or classical, determine the properties of the produced states. Nevertheless, in order to achieve a reliable quantification of correlations in the regime of rather intense pulsed fields, where conditioning would be relevant, it is necessary to determine the number of photons in each pulse. To this aim we show that the correlation coefficient between the two components of a rather intense pulsed bipartite state can be reliably determined [1] by using a pair of photodetectors (HPDs, R10467U-40, Hamamatsu) providing shot-by-shot quantifications of the number of photons [2-4].
We exploit the correlation properties in the experimental preparation of conditional states, by selecting the data on one component according to a rule set on the other. We perform either an "inconclusive" photon subtraction, by selecting the events corresponding to the simple presence of light [5], or a "conclusive" photon subtraction, by selecting the events corresponding to a precise and sizeable number of detected photons. The procedure realizes non-Gaussian operations on Gaussian states that produce highly non-Gaussian conditional states useful for applications in quantum information and communication.
We operated on a quantum correlated multimode twin beam generated by type-I spontaneous down-conversion [6] and on classically correlated single-mode (pseudo)-thermal fields [7]. We present thorough analyses of the generated conditional non-Gaussian states that are in agreement with the theory [8].

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Randomly Generated Semigroups and Quantum Information

Paolo Aniello
Università di Napoli

We will introduce an interesting class of semigroups of operators that arise in the study of various physical contexts, namely, the "randomly generated semigroups". We will focus, in particular, on the remarkable subclass formed by the so-called twirling semigroups, and we will observe that the twirling semigroups are quantum dynamical semigroups. Next, we will briefly discuss the role played by the twirling semigroups in quantum information. Finally, we will provide a characterization of the infinitesimal generators of this class of quantum dynamical semigroups.

A method for characterising "kittentronics" quantum gates

M. Barbieri*, R. Blandino, F. Ferreyrol, R. Tualle-Brouri and Ph. Grangier
*Laboratoire Charles Fabry, Palaiseau

We discuss and implement experimentally a method for characterising quantum gates operating on superpositions of coherent states. The peculiarity of this encoding of qubits is to work with a non-orthogonal basis, and therefore some technical limitations prevent us from using standard methods, such as process tomography. We adopt a different technique, that relies on some a-priori knowledge about the physics underlying the functioning of the device. A parameter characterising the global quality of the quantum gate is obtained by \virtually" processing an entangled state.

Data & Logic Buses from Cold Atom Chains

Sougato Bose
University College London

One of the central problems in many realizations of QIP is the lack of direct long distance interactions between qubits for implementation of quantum gates. An additional problem in many realizations, such as with cold atoms in optical lattices is the lack of specificity of gates i.e., doing gates to a pair of qubits without touching the others. Here we will describe a scalable QIP architecture where qubits are separately trapped distant atoms, while a cold atom chain in an optical lattice may serve as a logic bus for quantum gates involving arbitrary pairs of distant atoms. Additionally, I will describe some close to implementable schemes for information transfer through optical lattice cold atom chains, which also enable, for the first time, an exploitation of the short range entanglement inherent in typical many-body systems for communication purposes. Time permitting, I may also discuss a mechanism of quantum gates between flying atomic qubits through their collisions. (Note: All the above are collaborative works with the various coauthors being Bayat, Banchi, Verucchi, Song-Yang and Korepin).

Quantum representation of a Spiral Phase Plate

Fabio Antonio Bovino
SELEX Sistemi Integrati, Genova

We introduce a quantum representation of a Spiral Phase Plate acting on an electromagnetic field as a two mode phase operator. The representation is based on the Newton binomial expansion and on properties of rational power of lowering and raising operators of quantum field. The correctness of this representation is proved by obtaining the same results of the Paul's operator in the single mode limit and comparing the results of two particular problems solved both in the classical and quantum picture: the action of a Spiral Phase Plate on a Gaussian Beam (corresponding to the vacuum state of the two-dimensional harmonic oscillator) and on a off-axis Gaussian Beam (corresponding to the displaced vacuum state in quantum picture).

Exploring the spatio-temporal correlation of twin photons via frequency up-conversion

E. Brambilla*, A. Gatti, O. Jedrkiewicz, J.-L. Blanchet, P. Di Trapani, L. Lugiato
*Universita' dell'Insubria

The entangled photon pairs (biphotons) produced from parametric down-conversion (PDC) in a χ^2 nonlinear crystal are the key element for several quantum information and communication schemes. Recent theoretical investigations [1-2] have revealed the peculiar structure of the biphotonic correlation characterizing the entanglement of twin beams in the space-time domain. The biphotonic correlation in type I PDC is characterized by a X-shaped geometry, which turns out to be non-factorable in space and time, offering thus the relevant possibility of manipulating the temporal bandwidth of biphoton entanglement by acting on their spatial degrees of freedom. The name "X-entanglement" was coined to describe this geometry [1]. Another key feature which emerged is the extreme spatial and temporal localization of the biphotonic correlation, on the micrometer and femtosecond range, respectively, which is present only when biphotons are detected in the near field of the PDC source. From an experimental point of view, the full disclosure of the strongly localized X-shaped biphotonic structure is extremely challenging as i) it requires a careful manipulation of both the spatial and the temporal degree of freedom of the system and ii) any refractive optical elements must be avoided, since dispersion will destroy the biphoton correlation. In the high gain regime of PDC in which we work in Como, the usual Hong-Ou-Mandel (HOM) interferometric scheme is not suitable as the visibility of the HOM dip becomes exceedingly low when photon pairs cannot be resolved individually.
We propose an alternative detection scheme in which information on the biphoton correlation is obtained through the inverse process of sum-frequency generation (SFG) occurring in a second crystal identical to the first, which substitutes the coincidence counting device of the HOM scheme. We demonstrate that the proposed setup allows to retrieve precise information on the full spatio-temporal structure of the biphoton correlation from the measurement of the SFG intensity, by monitoring the temporal delay and the spatial transverse shift applied to two phase-conjugate components of the PDC field.
We analyze in details the feasibility of the experiment, discussing the issue of the visibility of the biphotonic structure against the incoherent background of the SFG field that derives from the random up-conversion of pairs of PDC photons which are not phase-conjugated. We also investigated the spectral properties of the SFG field in the temporal and the spatial frequency domain, showing that both spectral and far-field measurements allows to isolate the coherent component containing the information on the biphotonic correlation, thereby improving drastically its visibility. We also present preliminary experimental results that confirm this prediction, showing that the coherent component of the SFG spectrum reproduces the narrow spectrum of the pump beam and can be clearly distinguished from the speckle-like incoherent background of much lower intensity.

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[2] L. Caspani, E. Brambilla and A. Gatti, Tailoring the spatiotemporal structure of biphoton entanglement in type-I parametric down-conversion, Phys. Rev. A 81, 033808 (2010).

Information value of quantum states and channels

Francesco Buscemi
University of Nagoya

A famous theorem in statistics, proved by Blackwell, Sherman and Stein in 1951, characterizes statistical sufficiency in terms of the "information value" of statistical models in statistical decision problems. In this talk, I will extend some of these ideas by constructing a general framework for the comparison of (discrete and finite-dimensional) statistical models, valid in both classical and quantum decision theory. I will illustrate some consequences of such result in quantum information theory and quantum foundations.

Dynamical chaos, entanglement generation and complexity of quantum motion

Giulio Casati
Universita' dell'Insubria

Given two quantum systems how can we decide which one is more complex than the other? In classical mechanics the notion of complexity is rooted in the local exponential instability which leads to dynamical chaos. Such property is absent in quantum mechanics. Here we discuss the deep implications that chaos and entanglement have in characterizing quantum many-body dynamical complexity.

Testing the quantum speed limit in a BEC experiment

D. Ciampini*, M. Bason, M. Viteau, N. Malossi, O. Morsch, R. Mannella, E. Arimondo, V. Giovannetti, R. Fazio
*Universita' di Pisa

How fast a quantum state can evolve to an orthogonal state has attracted considerable attention in connection with quantum measurement and information processing. A lower bound on the orthogonalization time, based on the energy spread of the initial state, was found by Mandelstam and Tamm [1]. Another bound, based on the average energy E, was established by Margolus and Levitin [2]. Both inequalities play an important role in the study of quantum mechanical processes in Nature, since they provide general limits on the speed of dynamical evolution.
The time it takes a quantum system to complete a tunneling event (which in the case of cross-barrier tunneling can be viewed as the time spent in a classically forbidden area) is related to the time required for a state to evolve to an orthogonal state, and an observation, i.e., a quantum mechanical projection on a particular basis, is required to distinguish one state from another. We have performed time-resolved measurements of Landau-Zener tunneling of Bose-Einstein condensates in accelerated optical lattices [3], which are of current interest in the context of optimal quantum control and the quantum speed limit [4,5,6].
More generalized Landau-Zener protocols involving non-linear sweep functions are predicted to lead to shorter minimum times for completing a tunneling event [6,7]. Applying such protocols on Bose-Einstein condensates in optical lattices, we have measured a significant reduction of the tunneling time, approaching the predicted quantum speed limit.

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[7] J. Roland and N.J. Cerf, Phys. Rev. A 65, 042308 (2002)

Tomography with coupled Josephson oscillators

Matteo Cirillo
Universita' di Roma Tor Vergata and MINAS Lab

Several experiments have been reported describing the entanglement of Josephson systems oscillators. The interpretation of the experiments based on the quantum mechanics of two coupled two level systems has been reported and from there on it has been concluded that Josephson devices could offer interesting platforms for quantum coherence and computation.

In my talk I will review the work that we have been performing on the electrical model of most of the Josephson systems analyzed in the recent experiments. We find that this model, described by deterministic nonlinear equations, provides good explanations for the analyzed experiments. In particular, we have found that two Josephson oscillators (each represented by a superconducting loop closed by a tunnel junction), each described by nonlinear evolution equations and coupled by a capacitor, show the same features in terms of density matrix, entanglement of formation, and tomography as the experimentally investigated systems.

Transmission of classical and quantum information through a memory amplitude damping channel

Antonio D'Arrigo*, Giuliano Benenti, and Giuseppe Falci
*Universita' di Catania

We consider the transfer of classical and quantum information through a memory amplitude damping channel. Such a quantum channel is modeled as a damped harmonic oscillator, the interaction between the information carriers - a train of qubits - and the oscillator being of the Jaynes-Cummings kind. We prove that this memory channel is forgetful, so that quantum coding theorems hold for its capacities. We analyze entropic quantities relative to two uses of this channel. We show that memory effects improve the channel aptitude to transmit both classical and quantum information, and we investigate the mechanism by which memory acts in changing the channel transmission properties.

Entanglement in Luttinger Liquids

Elisa Ercolessi
Universita' di Bologna

We will discuss analytical expressions for the Renyi entropies of some lattice models which, in the continuum limit, exhibit Luttinger Liquid behaviour. A comparison with numerical (DMRG) data will be presented. We will examine both critical and off-critical situations, describing also the emergence of some peculiar situations, such as the presence of essential singularities.

Statistical mechanics of entanglement

Giuseppe Florio
Università di Bari

We apply the tools of statistical mechanics to the study of the properties of entanglement. In particular, we introduce a partition function and a fictitious temperature. In the limit of large systems we discover that entanglement exhibits a rich structure both for positive and negative temperature ranging, respectively, from maximally entangled to separable states.

Experimental quantum cryptography schemes based on orthogonal states

Marco Gramegna
INRIM Torino

Since, in general, non-orthogonal states cannot be cloned, any eavesdropping attempt in a Quantum Communication scheme using non-orthogonal states as carriers of information introduces some errors in the transmission, leading to the possibility of detecting the spy. Usually, orthogonal states are not used in Quantum Cryptography schemes since they can be faithfully cloned without altering the transmitted data. Nevertheless, L. Goldberg and L. Vaidman [1] proposed a protocol in which, even if the data exchange is realized using two orthogonal states, any attempt to eavesdrop is detectable by the legal users. In this scheme the orthogonal states are superpositions of two localized wave packets which travel along separate channels, i.e. two different paths inside a balanced Mach-Zehnder interferometer. Here we present an experiment realizing this scheme. Furthermore, we will discuss the perspectives of such protocol and other similar protocols.

[1] L. Goldberg and L. Vaidman, Phys. Rev. Lett. 75 (7), pp. 12391243, 1995

Frustration, entanglement, and factorization in complex quantum systems

Fabrizio Illuminati
Universita' di Salerno

We review some recent results on the properties of entanglement entropies and their use in the study of quantum many body systems. We will discuss the relations between geometric entanglement and a recently introduced universal measure of frustration. We will then analyze the scaling properties of entanglement entropies and entanglement spectra in quantum spin systems and their relation with entanglement phase transitions, multipartite to bipartite entanglement conversion, and ground state factorization. If time allows, we will briefly touch upon the subjects of long-distance and modular entanglement.

Quantum correlations beyond entanglement and Gaussian bound information

Natalia Korolkova
University of St. Andrews

We show the existence of Gaussian multipartite bound information which is a classical analog of Gaussian multipartite bound entanglement. We construct a tripartite Gaussian distribution from which no secret key can be distilled between any two parties yet it cannot be created by local operations and classical communication.
This demonstrates a close link between entanglement and secrecy in the domain of Gaussian continuous random variables. Further, the bound information can be activated and used to distributed secret correlations, that is to create a secret key. We discuss the connection between this phenomenon and the distribution of Gaussian entanglement by separable ancilla and comment of the role of quantum discord in these schemes.

Heat capacity versus entanglement in a simple spin model

B. Leggio*, A. Napoli, H. Nakazato, A. Messina
*Università di Palermo

A simple two-qubit model showing Quantum Phase Transitions as a consequence of ground state level crossings is studied in detail. Using the Concurrence of the system as entanglement witness and heat capacity as marker of thermodynamical properties, an analytical expression giving the latter in terms of the former is obtained. Exploiting some of its features, an experimental scheme for measuring entanglement is the system is reported and compared with a result recently obtained by Wiesniak, Vedral and Brukner.

On the Born Rule as a Theorem

Fabrizio Logiurato* and Augusto Smerzi
*Università di Trento

The first attempt to derive the Born rule from different postulates of QM goes back to Von Neumann in 1932. About twenty years later, Gleason provided a different important demonstration which, however, was rather obscure and apparently based on a property that seems not to be within the postulates of Quantum Mechanics: the non-contextuality of probability. In recent years, there has been a revival of interest on this problem, like Zurek ´s attempt based on the decoherence, or Deutsch ´s demonstration founded on the theory of decisions. But the physical meaning of their assumptions is still debated.

In this talk we demonstrate that the Born rule can follow from no-signaling. We also give a demonstration of the Born rule using the non-contextuality postulate. Finally, we prove that is possible to derive the Born even without explicitly assuming the non-contextuality of probability but only the postulates of QM.

Quantum communication networking and control

C. Lupo*, C. Cafaro, S. L'Innocente, O. V. Pilyavets, A. Eusebi, S. Mancini
*Università di Camerino

We present recent research activities and achievements in quantum information theory based in Camerino. First, we introduce the problem of quantum communication and discuss optimal communication rates through noisy quantum channel, also in the presence of correlated noise. In particular we focus on optical implementations with multimode squeezed states, as produced in waveguide parametric down-conversion. Then, we move to the problem of engineering hybrid light-matter quantum networks, and to the problem of feedback control and quantum error correction. Finally, we elaborate on recent applications of information geometric methods on quantum dynamics.

A trapped electron quantum computer?

Irene Marzoli
Università di Camerino

I'm going to present an overview of the proposals for a trapped electron quantum computer and discuss the experimental challenges and perspectives for this system.

Control of Many Body Quantum Systems

Simone Montangero
University of Ulm

We present some applications of the recently introduced CRAB optimization of many body quantum systems dynamics. These applications range from the dynamics of a quantum phase transition to coherent transport in open systems as FMO complexes involved in photosynthesis in bacteria.

BF Theory in Quantum Computation

Giandomenico Palumbo
Università di Pavia

In the context of a combinatorial approach to Topological Quantum Computation, we analyze the role of particular topological field theory (with a BF-type action) as an effective action of a fermionic system.

About the role of non-Gaussianity in continuous-variable quantum technology

Matteo Paris
Università di Milano

We address the quantification of non-Gaussianity for states of continuous-variable (CV) systems and its use in quantum technology. In particular, we present two theorems connecting non-Gaussianity and quantum estimation, and discuss the robustness of Gaussian and non Gaussian entanglement in noisy channels.

Non-classicality in a mechanical system through photon subtraction

Mauro Paternostro
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I will show how non-classical states of a massive mechanical mode operating at non-zero temperature are achieved in a scheme that combines radiation-pressure coupling to a light field and photon subtraction. The scheme embodies an original and experimentally realistic way to obtain mesoscopic quantumness by putting together two mature technologies for quantum control. The protocol is basically insensitive to detection inefficiency and mechanical damping and represents a new path towards the demonstration of non-classical behaviours in system of tremendous current interest.

Informational axioms for Quantum Theory

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Quantum theory was recently derived within an operational-probabilistic framework as the only information-processing model satisfying six axioms [1] that will be reviewed and discussed. After the operational-probabilistic framework is precisely settled, it provides a language in which the axioms can be just stated as rules that allow or forbid particular information-processing tasks. The main steps in the derivation are also reviewed in a highly non-technical summary, with focus shifted on the relation between the key operational-probabilistic statements and their information-theoretical translation and outcomes.

[1] G. Chiribella, G. M. D'Ariano and P. Perinotti, arXiv:10116451. Submitted to Phys. Rev. A.

Memory-keeping and forgetfulness in the dynamics of a qubit coupled to a spin chain

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Using a recently proposed measure for non-Markovianity [1], we study the dynamics of a qubit coupled to a spin environment via an energy-exchange mechanism.We show the existence of a point, in the parameter space of the system, where the qubit dynamics is effectivelyMarkovian and that such a point separates two regions with completely different dynamical behaviors. Indeed, our study demonstrates that the qubit evolution can in principle be tuned from a perfectly forgetful one to a deep non-Markovian regime where the qubit is strongly affected by the dynamical backaction of the environmental spins. By means of a theoretical quantum process tomography analysis, we provide a complete and intuitive characterization of the qubit channel.

[1] H.-P. Breuer, E. M. Laine, and J. Piilo, Phys. Rev. Lett. 103, 210401 (2009)

Ground state factorization and correlations in a quantum many-body system with broken symmetry

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We show how the reshuffling of correlations involved in the phenomenon of factorization in a many body system is of collective nature and represents a new kind of quantum transition. To this aim we study the quantum discord Q in the one dimensional quantum XY model in a transverse field.
We analyze the behavior of Q at both the critical point and at the (non critical) factorizing field. The factorization is found to be governed by an exponential scaling law of Q.
Finally we address the thermal effects fanning out from the anomalies occurring at zero temperature. A discontinuity of Q is found to characterize the symmetry-broken phase. Close to the quantum phase transition, Q exhibits a finite-temperature crossover with universal scaling behavior, while the factorization phenomenon results in a non trivial pattern of correlations present at low temperature.

New optical technologies for quantum information processing

Fabio Sciarrino
Università di Milano

In the last few years, the Quantum Optics group of Roma has contributed to develop different experimental photonic platforms to carry out quantum information processing based on different photon degrees of freedom.
The standard encoding process of quantum information adopting the methods of quantum optics is based on the two-dimensional space of photon polarization. Very recently the orbital angular momentum (OAM) of light, associated to the transverse amplitude profile, has been recognized as a new resource, allowing the implementation of a higher-dimensional quantum space, or a qudit, encoded in a single photon. Our research topic is based on the study of new optical devices able to couple the orbital and spinorial components of the angular momentum. Such devices allow to manipulate efficiently and deterministically the orbital angular momentum degree of freedom, exploiting both the polarization and the OAM advantages.
Another approach exploits integrated optical technology which may represent an excellent experimental platform to carry out quantum information processing. The few experiments performed so far with integrated quantum circuits have been based only on path encoded qubits. We report the realization of a laser written beam splitter in a bulk glass able to support polarization encoded information. We demonstrate the quantum coalescence with polarization entangled state and singlet state projection. The maskless technique, the single step easy fabrication, the possible three-dimensional layouts and the circular transverse waveguide profile able to support the propagation of gaussian modes with any polarization state make this approach promising to carry out optical quantum information processing

Initial correlations in the dynamics of open quantum systems: a trace distance analysis

Andrea Smirne
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In the study of open quantum systems dynamics it is generally assumed that the open system and its environment are initially uncorrelated, i.e. in a product total state. In this case the reduced dynamics can be described by means of completely positive maps. However, in the presence of initial system-environment correlations such an approach is no longer available. Thus, it becomes of interest to introduce different strategies in order to characterize in a quantitative way the reduced system dynamics. This task is accomplished by the trace distance, which measures the distinguishability between quantum states. After a general introduction on how the trace distance can be used to quantify the influence of the initial correlations on the subsequent dynamics, the paradigmatic and exactly solvable model provided by the Jaynes-Cummings Hamiltonian is discussed. In particular, the thermal correlations of the total system are considered, showing their connection to the entanglement properties of the eigenstates of the Hamiltonian. Then, the analysis of the trace distance evolution of the reduced states evolving from the thermal equilibrium state and its corresponding uncorrelated product state shows that the open system dynamically uncovers typical features of the initial correlations.

Long Range Distance Independent Entanglement Generation in Kondo Systems

Pasquale Sodano
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The Kondo effect is a remarkable non perturbative phenomenon firstly discovered in condensed matter systems where magnetic impurities interact with conduction electrons; later, it has been realized in a variety of quantum devices and in pertinent spin chains. I will show how this non perturbative phenomenon is usable to generate long range, thermally robust distance independent entanglement between two qubits. For this purpose, I firstly study the entanglement of an impurity at one end of a spin chain with a block of spins using a true measure of entanglement (negativity); this allows to determine the spatial extent of the Kondo screening cloud as well as to show that the impurity spin is indeed maximally entangled with the cloud. Then, I show that, in the gapless Kondo regime, a single local quench at the other end of the spin chain induces a fast and long-lived oscillatory dynamics: this establishes a high-quality, thermally robust and distance independent entanglement between the spins located at the opposite ends of the chain. To better evidence the uniqueness of the Kondo regime, I carry a parallel analysis of the entanglement properties of the same spin-chain model in the gapped dimerized regime. Finally, I show how these features of a spin chain in the Kondo regime may be used to route entanglement between very distant parties and review some realistic quantum devices where the Kondo effect may be realized.

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[3] A. Bayat, S. Bose and P. S., Phys. Rev. Lett. 105, 187204 (2010).

Towards quantum information processing with molecular nanomagnets.

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Molecular nanomagnets represent a wide class of spin cluster, whose magnetic properties can be widely engineered by chemical synthesis. In particular, different kinds of antiferromagnetic spin rings behave as effective two-level systems in realistic experimental conditions, and exhibit decoherence time in the macrosecond range at low temperature [1]. In these molecules, a high degree of control on intermolecular coupling has also been achieved, and has enabled experimental demonstration of thermal entanglement between pairs of rings [2].
In the present paper, we briefly review two possible approaches for the use of antiferromagnetic spin rings in quantum information processing. The first approach is based on the use of spin projection in heterometallic spin rings. Here, single- and two-qubit gates can be possibly implemented even in the presence of a permanent (exchange) interaction between the spin-cluster qubits [3], by exploiting spin ordering in the molecule ground state and specific excited states as auxiliary levels. The second approach is based on the use of a different degree of freedom (namely spin chirality) in magnetically frustrated systems such as homometallic spin triangles [4]. Unlike the spin projection, spin chirality can be manipulated by means of electric fields. The general conditions for the existence of spin electric coupling in spin rings will be

discussed, and preliminary results will be presented on hyperfine-induced decoherence of spin chirality.

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Quantum Communications in Free-Spac

Paolo Villoresi
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The sharing of quantum states among ground and orbiting terminal may be considered as feasible according to present optical technologies. The paradigm shift that Quantum Communications represent vs. classical counterpart allows to envisage the application of global cryptographic key distribution as well as the extension to Space of quantum technologies.

Generation of Quantum States by Ergodic Maps

Kazuya Yuasa
Waseda University, Tokyo

It is a nontrivial and important problem how to prepare desired quantum states, in particular nonclassical states and entanglement. Generally speaking, the generation of a quantum state requires a quantum channel that can bring a quantum system from any initial state to the target state, by repetition of a set of certain operations. We are going to discuss such schemes for generating quantum states. Our primary idea is to make use of the disturbances on quantum systems by projective measurements: by repeatedly performing measurements on an ancilla system, and by properly applying feedback depending on the outcomes of the measurements, we lead a quantum system interacting with the ancilla from its arbitrary initial state to the target state with probability 1. In order to construct such schemes, we make use of useful and interesting theorems on the "ergodicity" and the "mixing" of quantum channels. We present a few examples of entanglement generation and clarify how and why the systems converge to the target states by the ergodic maps.

Quantum aspects of synchronization

Roberta Zambrini
IFISC (Universitat de les Illes Balears and CSIC)

We consider coupled quantum harmonic oscillators and show how synchronization depends on the presence of one common or separate thermal environments. We then explore connections between synchronous dynamics and quantum correlations such as discord and mutual information.

High-fidelity noiseless amplification of light

Alessandro Zavatta
Universita' di Firenze

The possibility of amplifying quantum light states (although in a non-deterministic way) without introducing additional noise and without large distortions would be a precious tool for enhancing several quantum communication and quantum metrology tasks. For example, it could be used to distill and concentrate entanglement and could form part of a quantum repeater, or it could improve the performance of phase-estimation schemes and enable high-fidelity probabilistic cloning and discrimination of coherent states. By precise quantum state engineering at the level of single photons, we have experimentally realized a novel concept of such a non-deterministic noiseless amplifier, and we have demonstrated its superior effective gain and high fidelity of operation when applied to coherent states of light of moderate amplitudes. In its simplest realization, a fixed intensity gain of 4 is obtained by a sequence of single-photon addition and subtraction, experimentally implemented by means of conditional stimulated parametric down-conversion in a nonlinear crystal and conditional attenuation by a low-reflectivity beam-splitter. The application of this non-deterministic scheme for noiseless amplification has already shown that, for a given input coherent state amplitude, its effective gain and fidelity greatly outperform those of other existing approaches. In particular, the preservation of multi-photon contributions in the Fock base expansion of the amplified states is the main responsible for the exceptional performances of our method at larger amplitudes, where methods based on quantum scissors show limitations due to their abrupt state truncation.
Compared to schemes based on the addition of thermal noise, our scheme also has the additional advantage of producing a pure amplified state at the output instead of a mixed one. If a more complex interferometric scheme is adopted to produce a well-defined superposition of opposite sequences of photon addition and subtraction, a completely adjustable gain can be in principle obtained in the amplifier, and the same setup can be used to emulate Kerr nonlinearity.

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