## HL 18: Transport: Quantum Coherence and Quantum Information Systems 2 (jointly with TT, MA)

Time: Monday 15:00–17:30 Location: BH 243

HL 18.1 Mon 15:00 BH 243

**Control Pulse Engineering for Fast Controlled-Z Gates** — •Daniel Egger, Seth Taylor Merkel, and Frank Wilhelm — Universität des Saarlandes, Saarbrücken, Germany

When manipulating quantum systems it is key to do so before decoherence destroys the fragile states. For quantum computing this sets a time within which the desired qubit manipulations can be done. To increase the number of computations, either the coherence times must be increased or the gate durations must be decreased with the help of Optimal Control Theory. In the following work we show how Gradient Pulse Shape Engineering [1] can be used to optimize the time taken to perform a controlled-Z gate in the framework of the RezQu architecture [2]: two qubits, sufficiently far apart, are coupled to a bus resonator. The only controls considered are the two qubit-bus detunings. All elements have three levels to account for leakage. Additionally the finite bandwidth of the electronics is taken into account though an impulse response function. We give a value of the critical time below which a high fidelity gate can no longer be realized and explore what affects the control pulses. For the case of phase qubits we find that a controlled-Z gate with an error of $10^{-4}$ can be realized in 27 ns. Furthermore, the found control pulses are ready to be tested experimentally.

[1] N. Khaneja, J. Magn. Reson. **172**, 296
[2] M. Mariantoni, Science **334**, 6052

HL 18.2 Mon 15:15 BH 243

**Relaxation and decoherence dynamics in the spin-boson model** — •Oleksiy Kashuba, Mikhail Pletyukhov, Dirk Schuricht, and Herbert Schoeller — Institut für Theorie der statistischen Physik, RWTH Aachen, D-52056 Aachen

We study the real-time dynamics of the ohmic spin-boson model using a nonequilibrium renormalisation group method [1] successfully applied to the anisotropic Kondo model [2] and the interacting resonant-level model [3]. We discuss the relaxation and decoherence channel w/o bias. In all regimes of the coupling $\alpha$, we obtain power law time dependence from non-Markovian contributions but always accompanied by exponential decay. For $\alpha \sim 1/2$, we recover the well-known localization transition but obtain different power-law exponents for the time evolution in the biased case. Finally, for $\alpha \sim 1$, we discuss the time-evolution close to a quantum critical point.

[1] H. Schoeller, Eur. Phys. J. Spec. Top. 168, 179 (2009).
[2] M. Pletyukhov, D. Schuricht and H. Schoeller, Phys. Rev. Lett. 104, 106801 (2010).
[3] S. Andergassen, M. Pletyukhov, D. Schuricht, H. Schoeller, and L. Borda, Phys. Rev. B 83 205103 (2011).

HL 18.3 Mon 15:30 BH 243

**Simple ways to avoid leakage in qubit systems** — •Frank Wilhelm[1,2], Felix Motzoi[2], Seth Merkel[3], and Jay Gambetta[3] — [1]Theoretical Physics, Saarland University, Saarbrücken — [2]IQC and Department of Physics and Astronomy, University of Waterloo, Canada — [3]IBM Watson Research Laboratories, Yorktown Heights, NY, USA

No physical system is just a two-state qubit. Many qubit candidates are in fact weakly nonlinear oscillators with leakage transitions that lead outside the computational subspace that are spectrally close to the qubit transition. The simple DRAG pulse-shaping method allows to efficiently supress these leakage transitions. We will show that there is a whole family of DRAG pulses that also allow to enhance spectral selectivity through multiple channels, and that allow to selectively address qubits driven through a common control. These ideas are applied to superconducting phase qubits, Transmons, and circuit QED architectures.

[1] F. Motzoi, J.M. Gambetta, P. Rebentrost, and F.K. Wilhelm, Phys. Rev. Lett. 103, 110501 (2009)
[2] J.M. Gambetta, F. Motzoi, S.T. Merkel, and F.K. Wilhelm, Phys. Rev. A 2011

HL 18.4 Mon 15:45 BH 243

**Non-equilibrium dynamics of the central spin model** — •Alexandre Faribault and Dirk Schuricht — Institute for Theory of Statistical Physics RWTH Aachen Physikzentrum Sommerfeldstrasse 52074 Aachen Germany

A long standing proposal for a q-bit is to use the spin of a single electron trapped in a quantum dot. In such solid-state based systems, the dominant decoherence mechanism is the hyperfine coupling of the electron spin to the nuclear spins in the substrate. In this work, the Central spin model describing such a quantum system is studied numerically by exploiting its quantum integrability via the algebraic Bethe ansatz. In doing so, it becomes possible to efficiently compute exact eigenstates which we then use to study non-equilibrium dynamics in scenarios describing the relaxation and decoherence of prepared states.

HL 18.5 Mon 16:00 BH 243

**Impurity entanglement via electron scattering in a magnetic field** — Raoul Dillenschneider, •Alexandros Metavitsiadis, and Sebastian Eggert — Physics Department and Research Center OPTIMAS, Technical University of Kaiserslautern, Kaiserslautern, Germany

A possible mechanism to entangle two non-interacting magnetic moments is via successive electron scattering. Of particular interest is the case when the magnetic moments are considered as embedded impurities in a one dimensional lattice. The amount of entanglement can be modified by appropriately choosing the initial state of the system. Furthermore, the presence of a magnetic field may play a crucial role to the resulting entanglement. In this work, we present analytical as well as numerical results for the time dependence of the entanglement of magnetic moments, as manifested in the concurrence, especially stressing the role of external fields.

**15 min. break.**

HL 18.6 Mon 16:30 BH 243

**Decoherence of a qubit in a non-Markovian environment formed through a spin cluster** — •Wenling Qiao[1,2], Mohammad Ansari[2], and Frank Wilhelm-Mauch[1,2] — [1]Saarland University, Saarbrücken, Germany — [2]University of Waterloo, Waterloo, Canada

The error rate in quantum computing based on solid-state devices is mostly limited by the qubit decoherence behavior. While Markovian environments are well understood, the main experimental and theoretical challanges lie in the field of correlated non-Markovian noises. We study the quantum dynamics of a qubit in a toy non-Markovian environment model, a large spin cluster coupled to a thermal bath. By using the Holstein-Primokoff transformation,Bogoliubov transformation on the spin Hamiltonian and representing the master equation in phase space, we calculated the correlation function for the spin operator coupled to the qubit. This permits insight into the decoherence of the qubit.

HL 18.7 Mon 16:45 BH 243

**Quantum state transfer in boundary-controlled and fully engineered spin chains** — Analia Zwick[1,2], Gonzalo A. Álvarez[1], •Joachim Stolze[1], and Omar Osenda[2] — [1]Institut für Physik, TU Dortmund, Germany — [2]Facultad de Matemática, Astronomía y Física and Instituto de Física Enrique Gaviola, Universidad Nacional de Córdoba, Argentina

Quantum state transfer in presence of noise is one of the main challenges for building quantum computers. We compare the quantum state transfer properties for two classes of qubit chains under the influence of static randomness. In fully engineered chains all nearest-neighbor couplings are tuned in such a way that a single-qubit state can be transferred perfectly between the ends of the chain, while in boundary-controlled chains only the two couplings between the transmitting and receiving qubits and the remainder of the chain can be optimized. We study how the noise in the couplings affects the state transfer fidelity depending on the noise model and strength as well as the chain type and length. We show that the desired level of fidelity and transfer time are important factors in designing a chain. In particular we demonstrate that transfer efficiency comparable or better than that of the most robust engineered systems can also be reached in boundary-controlled chains without the demanding engineering of a large number of couplings.

HL 18.8 Mon 17:00 BH 243

**Pauli blockade for Kramers-qubit readout in carbon nanotubes** — •gábor széchenyi and andrás pályi — Institute of Physics, Eötvös University, Hungary

Carbon nanotube double quantum dots are promising candidates for a solid-state platform of quantum-information processing. In the ground state of the nanotube the physical qubit is a Kramers doublet, which involves two states with antiparallel alignment of spin and valley. To evaluate the potential in Pauli-blockade-based Kramers-qubit readout, we theoretically investigate electron transport in a situation where Pauli or spin-valley blockade is lifted by the combined effect of axial and transverse magnetic-field and short range disorder. We can identify a parameter regime where four-level (spin and valley) carbon nanotube quantum dot is reduced to an effective two-level system. We derive analytical formulas of the current as a function of applied transverse and axial magnetic field, which we compare with our numerical results.

HL 18.9 Mon 17:15 BH 243

**Entanglement, Fluctuations, and Quantum Critical Points** — •Stephan Rachel[1], Nicolas Laflorencie[2], H. Francis Song[1], and Karyn Le Hur[3,1] — [1]Department of Physics, Yale University, New Haven, CT 06520, USA — [2]Laboratoire de Physique Theorique, Universite de Toulouse, UPS, (IRSAMC), F-31062 Toulouse, France — [3]Center for Theoretical Physics, Ecole Polytechnique, 91128 Palaiseau Cedex, France

We show that bipartite fluctuations F can be considered an entanglement measure. We further demonstrate that the concept of bipartite fluctuations F provides a very efficient tool to detect quantum phase transitions in strongly correlated systems. We investigate paradigmatic examples for both quantum spins and bosons in one and two dimensions. As compared to the von Neumann entanglement entropy, we observe that F allows to find quantum critical points with a much better accuracy in one dimension. We further demonstrate that F can be successfully applied to the detection of quantum criticality in higher dimensions with no prior knowledge of the universality class of the transition. Promising approaches to experimentally access fluctuations are discussed for quantum antiferromagnets and cold gases.