QID 2011

From Field Theory to Quantum Information and Quantum Devices

Abstracts

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Saturday, January 8 - 10:15

Entanglement in Kondo Spin Chain Model

We study the unique features of the gapless Kondo regime in the spin chain Kondo model. We determine the spatial extent of the Kondo screening cloud with a means of entanglement measures. This provides an optimal situation in which a single local quench at one end of a Kondo spin chain induces a fast and long lived oscillatory dynamics which quickly establishes a high quality entanglement between the ending spins. This entanglement is mediated by the Kondo Cloud and attains a constant high value independent of the length for large chains, and shows thermal robustness. Furthermore, we show that it is possible to make an entanglement router which generates entanglement between multiple users by suddenly connecting two long Kondo spin chains.

Raffaella Burioni

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Friday, January 7 - 10:15

Quantum particles and spectral properties of graphs: BEC, confined superfluidity and solitons in inhomogeneous arrays

The topological features of disordered and complex networks have a strong influence on their physical properties and they can gives rise to interesting and intriguing phenomena. Here we review general results on the topological characterization of graphs in terms of their spectral properties and we discuss the effects of inhomogeneous topology on Bose-Einstein condensates, confined superfluidity and solitons propagation in combs and tree-like topologies.

David K. Campbell

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Friday, January 7 - 17:00

Transfer of Bose-Einstein Condensates through Discrete Breathers in an Optical Lattice

Atomic Bose-Einstein condensates (BECs) trapped in optical lattices (OLs) have been the subject of great recent experimental and theoretical interest, both in their own right and as analog models of certain solid state systems. Recent studies of the leakage of a BEC trapped in an OL have shown that localized nonlinear excitations known as "Discrete Breathers" (DBs) can prevent atoms from reaching the leaking boundaries, thereby slowing the decay of the condensate.

In this talk I report the results of a recent study (conducted with Holger Hennig and Jerome Dorignac) of this problem. To understand the mechanism by which these DBs enhance the trapping, we study the case of atom transport - "tunnelin" - through a DB on a nonlinear trimer. We show that this transport is related to the destabilization and subsequent motion of DB and that there exists a threshold in the total energy on the trimer that controls this destabilization. We find that this threshold and the resultant tunneling can be described analytically by defining a two-dimensional "Peierls-Nabarro" energy landscape which restricts the dynamics of the trimer to a limited region of phase space. We further establish that the value of the threshold is related to the Peierls-Nabarro barrier of a single DB. We then embed our nonlinear trimer in an extended lattice and show numerically that the same destabilization mechanism applies in the extended lattice. Our results suggest a possible means for controlling the transmission of coherent atomic beams in interferometry and other processes. This work has been carried out in collaboration with Holger Hennig and Jerome Dorignac.

Andrea Cappelli

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Friday, January 7 - 12:15

Non-Abelian anyons in the quantum Hall effect

Electrons in the quantum Hall effect form a nonperturbative state with anyon excitations having fractional charge and fractional exchange statistics. Within the conformal field theory approach, anyon multiplets with "non-Abelian" statistics are also possible: these are now actively investigated for their possible use in quantum computers. I discuss their description by means of partition functions in conformal field theory that obey modular invariance.

Francesco Guerra

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Friday, January 7 - 9:30

Quantum Field Theory in Naples in the Sixties

Roman Jackiw

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Friday, January 7 - 15:00

Scale and Conformal transformations in diverse dimensions

I describe some peculiarities and universalities of scale and conformal transformations and symmetries.

Giuseppe Mussardo

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Saturday, January 8 - 9:30

Expectation values in the Lieb-Liniger Bose gas

The repulsive Lieb-Liniger model can be obtained as the non-relativistic limit of the Sinh-Gordon model: all physical quantities of the latter model (S-matrix, Lagrangian and operators) can be put in correspondence with those of the former. We use this mapping, together with the Thermodynamical Bethe Ansatz equations and the exact form factors of the Sinh-Gordon model, to set up a compact and general formalism for computing the expectation values of the Lieb-Liniger model both at zero and finite temperature. The computation of one-point correlators is thoroughly detailed and, when possible, compared with known results.

Giorgio Parisi

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Friday, January 7 - 11:30

Theoretical progresses in off-equilibrium behaviour

Many systems approach equilibrium very slowly: the equilibration time becomes macroscopic and sometimes it is so large that it cannot be measured. Many progresses have recently done in understanding their behavior.

This talk will contain:

- A mini introduction to structural glasses and spin glasses.
- Some experimental and numeric results for aging in structural glasses and spin glasses.
- Generalized fluctuation dissipation relations and the definition of a scale dependent temperature.
- A theoretical interpretation of these results.

Michel Peyrard

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Friday, January 7 - 17:45

Nonlinear excitations as tools to analyze DNA thermodynamics and dynamics.

DNA is not the static object that structural images show. It is a highly dynamical molecule. The base pairs, which encode the genetic information, fluctuate widely. The lifetime of a base pair, i.e. the time during which it stays closed, is only of the order of a few milliseconds. At high temperature some parts of the double helix open locally and form the so called "denaturation bubbles", which play a role in biological function. When it is viewed at the scale of base pairs, DNA appears as a nonlinear lattice which allows experimental investigations that can take advantage of its exceptional properties and rely on techniques developed by biologists. This is why, besides its biological interest, DNA is a remarkable model system for a theoretical physicist. There are no solitons in DNA but nonlinear localized excitations are nevertheless very helpful to analyze its properties. Computing the free energy of the "domain walls", which separate open and closed regions, we can predict the temperature at which the two strands fully separate due to thermal fluctuations (the "melting" transition of DNA) with a much better accuracy than with the standard methods of statistical physics. The local fluctuations of the double helix can be described in terms of localized modes (discrete breathers) but establishing a satisfactory model is a challenge because the accurate experiments which can be performed on this molecule impose severe constraints on the models. The analysis of the time scales of the fluctuations led us to a model that sustains a new class of discrete breathers.

So-Young Pi

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Friday, January 7 - 15:45

Majorana Fermions in a Superconductor

A Dirac-type matrix equation governs surface excitations in a topological insulator in contact with an s-wave superconductor. I discuss the topological features and the quantization of this model.

Mario Rasetti

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Saturday, January 8 - 12:15

New frontiers for quantum information processing: from topological invariants to the theory of formal languages

A novel realm of applications of quantum information processing is discussed, grounded on quantum algorithms that can be designed to efficiently evaluate most of the significant quantities of the $SU(2)$ topological quantum field theory (TQFT) of Chern-Simons-Witten. Efficiently means here polynomial time on a quantum computer - a feature that reflects the intrinsic field-theoretic solvability of the theory - at finite values of the coupling constant.

It has been long conjectured that non-Abelian TQFT's might exhibit the properties necessary to support a model of computation capable of solving $\#P$ problems in polynomial time. For a wide class of systems realistically described by finite TQFT's, a discrete universal representation exists, the "Spin Network Quantum Simulator" (SNQS), where coding of quantum information is based on the angular momentum (re-)coupling scheme. The SNQS has three crucial features: *i)* its combinatorial structure - induced by the intrinsic $\mathfrak{su}(2)_q$ co-algebra - allows us representing any computation process as a path over a graph, as in the classical case. Here the graph is in fact the base space of a fibre bundle which sustains the simulator dynamics as well as information coding; *ii)* in view of such structure, the simulator naturally implements holonomic quantum computation; *iii)* the ensuing computational scheme is to a large extent independent on the details of the physical system. The SNQS models bridge standard circuit schemes of quantum computation and notions from TQFT, and they are the natural setting of a quite general and far-reaching formal quantum automaton model, whose structure makes it possible to perform the evaluation of quantum topological invariants. In particular, the Jones polynomial of coloured oriented links can be obtained in such framework, with a quantum algorithm derived by the use of known results in conformal field theory, whereas the invariants of 3-manifolds can be evaluated by the q-deformed spin network model, equivalent to a more general object than the quantum automaton - a quantum recognizer - where each basic unitary transition function can be efficiently processed by a standard quantum circuit. Finally, the SNQS model lends itself to a semi-classical version, based on the Ponzano-Regge approximation of the 3nj recoupling operators.

Another leading idea of the talk is to argue that quantum information manipulation tools may allow us to explore wider fields than mere computation, reaching beyond its boundaries to touch the very roots of the universal structure of languages. Building on the conceptual framework induced by the SNQS topological approach to quantum information processing, it will be shown how a complex blend of notions coming from formal language theory, finite group theory, and topological quantum information theory may lead to a novel perspective in the science of formal languages, bridging language theoretical with structural and quantum algorithmic issues.

Angelo Vulpiani

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Saturday, January 8 - 11:30

About the dichotomies chaos-noise and discrete-continuous

Some aspects of the characterization of the "complexity" problem are reviewed, in particular for the two ubiquitous dichotomies chaos-noise and discete-continuous. A special attention is devoted to finite-resolution effects on predictability. The problems involved in systems with intrinsic randomness is discussed, with emphasis on the important problems of distinguishing chaos from noise and of modeling the system.