International Workshop on Quantum Information, Quantum Control and Quantum Devices (II)

Bilbao, Campus of Leioa: September 13-14, 2012

Theoretical Physics and History of Science Department, Seminar room

Lianao Wu

Workshop Organizer

Lluc Garcia

Local Organizer

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Speakers

Thursday September 13th

Temporal Behaviour of Entanglement: Death, Revival and Control **11:00h**

Ting Yu

Department of Physics and Engineering Physics, Stevens Institute of Technology, New Jersey 07030, USA

Coherence dynamics of quantum systems is a generic paradigm that has been widely discussed in research fields ranging from atomic and optical physics to condensed matter physics and to quantum information science. In this talk I will present highlights of our recent work on several key issues in entanglement dynamics including evolution of spin entanglement under phonon noise, the decay of entanglement, many-body quantum open system, probing many-body entanglement subject to colored noise, entanglement estimation and entanglement control.

Photonic Quantum Cloud Computing and Quantum Simulation **12:00h**

Philip Walther

University of Vienna

The applications of photonic entanglement manifold and reach from quantum communication [1] to quantum metrology [2] and optical quantum computing [3]. The advantage of the photon's mobility makes optical

quantum computing unprecedented in speed, including feed-forward operations with high fidelity [4]. During the last few years the degree of control over photonic multi-particle entanglement has improved substantially and allows for the quantum simulation of other quantum systems [5]. Here, I will also present the simulation of four spin-1/2 particles interacting via any Heisenberg-type Hamiltonian [6]. Moreover, recent experimental and theoretical progress, using the concepts of measurement-based quantum computation, indicates that photons are best suited for quantum networks. I will also present results for the realization for such a client-server environment, where quantum information is securely communicated and computed using the same physical system [7]. Finally I will mention a recent experiment showing that quantum discord can be used as resource for the remote state preparation, which might shine new light on the requirements for quantum-enhanced information processing [8].

References: [1] PRL **103**, 020503 (2009); [2] Nature **429**, **158** (2004); [3] Nature **434**, **169** (2005); [4] Nature **445**, **65** (2007); [5] Nature Physics **8**, **285** (2012); [6] Nature Physics **7**, **399** (2011); [7] Science **335**, **303** (2012); [8] Nature Physics DOI: 10.1038/NPHYS2377 (2012).

Probing the quantum behaviour of a nanomechanical resonator coupled to a double quantum dot 15:00h

J. Q. You

Department of Physics, Fudan University, Shanghai 200433, China and Beijing Computational Science Research Center, Beijing 10084, China

We propose a current correlation spectrum approach to probe the quantum behaviour of a nano mechanical resonator (NAMR). The NAMR is coupled to a double quantum dot (DQD), which acts as a quantum transducer and is further coupled to a quantum-point contact (QPC). By measuring the current correlation spectrum of the QPC, shifts in the DQD energy levels, which depend on the phonon occupation in the NAMR, are determined. Quantum behaviours of the NAMR could thus be observed. In particular, the cooling of the NAMR into the quantum regime could be examined. In addition, the effects of the coupling strength between the DQD and the NAMR on these energy shifts are studied. We also investigate the impacts on the current correlation spectrum of the QPC due to the back-action from the charge detector on the DQD.

Percolation in quantum communication networks 16:00h

Ravindra Chhajlany

Adam Mickiewicz University

Percolation (long range connectivity) is a natural concept that emerges in the description of spreading processes in the presence of medium imperfections. In the context of quantum communication, Acin et al [Acin, Cirac and Lewenstein, Nature Physics **VOL 3**, **258** (2007)] have shown that intriguing percolation effects on lattices can emerge when one considers the problem of creation of maximally entangled states (perfect quantum channels) between distant nodes, from an initial network of imperfectly entangled nodes. The first part of the talk will consist of a review of these *entanglement percolation* phenomena. The quantum advantage in communication scenarios can be captured in terms of superadditivity (i.e. breaking of additivity) of channel capacities induced by the subtle use of entanglement. We shall consider percolation of classical information through noisy networks consisting of certain quantum multi-access channels [Czekaj, Chhajlany and P. Horodecki, Phys. Rev. A **85**, 032328 (2012)]. Superadditivity effects are shown to generate lowering of percolation thresholds for long range, enhanced capacity, communication in the networks thus making them more error resilient. Importantly, this problem leads to the concept of directed communication and so to a separate class of percolation phenomena, viz. oriented (correlated) bond percolation that does not appear in Acin et al. and related schemes. We show that a new feature associated with this is that by tuning the parameters of the network, one may switch from the so-called Directed Percolation (DP) universality class (which is characterized by anisotropic clusters) to the Isotropic Percolation (IP) class characterized by isotropic clusters and completely different critical exponents. Our results are also useful for providing bounds for quantum capacities in analogous networks.

Friday September 14th

Quantum Correlations in Multipartite Systems **11:00h**

Marcelo Silva Sarandy
Universidade Federal Fluminense

The aim of this talk is to discuss a global measure of quantum correlation in multipartite systems, which is obtained by suitably recasting quantum discord in terms of relative entropy. This measure is illustrated in the Werner-GHZ state and in spin chains undergoing quantum phase transitions. In particular, we provide a witness operator to characterize globally quantum correlated states. Moreover, we apply the multipartite measure to introduce a monogamy inequality for pairwise quantum discord, which implies that the sum of pairwise quantum correlations is upper limited by the amount of multipartite quantum correlations as measured by the global quantum discord. As a by-product, the monogamy bound is used to investigate genuine multipartite correlations.

References: H. C. Braga et al., arXiv:1207.2650 (2012); A. Saguia, et al., PRA **84**, 042123 (2011); C. C. Rulli and M. S. Sarandy, PRA **84**, 042109 (2011).

On non-Markovian quantum dynamics **12:00h**

Dariusz Chruściński
Nicolaus Copernicus University

We characterize non-Markovian quantum dynamics both in terms of non-local memory kernels and local in time master equations. Moreover we provide a family of criteria which can distinguish Markovian and non-Markovian dynamics. These "Markovianity criteria" are based on a simple observation that Markovian dynamics implies monotonic behaviour of several well known quantities like distinguishability of states, fidelity, relative entropy and genuine entanglement measures. Our analysis is illustrated by several simple examples.