DY 8: Quantum dynamics, decoherence and quantum information

Time: Monday 16:15–18:00 Location: H2

DY 8.1 Mon 16:15 H2

Normal and Ballistic Transport in Coupled Spin Chains — •Hendrik Weimer, Mathias Michel, and Günter Mahler — Institut für Theoretische Physik I, Universität Stuttgart

We consider a three-dimensional model of coupled spin chains. The interaction inside the chains is a Heisenberg coupling while the interaction between the chains is random. In the one-particle excitation band we obtain ballistic transport along the spin chains and normal transport in the perpendicular direction. The numerical solution of the time-dependent Schrödinger equation confirms these results.

DY 8.2 Mon 16:30 H2

Dephasing by non-Gaussian shot noise in an electronic which-path experiment — •Florian Marquardt[1], Izhar Neder[2], and Mordehai Heiblum[2] — [1]Arnold Sommerfeld Center for Theoretical Physics, Department für Physik, und Center for NanoScience, Ludwig-Maximilians-Universität München, Germany — [2]Braun Center for Submicron Research, Department of Condensed Matter Physics, Weizmann institute, Rehovot, Israel

The usual models for dissipative environments involve a bath of harmonic oscillators, producing Gaussian fluctuations. However, modern experiments on dephasing in qubits and electronic interferometers indicate strong coupling to *non-Gaussian* quantum noise. Most strikingly, the coherence (interference contrast) may oscillate as a function of interaction time and other control parameters (such as detector voltage). We discuss in detail the theory behind a recent "controlled dephasing"experiment involving a Mach-Zehnder interferometer strongly coupled to the non-Gaussian shot noise of a detector edge channel [cond-mat/0610634,cond-mat/0611372].

DY 8.3 Mon 16:45 H2

Room Temperature Coherence Transfer between a Single Electron and Nuclear Spin in Diamond — •Philipp Neumann, Torsten Gaebel, Fedor Jelezko, and Jörg Wrachtrup — 3. Physikalisches Institut, Universität Stuttgart, Germany

Coherent control of single spins is one basic requirement for quantum information technology. For the processing of qubit information the coupling to at least one other spin is necessary. Especially when it comes to storage of quantum information the coherence of one spin has to be transferred to another very long lived spin system. Promising candidates for this are nuclear spin states. We demonstrate recent progress on the coherence transfer between the electron spin of a single NV center in diamond and its ^{15}N nuclear spin at room temperature. For this we present a novel method to initialize the nuclear spin and by this cool it down from room temperature to μK. In addition its long lasting coherent evolution will be shown.

DY 8.4 Mon 17:00 H2

Quantum Thermodynamic Machines and their Limits — •Markus Henrich, Mathias Michel, and Günter Mahler — 1. Institut für Theoretische Physik, Universität Stuttgart, Deutschland

How small can a system be to act as a thermodynamic machine? We show that a 3-spin system driven with finite speed and interfaced between two split baths constitutes such a minimal model. The spins are arranged in a chain with nearest-neighbor interaction and different local Zeeman-splittings. The working spin in the middle is driven in σ_Z-direction and exercises Carnot cycles the area of which defines the exchanged work [1].

We compare the numerical results of this machine with an ideal one which can be solved analytically. It can be shown under which conditions the Carnot efficiency should be reached and that a critical temperature exists where the machine begins acting as a heat pump [2]. The influence of leakage heat currents on the efficiency are investigated additionally.

[1] M. J. Henrich et al, "'Small quantum networks operating as quantum thermodynamic machines"', cond-mat/0604202
[2] T. D. Kieu, "'Quantum heat engines, the second law and Maxwell's daemon"', Eur. Phys. J. D **39**, 115-128 (2006)

DY 8.5 Mon 17:15 H2

A Boltzmann equation approach to transport in finite modular quantum systems — •Mehmet Kadiroglu and Jochen Gemmer — Departement of Physics, University of Osnabrück, D-49069

We investigate the transport behaviour of finite quantum systems based on a Boltzmann equation [1] (BE). To make the BE applicable for our quantum systems we consider quasiparticles which are essentially the current eigenmodes of the system. We propose to identify the classical particle density in the BE with the quantum mechanical occupation numbers of the current eigenstates. It is demonstrated analytically and numerically by solving the time dependent Schrödinger equation that this concept is justifiable and that the dynamics of the quantum mechanical occupation numbers are indeed well described by an appropriate linear BE. Furthermore we determine the diffusion coefficient of a diffusive solution of the linear BE which is in accordance with results of previous works [2]. An ab initio numerical analysis of the full dynamics of the quantum system shows that it indeed exhibits diffusive behaviour controlled by this diffusion constant under certain conditions.

[1] L. Boltzmann, *Lectures on Gas Theory*, University of California Press, Los Angeles, (1964)
[2] M. Michel, J. Gemmer, G. Mahler, *Phys. Rev. Lett.*, **95**, 180602, (2005)

DY 8.6 Mon 17:30 H2

Transport in the Anderson model — •Robin Steinigeweg and Jochen Gemmer — Physics Department, University of Osnabrück, Barbarastr. 7, 49069 Osnabrück, Germany

We investigate a model of non-interacting spinless fermions on a finite lattice with a disordered on-site potential or, shortly, the Anderson model. It is well-known that strong disorder causes localized eigenstates such that the model behaves like an insulator. Inversely, weak disorder causes extended eigenstates which are Bloch waves in the the case of no disorder. Between these extreme cases the model is believed to exhibit diffusive dynamics. We examine the intermediate case in more detail and especially address the conditions under which diffusion occurs. Our approach uses projection operator techniques (TCL) and the Hilbertspace Average Method (HAM). These methods have been already applied successfully to another model which turns out to be very similar to the Anderson model in the intermediate case.

DY 8.7 Mon 17:45 H2

Efficiency of quantum and classical transport on graphs — •Oliver Mülken and Alexander Blumen — Theoretische Polymerphysik, Universität Freiburg, 79104 Freiburg i.Br., Germany

We propose a measure to quantify the efficiency of classical and quantum mechanical transport processes on graphs. The measure is given by the temporal decay of the space average of the probability to be still or again at the initial node of the graph, i.e., classically by $\overline{p}(t)$ and quantum mechanically by $\overline{\pi}(t)$, where

$$\overline{p}(t) \equiv \frac{1}{N}\sum_{j=1}^{N} p_{j,j}(t) \qquad \text{and} \qquad \overline{\pi}(t) \equiv \frac{1}{N}\sum_{j=1}^{N} \pi_{j,j}(t) \geq |\overline{\alpha}(t)|^2.$$

Quantum mechanically we use the envelope $\text{env}[|\overline{\alpha}(t)|^2]$ of a lower bound obtained via the Cauchy-Schwarz inequality. Both measures only depend on the density of states (DOS). For some DOS, the measure shows a power law behavior, where the exponent for the quantum transport is twice the exponent of its classical counterpart, i.e.,

$$\overline{p}(t) \sim t^{-(1+\nu)} \qquad \text{and} \qquad \text{env}[|\overline{\alpha}(t)|^2] \sim t^{-2(1+\nu)}.$$

For small-world networks, however, the measure shows rather a stretched exponential law but still the quantum transport outperforms the classical one. Some finite tree-graphs have a few highly degenerate eigenvalues, such that, on the other hand, on them the classical transport may be more efficient than the quantum one.

[1] O. Mülken and A. Blumen, Phys. Rev. E **73**, 066117 (2006)