TT 18: TR: Quantum Coherence and Quantum Information Systems 1

Time: Tuesday 14:00–16:15 Location: H21

TT 18.1 Tue 14:00 H21

Optimized Pulse Sequences for the Suppression of Decoherence in Quantum Information — •Stefano Pasini and Götz S. Uhrig — Lehrstuhl für Theoretische Physik I, TU Dortmund, 44221 Dortmund

The dynamical decoupling (DD) aims at suppressing the decoherence by means of coherent control pulses. Even if devices exist where instantaneous pulses are an adequate approximation, experimentally a finite duration τ_p and a bounded amplitude are inevitable. They are the cause of additional errors which can be corrected by designing the pulse shape appropriately. The new pulse has the overall effect of an ideal, instantaneous pulse with the advantage of decoupling the spin (or qubit) from the bath up to the order $O(\tau_p^3)$ [1]. The limitation of the no-go theorem for π pulses [2] is avoided. Hence, the Uhrig sequence (UDD) [3], originally thought for ideal π pulses, works also for bounded control Hamiltonians [4]. Numerical simulations show that concatenated sequences of real pulses are effective against general decoherence.

[1] S. Pasini, P. Karbach, C. Raas and G.S. Uhrig, Phys. Rev. A **80**, 022328 (2009)
[2] S. Pasini, T. Fischer, P. Karbach and G.S. Uhrig, Phys. Rev. A **77**, 032315 (2008)
[3] G.S. Uhrig, Phys. Rev. Lett. **98**, 100504 (2007)
[4] G.S. Uhrig and S. Pasini, arXiv:0906.3605

TT 18.2 Tue 14:15 H21

Landau-Zener Transitions in a Dissipative Environment: Numerically Exact Results — •Peter Nalbach and Michael Thorwart — Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs-Universität Freiburg, Albertstraße 19, 79104 Freiburg, Germany

We study Landau-Zener transitions in a dissipative environment by means of the numerically exact quasiadiabatic propagator path-integral [1]. It allows to cover the full range of the involved parameters. We discover a nonmonotonic dependence of the transition probability on the sweep velocity which is explained in terms of a simple phenomenological model. This feature, not captured by perturbative approaches, results from a nontrivial competition between relaxation and the external sweep.

[1] P. Nalbach and M. Thorwart, Phys. Rev. Lett. 103, 220401 (2009)

TT 18.3 Tue 14:30 H21

Spin and entanglement dynamics in Double Quantum Dots due to hyperfine interaction: A homogenous coupling approach — •Bjoern Erbe and John Schliemann — Institute of Theoretical Physics, University of Regensburg

Quantum dot spin qubits are among the most promising and most intensively investigated building blocks of possible future solid state quantum computation systems [1]. One of the major limitations of the decoherence time of the confined electron spin is its interaction with surrounding nuclear spins by means of hyperfine interaction [2]. Apart from this adverse aspect, hyperfine interaction can act as a ressource of quantum information processing [3]. For the above reasons it is of key interest to understand the hyperfine induced spin dynamics.

We consider the hyperfine interaction in a double quantum dot in zero magnetic field. We give an exact solution of the model for homogenous hyperfine coupling constants and derive the dynamics therefrom. By a detailed investigation of the short time spin dynamics we calculate the decoherence time, which turns out to be in very good agreement with experimental data.

[1] D. Loss and D.P. DiVincenco, Phys. Rev. A 57, 120 (1998)
[2] J. Schliemann, A. Khaetskii, and D.Loss, J. Phys.: Condens Matter 15, R1809-R1833 (2003)
[3] see e.g.: J.M. Taylor, A. Imamoglu, and M.D. Lukin, Phys. Rev. Lett.91, 246802 (2003

TT 18.4 Tue 14:45 H21

Probing Phases of Interacting Polaritons in Circuit QED Setups — •Martin Leib and Michael Hartmann — TU München,Munich,Germany

Circuit QED systems pose a new paradym for reaching the strong coupling regime of photonic and atomic degrees of freedom and are thus ideal candidates for quantum simulation and computation. We are investigating one-dimensional arrays of transmission-line cavities, where each cavity is coupled to a transmon-qubit. This system can be used as a quantum many-body simulator, lowering the experimental requirements for prescission control with respect to the use as a quantum computing device. We exploit the intermediate qubit-harmonic oscillator regime of the transmon to simulate Bose-Hubbard physics. As a suitable experimental setup we consider a system where the first cavity is driven by a classical microwave source and the output voltage is monitored, with respect to signatures of a quantum phase transition, at the last cavity.

15 min. break

TT 18.5 Tue 15:15 H21

Exact matrix product solutions in the Heisenberg picture of an open quantum spin chain — Stephen Clark[1,2], Javier Prior[3,4,5], •Michael Hartmann[6], Dieter Jaksch[2,1], and Martin Plenio[3,5,7] — [1]Centre for Quantum Technologies, National University of Singapore, Singapore — [2]Clarendon Laboratory, University of Oxford, United Kingdom — [3]Institute for Mathematical Sciences, Imperial College London, United Kingdom — [4]Departamento de Física Aplicada, Universidad Politécnica de Cartagena, Spain — [5]QOLS, The Blackett Laboratory, Imperial College London, United Kingdom — [6]Technische Universität München, Physik Department, Garching, Germany — [7]Institut für Theoretische Physik, Universität Ulm, Germany

The classical simulation of the dynamics of open 1D quantum systems with matrix product algorithms can often be significantly improved by performing time evolution in the Heisenberg picture [1]. For a closed system that is quadratic in fermionic (or bosonic) fields, the time-evolution of a creation operator can be represented exactly with matrices of dimension two for arbitrary long times. Here we show that this exact solution can be significantly generalized to include the case of an open quadratic fermi chain subjected to master equation evolution with Lindblad operators that are linear in the fermionic operators [2].

[1] M.J. Hartmann et al., Phys. Rev. Lett. **102** 057202 (2009)
[2] S.R. Clark et al., arXiv:0907.5582

TT 18.6 Tue 15:30 H21

Two-resonator circuit QED: Dissipative Theory — •Georg M. Reuther[1], David Zueco[1], Frank Deppe[2], Elisabeth Hoffmann[2], Edwin P. Menzel[2], Thomas Weissl[2], Matteo Mariantoni[2], Sigmund Kohler[3], Achim Marx[2], Enrique Solano[4], Rudolf Gross[2], and Peter Hänggi[1] — [1]Institut für Physik, Uni Augsburg, D-86135 Augsburg — [2]Walther-Meißner-Institut, Bayer. Akademie der Wissenschaften, D-85748 Garching — [3]Instituto de Ciencia de Materiales de Madrid, CSIC, E-29049 Madrid — [4]Departamento de Quimica Fisica, Univ. del Pais Vasco, E-48080 Bilbao

Managing the interaction between two quantum objects is a fundamental issue for quantum information processing. A promising approach is a two-resonator circuit quantum electrodynamics setup referred to as quantum switch [1]. Here, a superconducting qubit provides switchable coupling between the resonators. This requires operation in the dispersive regime, where the qubit transition frequency is far detuned from those of the resonators. In our contribution we present a dissipative theory for the quantum switch [2]. We derive an effective Hamiltonian beyond rotating-wave approximation and study the dissipative dynamics within a quantum master equation approach. We derive analytically how the qubit affects the dynamics and the coherence of the switch even if its state remains constant, and we estimate the strength of this influence. Our results are corroborated by numerical simulations. We acknowledge support from SFB631 and NIM.

[1] M. Mariantoni *et al.*, Phys. Rev. B **78**, 104508 (2008)
[2] G. M. Reuther *et al.*, arXiv:0911.2657

TT 18.7 Tue 15:45 H21

Ferromagnetic spin quantum bits — •Audrey Cottet[1,2] and Takis Kontos[1,2] — [1]Ecole Normale Supérieure, Laboratoire Pierre Aigrain, 24 rue Lhomond, F-75231 Paris Cedex 05, France — [2]CNRS

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We propose theoretically a scheme for implementing a spin quantum bit in a quantum dot circuit with ferromagnetic leads. This setup does not rely on any specific band structure and therefore can be realized with many different types of nanoconductors. In this talk, we will discuss its implementation with carbon nanotubes. We can reach the strong coupling limit between the electron spin and a superconducting photon cavity, with experimentally realistic parameters compatible with a slow enough decoherence of the spin quantum state. This allows us to envision the use of circuit cavity quantum electrodynamics methods for single spin manipulation and readout.

TT 18.8 Tue 16:00 H21

Spectroscopy of a Periodically Driven Qubit Coupled to a Non-Gaussian Bath — •Cheng Guo, Florian Marquardt, and Jan von Delft — Physics Department, Arnold Sommerfeld Center for Theoretical Physics, and Center for NanoScience, Ludwig-Maximilians-Universität München, D-80333 München, Germany

The dynamics and decoherence of solid-state qubits are often determined by a few non-Gaussian fluctuators. Paradigmatic models often used to represent the qubit-environment system like the spin-boson model cannot be applied here because they describe Gaussian-distributed fluctuations. The simplest model for non-Gaussian quantum noise is the so-called "quantum telegraph noise" model. It involves a qubit subject to the charge fluctuations of a single electron level that is tunnel-coupled to a reservoir. We use the adaptive time-dependent density-matrix renormalization group method (tDMRG) to study the dynamics of this model with arbitrary time-dependence. In particular, we present tDMRG-results on spectroscopy of the qubit under periodic driving.