TT 7: Quantum Coherence and Quantum Information Systems II

Time: Monday 14:00–16:00 Location: H20

TT 7.1 Mon 14:00 H20

Use of dynamical coupling for improved quantum state transfer — •Andriy Lyakhov and Christoph Bruder — University of Basel, Switzerland

Efficient short-distance quantum state transfer is an important problem in quantum information processing. One of the most promising solutions is to use chains constructed from qubits that are statically coupled to each other [1]. Here, we propose a method to improve quantum state transfer in such transmission lines. The idea is to localize the information on the last qubit of a transmission line by dynamically varying the coupling constants between the first and the last pair of qubits. We also show that this method increases the fidelity of the state transfer and that this effect is stable to static disorder in the coupling constants and dynamical fluctuations in the coupling/decoupling functions [2].

[1] S. Bose, Phys. Rev. Lett. 91 207901 (2003)
[2] A. O. Lyakhov and C. Bruder, Phys. Rev. B 74, 235303 (2006)

TT 7.2 Mon 14:15 H20

A 2D array of Cooper pair boxes as a candidate for a protected qubit — •Jörg-Hendrik Bach, Alexander Shnirman, and Gerd Schön — Institut für theoretische Festkörperphysik, Universität Karlsruhe, 76131-Karlsruhe

We consider a 2-dimensional array of double-island Cooper pair boxes as a candidate for a protected qubit. Two types of couplings are implemented in the array. These are inductive nearest-neighbour couplings along the array's rows and capacitive nearest-neighbour couplings between the array's columns. Projected onto the doubly degenerate ground states of the Cooper pair boxes the two couplings do not commute. Thus the system reduces effectively to an array of spin-1/2 particles with non-commuting row- and column couplings. This reminds of the system proposed by Doucot et al. [Phys. Rev. B 71, 024505 (2005)] in the context of protected quantum computing. Similarities and differences to this system are pointed out; furthermore, the influence of the third level of the Cooper pair box is investigated.

TT 7.3 Mon 14:30 H20

Macroscopic quantum tunneling in globally coupled series arrays of Josephson junctions — •Mikhail V. Fistul — Theoretische Physik III, Ruhr-Universität Bochum, D-44801, Bochum Germany

A quantitative analysis of an escape rate for switching from the superconducting state to a resistive one in series arrays of globally coupled Josephson junctions will be presented. A global coupling is provided by an external shunting impedance. Such an impedance can strongly suppress both the crossover temperature from the thermal fluctuation to quantum regimes, and the macroscopic quantum tunneling (MQT) in short Josephson junction series arrays [1]. However, in large series arrays we obtain an enhancement of the crossover temperature, and a giant increase of the MQT escape rate [2]. The effect is explained by excitation of a *spatial-temporal charge instanton* distributed over a whole structure. The model gives a possible explanation of recently published experimental results on an enhancement of the MQT in single crystals of high-T_c superconductors [3].

[1]. D. Esteve, M. H. Devoret, and J. M. Martinis, Phys. Rev. B **34**, 158 (1986).
[2]. M. V. Fistul, cond-mat/0608456.
[3]. X. Y. Jin, J. Lisenfeld, Y. Koval, A. Lukashenko, A. V. Ustinov, and P. Müller, Phys. Rev. Lett. **96**, 177003 (2006).

TT 7.4 Mon 14:45 H20

Observation of Macroscopic Quantum Behavior in π Josephson Junctions with Ferromagnetic Interlayer — •Karl Madek[1], Martin Weides[2], Sven Beutner[1], Achim Marx[1], Hermann Kohlstedt[2], and Rudolf Gross[1] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, D-85748 Garching — [2]Institut für Festkörperforschung und CNI, Forschungszentrum Jülich, D-52425 Jülich

Superconducting circuits are particularly interesting for the implementation of quantum information systems. For the realization of superconducting flux qubits the use of π-Josephson junctions is promising, since it would allow the design of qubits in a quiet configuration. Such π-junctions have been successfully realized using Josephson junctions with an additional thin ferromagnetic interlayer. However, nothing is known so far on the quantum behavior of these junctions.

We performed measurements of both the macroscopic quantum tunneling of the phase variable and the level quantization in $Nb/AlO_x/CuNi/Nb$ π-Josephson junctions. Escape rate measurements show a crossover from the thermally activated regime, in which the phase variable escapes by thermal activation from a local minimum of the potential well, to the quantum regime, where macroscopic quantum tunneling dominates. Microwave spectroscopy experiments give direct evidence for energy level quantization. Both quantized energy levels in the tilt washboard potential as well as multi-photon transitions between the levels have been observed.

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TT 7.5 Mon 15:00 H20

Spin-boson dynamics: A unified approach from weak to strong coupling — •Francesco Nesi[1], Milena Grifoni[1], Elisabetta Paladino[2], and Michael Thorwart[3] — [1]Theoretische Physik, Universität Regensburg, Germany — [2]Dipartimento di Metodologie Chimiche e Fisiche, Università di Catania, 95128 Italy and MATIS-CNR-INFM, Catania Italy — [3]Institut für Theoretische Physik, Heinrich-Heine-Universität Düsseldorf, 40225 Germany

We present a novel approximation scheme to describe in a unified way the influence of a harmonic bath on the dynamics of a two-level particle over the *whole* regime of temperatures and coupling to the environment, and for a wide class of bath spectral densities. Starting from the exact path-integral solution for the two-level system density matrix, effective intra-blip correlations are fully included, while inter-blip and blip-sojourns interactions are considered up to first order. In the proper regime of parameters, results of conventional perturbative approximation schemes are recovered and an excellent agreement with ab-initio path-integral results is found.

→ http://arxiv.org/abs/cond-mat/0612396

TT 7.6 Mon 15:15 H20

Quantum Telegraph Noise — •Benjamin Abel and Florian Marquardt — Physics Department, Center for NanoScience, and Arnold Sommerfeld Center for Theoretical Physics, München

We analyze the effect of quantum telegraph noise, produced by a single electronic defect level, on the decoherence of a charge qubit. In contrast to earlier works, [1], [2], [3], we describe the full time-evolution of the coherence factor even at short and intermediate times. In striking contrast to the well-known case of decoherence by a bath of harmonic oscillators, the coherence factor displays oscillations as a function of time and other parameters. We analyze these in detail using a numerical evaluation of the exact solution for the density matrix of the qubit.

[1] Y. Makhlin, A. Shnirman, Phys. Rev. Lett. 92, 178301 (2004).
[2] Alex Grishin, Igor V. Yurkevich, and Igor V. Lerner, Phys. Rev. B 72, 060509(R) (2005)
[3] Galperin, Y. M., Altshuler, B. L., and Shantsev, D. V., Phys. Rev. Lett. 96 097009 (2006)

TT 7.7 Mon 15:30 H20

Spin Dynamics and Hyperfine Interaction in Quantum Dots — •Daniel Klauser, William Anthony Coish, and Daniel Loss — Departement of Physics and Astronomy, University of Basel, Klingelbergstrasse 82, CH-4056 Basel, Switzerland

The idea of using the spin of electrons confined to quantum dots for quantum information processing [1], has triggered research to understand the effect of hyperfine interaction on the evolution of electron spins in (double) quantum dots. The hyperfine interaction between the electron spin and the surrounding nuclear spins leads to decoherence of the electron spin state, but also allows to gain information on the nuclear spins through measurement of the electron spin evolution [2]. We discuss recent experimental and theoretical progress in controlling electron spin dynamics under hyperfine interaction.

[1] D. Loss and D. P. DiVincenzo, Phys. Rev. A 57, 120 (1998).
[2] D. Klauser, W. A. Coish, D. Loss, Phys. Rev. B 73, 205302 (2006).

TT 7.8 Mon 15:45 H20

Spin qubits with electrically gated polyoxometalates — •Jörg Lehmann[1], Alejandro Gaita-Ariño[2], Eugenio Coronado[2], and Daniel Loss[1] — [1]Departement für Physik und Astronomie, Universität Basel, Schweiz — [2]Institute of Molecular Science, Universitat de Valencia, Spain

We present a scheme for the implementation of a fundamental quantum gate, the so-called square-root-of-swap operation, in electrically gated polyoxometalates. The specific molecules we consider comprise three parts: two localized spins 1/2 forming the qubits and a central core, which couples the two spins via an indirect exchange mechanism. By charging and decharging the central core the exchange interaction between the two qubits can be controlled and the square-root-of-swap gate can be realized. Based on a Bloch-Redfield description of the charging dynamics of the molecule coupled to metallic leads we calculate the gate fidelity. Using parameters obtained from an ab-initio description of the molecule, we show that fidelities of up to 99% can be achieved.