TT 29: Poster Session: Quantum Information Systems, Quantum Coherence (jointly with SAMOP)

Time: Tuesday 18:00–21:00 Location: P1

TT 29.1 Tue 18:00 P1

Temperature Dependence of Driven Duffing Oscillators — •Lingzhen Guo[1,3], Michael Marthaler[1,2], Stephan André[1,2], and Gerd Schön[1,2] — [1]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany — [2]DFG Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany — [3]Department of Physics, Beijing Normal University, Beijing 100875, China

A broad class of physical systems such as Josephson junctions, trapped electrons, and nanomechanical oscillators, can be well described by the Duffing oscillator under proper conditions. A driven Duffing oscillator (DDO) can exhibit many profound features, such as dynamical bifurcation. Near the bifurcation point, the oscillator state is highly sensitive to perturbation. This property can be exploited for applications such as sensing devices, amplifiers, and logic devices. In the light of nanomechanics, the quantum properties of the driven Duffing oscillator gained renewed interest in the past years, such as resonant tunneling and photon-assisted tunneling and the switching rate between thebistable states near the bifurcation point due to quantum and/or thermal fluctuations. In the bistable region of a DDO, the stationary probability distribution in phase space (i.e., Wigner function) or the distribution over energy levels of DDO in the finite temperature is also an important and interesting problem. Based on simulating a Lindblad-type master equation, we investigate the relationship of the statiobary probability distribution and the temperature.

TT 29.2 Tue 18:00 P1

The effect of solid-state noise sources on three-level systems — •Nicolas Vogt[1], Michael Marthaler[1], Jared H. Cole[1], and Gerd Schön[1,2] — [1]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, D-76131 Karlsruhe, Germany — [2]DFG Forschungszentrum Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany

We investigate the behaviour of a three level quantum system in contact with a two level fluctuator. There are a number of established ways to treat the TLF as a noise source and obtain an equation of motion for the three level system, for example Bloch-Redfield theory. We compare such perturbative methods with the fully coherent treatment of the TLF in a parameter regime where the assumptions made in the derivation of these perturbative methods are no longer guaranteed to hold. Using these results, we consider the effect of intrinsic decoherence sources on the process of stimulated Raman adiabatic passage, within a three-level system.

TT 29.3 Tue 18:00 P1

Decoherence of Josephson junction qubits due to surface spins — •Pablo Schad[1], Boris Narozhny[1], Alexander Shnirman[1,2], and Gerd Schön[3] — [1]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [2]DFG Center for Functional Nanostructures (CFN), Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — [3]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany

Spins on surfaces of superconductors are currently believed to be responsible for the 1/f flux noise in SQUIDs and Josephson qubits [1,2,3,4,5]. In recent experiments the spin contribution to the inductance of superconducting wires was measured [6]. This inductance describes the response to a current, which polarizes spins by creating magnetic fields on the surface. In particular low frequency fluctuations of the complex inductance were observed with roughly a 1/f noise spectrum. We provide an analysis of inductance noise in analogy to the well known theory of "noise of noise" and analyze some microscopic models that could explain these experiments.

[1] F. C. Wellstood et al., Appl. Phys. Lett. 50, 772 (1987).
[2] S. Sendelbach et al., Phys. Rev. Lett. 100, 227006 (2008).
[3] H. Bluhm et al., Phys. Rev. Lett. 103, 026805 (2009).
[4] R. H. Koch et al., Phys. Rev. Lett. 98, 267003 (2007).
[5] L. Faoro and L. B. Ioffe, Phys. Rev. Lett. 100, 227005 (2008).
[6] S. Sendelbach et al., Phys. Rev. Lett. 100, 227006 (2008).

TT 29.4 Tue 18:00 P1

Two Level Fluctuators in Josephson qubits — •Daniel Mischek[1], Clemens Müller[1,2], and Alexander Shnirman[1,2] — [1]Institut für Theorie der Kondensierten Materie, Karlsruhe, Germany — [2]DFG-Center for Functional Nanostructures (CFN), Karlsruhe, Germany

Spectroscopic analysis of superconducting qubits often shows clear signatures of avoided level crossings, indicating the presence of microscopic two-level fluctutors (TLFs) coupling to the qubit[1].

Within "direct coherent control" method it was possible for the first time to investigate coherence times and temperatures properities of single TLFs[2].

Measurements of relaxation time shows unusual behaviour of temperature dependence. Within Bloch Redfield formalism we analyse the influence of higher qubit levels on the resonance shape of relaxation time.

[1] R.W.Simmonds et al., Phys. Rev. Lett. 93, 077003 (2004)
[2] J.Lisenfeld et al., arXiv: 1008.0337

TT 29.5 Tue 18:00 P1

Dispersive readout scheme for a Josephson phase qubit — •Tobias Wirth, Jürgen Lisenfeld, Alexander Lukashenko, and Alexey V. Ustinov — Physikalisches Institut, Karlsruhe Institute of Technology and DFG Center for Functional Nanostructures, 76128 Karlsruhe, Germany

A vital ingredient of experiments on quantum bits is a detection tool to efficiently read out the state of a qubit. This detector must introduce as little back-action as possible, while showing a large measurement contrast; it should have negligible dissipation and offer fast operation.

The standard method to read out a Josephson phase qubit is to record the dc bias current at which the SQUID switches to its non-superconducting state. This process generates heat directly on the chip and quasi-particles in the circuitry. Both effects are responsible for a relatively long cool-down time of about 1-2 ms required after each switching event. Together with the time needed to ramp up the bias current of the SQUID, this limits the repetition rate of the experiment.

We present experimental results on a dispersive scheme for reading out a Josephson phase qubit. A capacitively shunted dc-SQUID is used as a nonlinear resonator which is inductively coupled to the qubit. The flux state of the qubit is detected by measuring the amplitude and phase of a microwave pulse reflected from the SQUID resonator. By this low-dissipative method, the qubit state measurement time is reduced to 25 μs, which is much faster than the conventional readout.

TT 29.6 Tue 18:00 P1

Light Effects on High Q-Resonators for Hybrid Quantum Systems — •Christian Koller, Robert Amsüss, Tobias Nöbauer, Matthias Schramböck, Jörg Schmiedmayer, and Johannes Mayer — Atominstitut, TU Wien, Stadionalle 2, 1020 Wien, Österreich

Over the last years hybrid quantum systems have drawn attention in the field of quantum information processing, because of their ability to combine the advantages of different quantum worlds. A number of proposals for the combination of systems with long coherence times (e.g. atoms, cold molecules, nitrogen vacancies (NV) in diamond, ...) with solid-state systems featuring fast manipulation (e.g. Cooper-pair boxes, flux qubits, transmons, ...) have been made.

The heart of these hybrid systems are planar resonators with high quality factors (on the order of one million) formed by superconducting coplanar microwave transmission lines. The properties of these resonators under the influence of light is crucial, since many of the hybrid applications involve laser light, for example imaging and manipulation of cold atoms and molecules as well as the initialization and read-out of NV centers.

We will present measurements of the shift of resonator frequency as a function of the applied light power. Furthermore, we show the effects on the Q value due to the generation of quasi particles and the saturation of two-level fluctuators in the superconducting thin films. We will also put these facts in perspective with resent measurements of resonators strongly coupled to an ensemble of NV centers.

TT 29.7 Tue 18:00 P1

Dual-path state reconstruction scheme for propagating quantum microwaves — Edwin P. Menzel[1], Frank Deppe[1], •Peter Eder[1], Matteo Mariantoni[1], Miguel Angel Araque Caballero[1], Alexander Baust[1], Thomas Niemczyk[1], Elisabeth Hoffmann[1], Achim Marx[1], Rudolf Gross[1], Enrique Solano[2], Kunihiro Inomata[3], Tsuyoshi Yamamoto[3,4], and Yasunobu Nakamura[3,4] — [1]Walther-Meissner-Institut and TU München, Garching, Germany — [2]Universidad del Pais Vasco and Ikerbasque Foundation, Bilbao, Spain — [3]RIKEN, Wako, Japan — [4]NEC Corporation, Tsukuba, Japan

Weak propagating microwave signals on the quantum level can be characterized using two amplification chains and suitable correlations between their outputs. In such a dual path setup all quadrature moments of an input signal can be determined, although the noise added by each individual amplifier chain can be larger than the microwave signal to be measured [E.P. Menzel et al., PRL 105, 100401 (2010)]. This allows for a full quantum tomography of propagating microwaves. As a possible application of the dual-path method, we discuss detecting squeezed states generated by a superconducting Josephson parametric amplifier or other circuit QED setups.

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TT 29.8 Tue 18:00 P1

Characterization of flux-driven Josephson parametric amplifiers — •Alexander Baust[1], Edwin P. Menzel[1], Thomas Niemczyk[1], Elisabeth Hoffmann[1], Max Haeberlein[1], Friedrich Wulschner[1], Frank Deppe[1], Achim Marx[1], Rudolf Gross[1], Enrique Solano[2], Kunihiro Inomata[3], Tsuyoshi Yamamoto[3,4], and Yasunobu Nakamura[3,4] — [1]Walther-Meissner-Institut and TU München, Garching, Germany — [2]Universidad del Pais Vasco and Ikerbasque Foundation, Bilbao, Spain — [3]RIKEN, Wako-shi, Japan — [4]NEC Corporation, Tsukuba, Japan

Phase sensitive linear amplifiers receive increasing interest for applications in the field of circuit QED as they allow for the amplification of one signal quadrature without, in principle, adding noise. The flux-driven Josephson parametric amplifier characterized in this work is formed by a SQUID-terminated transmission line resonator with resonant frequency that can be varied by applying an ac magnetic flux signal through the SQUID. We have characterized two Josephson parametric amplifiers with different design parameters with respect to the center frequency and quality factor of the resonator, phase-dependent and phase-independent gains, as well as compression points and bandwidths.

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TT 29.9 Tue 18:00 P1

The influence of noise on the measurement of the Berry phase in superconducting circuits — •Vera Gramich and Joachim Ankerhold — Institut für Theoretische Physik, Universität Ulm, D-89069 Ulm

Motivated by recent experiments of Cooper pair pumping in a novel type of a phase-biased charge pump (‘Cooper pair sluice’), we study the influence of noise on the measurement of the Berry phase for such a configuration embedded in a superconducting loop. In the adiabatic regime a master equation beyond the RWA (Rotating Wave Approximation) for an open two level quantum system is derived taking consistently into account the combined effect of drive and dissipation. This also includes the driving and friction induced Lamb-shifts. Their impact on the steady state density matrix, which determines the pumped charge, is analyzed for an experimental set-up. Strategies to measure the Lamb-shift in a condensed matter environment are discussed.

TT 29.10 Tue 18:00 P1

Different types of integrability and their relation to decoherence in central spin models — •Bjoern Erbe and John Schliemann — Department of Physics, University of Regensburg, 93040 Regensburg, Germany

In a large variety of nanostructures spins couple to a bath of other spin degrees of freedom. Important examples are given by semiconductor and carbon nanotube quantum dots, phosphorus donors in silicon, nitrogen vacancy centers in diamond and molecular magnets. Commonly such systems are described by so-called central spin models [1,2].

We present recent results on the relation between integrability and decoherence in central spin models with more than one central spin [3]. We show that there is a transition between integrability ensured by Bethe ansatz and integrability ensured by complete sets of commuting operators. This has a significant impact on the decoherence properties of the system, suggesting that it is not necessarily integrability or non-integrability which is related to decoherence, but rather its type or a change from integrability to non-integrability.

[1] J. Schliemann, A. Khaetskii, and D. Loss, J. Phys.: Condens. Mat. 15, R1809 (2003).
[2] W. A. Coish and J. Baugh, phys. stat. sol. B 246, 2203 (2009).
[3] B. Erbe and J. Schliemann, Phys. Rev. Lett. 105, 177602 (2010).

TT 29.11 Tue 18:00 P1

Non-Equilibrium Transport Properties of a Tunnel Junction Coupled to an Harmonic Oscillator in the Non-Markovian Regime — •Stefan Walter and Björn Trauzettel — Institute for Theoretical Physics and Astrophysics, University of Würzburg, D-97074 Würzburg, Germany

We are interested in the true quantum behavior of the coupled system of a quantum harmonic oscillator and a tunnel junction beyond Born and Markov approximation. The non-equilibrium transport properties of the tunnel junction (I-V characteristics and finite frequency noise) are perturbatively calculated in the tunneling Hamiltonian using the Keldysh formalism. We find that the transport properties of the tunnel junction significantly depend on the properties of the oscillator.

For a non-stationary oscillator, we find a complex noise (in second order in the tunnel amplitudes) which complements the proposal for a momentum detector in Ref. [1].

We further investigate the noise signatures of the oscillator to fourth order in the tunneling similar to Ref. [2]. As in Ref. [1] we additionally include an arbitrary relative phase between the tunnel amplitudes, allowing for the detection of the oscillator's momentum. The non-equilibrium treatment permits us to extend previous results to the non-Markovian regime.

[1] C. B. Doiron, B. Trauzettel, and C. Bruder., *Phys. Rev. Lett.* **100**, 027202 (2008)
[2] J. Wabnig, J. Rammer, and A. L. Shelankov, *Phys. Rev. B* **75**, 205319 (2007)