TT 36: TR: Poster Session

Time: Thursday 14:00–18:00 Location: Poster A

TT 36.1 Thu 14:00 Poster A

Lithographically fabricated mechanically controlled break junctions (MCBJ) made of Platinum — •Florian Strigl, Reimar Waitz, and Elke Scheer — Department of Physics, University of Konstanz, 78475 Konstanz, Germany

We present the fabrication scheme and electrical transport properties of lithographically fabricated platinum break junctions for adjusting atomic-size platinum contacts. Platinum atomic contacts are interesting for contacting individual molecules [1] as well as for studying photo-assisted transport [2, 3]. Because of the high melting point of platinum the standard electron beam lithography process for lithographic MCBJs [4] cannot be applied, but a procedure using subtractive dry etching of the platinum layer has to be used. We present here the first electronic transport properties of atomic size contacts produced from these MCBJs under ambient conditions as well as at cryogenic vacuum. We study the conductance as a function of the contact size and calculate histograms from these data. Furthermore we study the current-voltage characteristics of single-atom contacts. Our preliminary data yields a preferred conductance of the single-atom contact in the order of 1.6 to 2 G_0 in agreement with results obtained on "classical" MCBJs [5].

[1] Nature 419 (2002) 906
[2] Phys. Rev. Lett. 99 (2007) 086801
[3] Phys. Rev. B 75 (2007) 075406
[4] Rev. Sci. Instrum. 67 (1996) 108-11,
[5] Phys. Rev. B, 67 (2003) 245411

TT 36.2 Thu 14:00 Poster A

Nonequilibrium transport through a correlated quantum dot with magnetic impurity — •Daniel Becker[1], Stephan Weiss[2], Jens Eckel[3], Michael Thorwart[3], and Daniela Pfannkuche[1] — [1]I. Institute for Theoretical Physics, University of Hamburg, D-20355 Hamburg, Germany — [2]Niels Bohr Institutet, Nano-Science Centret, Universitetsparken 5, DK-2100 Copenhagen, Denmark — [3]FRIAS, Albert-Ludwigs-Universität Freiburg, Albertstr.19, 79104 Freiburg, Germany

The iterative summation of path integrals (ISPI)[1] is adopted to a single-level quantum dot, in which a quantum spin-1/2 magnetic impurity interacts with the dot-electron spins. For two electrons on the dot, Coulomb interaction is taken into account. Based on a generating function, the tunneling current at finite bias voltages and the orientation of the impurity spin are calculated numerically. The scheme is deterministic by construction and non-perturbative and allows to study real-time nonequilibrium transport for strong electron-impurity and Coulomb interaction, even at low temperatures and for a wide range of bias voltages. Of particular interest is the mutual influence between tunneling current and the impurity spin dynamics in the presence of the Coulomb interaction and a magnetic field.

[1] S. Weiss et al., Phys. Rev. B 77, 195316 (2008)

TT 36.3 Thu 14:00 Poster A

Transport through a vibrating quantum dot: Polaronic effects — •Thomas Koch[1], Jan Loos[2], Andreas Alvermann[1], Alan Bishop[3], and Holger Fehske[1] — [1]Institute of Physics, Ernst-Moritz-Arndt University Greifswald, 17487 Greifswald, Germany — [2]Institute of Physics, Academy of Sciences of the Czech Republic, 16200 Prague, Czech Republic — [3]Theory, Simulation and Computation Directorate, Los Alamos National Laboratory, Los Alamos, New Mexico 87545, USA

We present a Green's function based treatment of the effects of electron-phonon coupling on transport through a molecular quantum dot in the quantum limit. Thereby we combine an incomplete variational Lang-Firsov approach with a perturbative calculation of the electron-phonon self energy in the framework of generalised Matsubara Green functions and a Landauer-type transport description. Calculating the ground-state energy, the dot single-particle spectral function and the linear conductance at finite carrier density, we study the low-temperature transport properties of the vibrating quantum dot sandwiched between metallic leads in the whole electron-phonon coupling strength regime. We discuss corrections to the concept of an anti-adiabatic dot polaron and show how a deformable quantum dot can act as a molecular switch.

TT 36.4 Thu 14:00 Poster A

Modification of the electronic transport in Au by prototypical impurities and interlayers — •Mohamed Fadlallah[1,2], Cosima Schuster[1], Udo Schwingenschlögl[3], and Ulrich Eckern[1] — [1]Universität Augsburg, 86135 Augsburg, Germany — [2]Benha University, Benha, Egypt — [3]KAUST, Thuwal 23955-6900, Kingdom of Saudi Arabia

Electronic tranport calculations using the Smeagol code based on density functional theory and the non-equilibrium Green's functions method are presented. We study the modifications of the transport through Au due to prototypical impurities and interlayers. Our results demonstrate that non-metallic impurities (S or Si) act upon transport similar to vacancies, since they do not contribute to the electronic states at the Fermi energy. On the other hand, metallic impurities and interlayers (Cu or Ni) can have drastic effects on the transport, in particular when the Au *sd* hybridized states at the Fermi energy are perturbed. For Au/nAg/Au heterostructures the conductance decreases as the interlayer thickness increases but no saturation is found up to n=8 interlayers. The formation of an interface alloy is also considered. The transmission through a two component interlayer system can be described as a superposition of the effects of the individual layers.

TT 36.5 Thu 14:00 Poster A

A Real-Time Path Integral Approach for a Dissipative Nonequilibrium Quantum Dot — •Klaus Ferdinand Albrecht[1,2], Lothar Mühlbacher[1], and Andreas Komnik[2] — [1]Physikalisches Institut, Universität Freiburg — [2]Institut für Theoretische Physik, Universität Heidelberg

Based on a recently developed real-time path integral approach, we apply a diagrammatic Quantum Monte Carlo method to study the nonequilibrium dynamics of a contacted quantum dot coupled to a phonon environment, which consists of either one or several phonon modes. The timescales reached by this exact method are long enough to exploit transient behavior as well as transport properties of the system.

TT 36.6 Thu 14:00 Poster A

Dephasing in a mesoscopic ring connected via arms to leads — •M. Treiber[1], O. M. Yevtushenko[1], F. Marquardt[1], J. von Delft[1], and I. V. Lerner[2] — [1]Physics Department, ASC, and CeNS, Ludwig-Maximilians-Universität, Theresienstrasse 37, 80333 Munich, Germany — [2]School of Physics and Astronomy, University of Birmingham, Birmingham, B15 2TT, UK

We recently considered dephasing by electron interactions in an almost isolated ring using a model of homogeneous electron dissipation [1]. We showed that the amplitude of the Altshuler-Aronov-Spivak (AAS) oscillations crosses over to 0D behavior ($\Delta g_{\mathrm{AAS}} \sim T^{-2}$) when the temperature T drops below the Thouless energy. In the 0D regime, dephasing is dominated by large energy transfers, only restricted by T due to Pauli blocking. Therefore, the observation of this hitherto elusive crossover would allow quantitative tests of the role of T as UV-cutoff in the theory of dephasing. We discussed in [1] that by filtering Δg_{AAS} from its nonoscillatory background, the influence of the leads, which may mask the predicted crossover, can be substantially reduced.

In this presentation, we consider a "lead-arm-ring-arm-lead" geometry, which is closer to the experimental situation. We assume absorbing leads and ballistic (not tunneling) contacts between arm and ring, having different numbers of conducting channels at both sides. We study the T dependence of the dephasing time, analyze in detail arm-ring cross contributions, which were neglected in [1], and discuss the possibility for an experimental observation of 0D dephasing in this model.

[1] M. Treiber et al., Phys. Rev. B **80**, 201305(R) (2009).

TT 36.7 Thu 14:00 Poster A

Quantum transport through magnetic quantum dots — •Benjamin Baxevanis and Daniela Pfannkuche — I. Institute for Theoretical Physics, University of Hamburg, D-20355 Hamburg, Germany

The non-equilibrium transport of charge carriers through magnetic quantum dots is studied theoretically. A single-level quantum dot with a coupling of the electron spin to a local spin 1/2 of a magnetic impurity represents the underlying model. The Coulomb interaction of two electrons as well as the interaction between electrons and the spin impurity are taken into account in a numerically exact manner by means of the recently proposed real-time version of the diagrammatic Monte Carlo method [1]. This approach is applied to investigate the transient dynamics in the system subject to external parameters. In particular, the effects due to the mutual interplay between charge carriers and the impurity spin are examined.

[1] P. Werner, T. Oka, and A. J. Millis, Phys. Rev. B **79**, 035320 (2009)

TT 36.8 Thu 14:00 Poster A

Nonequilibrium cotunneling in quantum dots: Building the bridge between the T-matrix approach and exact perturbation theory — •Georg Begemann[1], Sonja Koller[1], Milena Grifoni[1], and Jens Paaske[2] — [1]Universität Regensburg — [2]Nano-Science Center, University of Copenhagen

Using a T-matrix based rate equation approach, it is possible to perform fast calculations on fourth order transport, i.e. on the cotunneling regime of transport across quantum dots. However, there is the long standing question about the quality of such calculations in comparison to exact, but numerical costly perturbation theory results. In this poster, we present the exact perturbation theory and show the fundamental relation which exists between the two. We can pinpoint to which approximations to the exact method the T-matrix approach corresponds and give a detailed comparison between results on transport across quantum double dots. We also show how an effective Kondo Hamiltonian can be derived in the deep Coulomb blockade regime for Coulomb diamonds with odd filling and that it is equivalent to the fourth order T-matrix contributions.

TT 36.9 Thu 14:00 Poster A

Non-Equilibrium Dynamics of Electron Transport through Interacting Quantum Dots — •Alexander Croy and Ulf Saalmann — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden, Germany

The transport of electrons through nanoscale devices, including quantum dot systems, has been a subject of intense research in the past decades. The study of time-resolved phenomena is of particular interest in this regard. This interest is driven not only by the prospect of realizing quantum computers using such systems, but also by the rapid experimental progress in this field.

In this context we study theoretically the *time-resolved* electric currents flowing through single and double quantum dots that are subject to a voltage pulse. Our numerical calculations are based on a recently developed propagation scheme for non-equilibrium Green functions [1]. This scheme relies on an efficient auxiliary-mode expansion of the Fermi function [2] and facilitates the study of arbitrary time-dependencies. We also present an extension of this scheme which allows treating interacting electrons for energies above the Kondo temperature. The results are compared to quantum master equations for the many-body density matrix describing the state of the quantum dot system.

[1] A. Croy and U. Saalmann, PRB, in print (2009), arXiv:0908.2936
[2] A. Croy and U. Saalmann, PRB 80, 073102 (2009)

TT 36.10 Thu 14:00 Poster A

Transmission through metallic chains: Role of distortions and contact geometry — •Thomas Wunderlich, Berna Akgenc, Cosima Schuster, and Ulrich Eckern — Institus für Physik, Universität Augsburg, 86135, Germany

We present results of electronic structure and transport calculations for metallic chains, based on density functional theory and scattering theory combined with the the non-equilibrium Green's function technique. Starting from a simple model system of monovalent metallic chains we investigate the influence of distortions on the electronic structure and the transport properties of H and Li chains. Furthermore we calculate the electronic structure of Au chains which are contacted to leads via different geometries, and study the influence of the contact geometry on the transmission coefficient. In particular, we compare chains, pyramides and planes in the contact region. A comparison with analytical results is given.

TT 36.11 Thu 14:00 Poster A

Transport characteristics of carbon nanotube devices with spin-orbit coupling and parallel magnetic field — •Miriam del Valle, Magdalena Marganska, and Milena Grifoni — Institute for Theoretical Physics, University of Regensburg, 93 053 Regensburg, Germany

Spin-orbit interaction was long thought to be negligible in carbon nanotubes (CNTs) due to the low atomic mass of carbon. However, recent experiments on CNT devices have shown a clear signature of spin-orbit coupling, originating in the curvature of the nanotube. We present here the calculations of density of states and transport characteristics of CNT devices including spin-independent curvature effects, spin-orbit coupling and the presence of a parallel magnetic field.

The calculations are done both with an effective model in reciprocal space and a real space tight-binding Hamiltonian with one p_z orbital per atom. The results allow us to interpret experimental data, throwing light onto the role of curvature and spin-orbit coupling in CNT systems. Among their most interesting effects is the possibility of highly spin-polarized currents close to the charge neutrality point, which may be useful in spintronics devices.

TT 36.12 Thu 14:00 Poster A

Controlled ballistic electron beam propagation in a Rashba spin orbit split two dimensional electron gas — •Mathias J. Mühlbauer, Christoph Brüne, Elena G. Novik, Hartmut Buhmann, and Laurens W. Molenkamp — Physikalisches Institut (EP3), Universität Würzburg, 97074 Würzburg, Germany

For spintronic applications, systems with high spin orbit (SO) coupling strength provide a promising environment. There it should be possible to observe the electronic analogue of the birefringent effect for polarized light as proposed by M. Khodas et al. [1]. The beam polarization takes place at a junction between regions with different SO splitting. HgTe/HgCdTe quantum wells are the material of choice. Electron beam injection and detection can be provided by quantum point contacts (QPCs). However, the realization of QPCs in HgTe/HgCdTe structures is not trivial due to the narrow band gap and the presence of the Quantum Spin Hall Effect (QSHE) [2]. Here, we demonstrate that it is possible to fabricate QPCs using electron beam lithography and dry etching techniques and to control its transmission with a top gate electrode. The functionality of the devices is confirmed by measurements of conductance and electron beam collimation effect. The quantized conductance is the first demonstration for a HgTe based structure. We would like to note that the conductance sequence shows steps of e^2/h indicating the influence of the Rashba SO splitting. We will present and discuss measurements on these devices.

[1] M. Khodas et al.,Phys. Rev. Lett. 92, 086602 (2004).
[2] M. König et al.,Science, 318, 766, (2007).

TT 36.13 Thu 14:00 Poster A

Micromagnetic properties of narrow PdFe and PdNi strips — •Daniel Steininger, Dominik Preusche, Maurice Ziola, Günther Bayreuther, and Christoph Strunk — Institut für Angewandte und Experimentelle Physik, Universität Regensburg

We present an investigation of submicron ferromagnetic strips from PdFe and PdNi intended to act as contact electrodes to carbon nanotube-based spin devices.

Various strips are studied for their magnetic properties with respect to coercive fields, ferromagnetic transition temperature and micromagnetic structure depending on their aspect ratio and material composition.

Magnetic hysteresis measurements on $Pd_{0.95}Fe_{0.05}$-, $Pd_{0.83}Ni_{0.17}$- and $Pd_{0.3}Ni_{0.7}$ using a magneto optical Kerr magnetometer were performed on arrays containing strip widths from 100nm to 2.5μm. For further investigation of the spontaneous magnetization we measured the anisotropic magnetoresistance on individual $Pd_{0.3}Ni_{0.7}$ strips and performed wide angle x-ray scattering to examine the lattice texture of $Pd_{0.3}Ni_{0.7}$-Films. Atomic- and magnetic force microscopy confirm independently the micromagnetic structure of $Pd_{0.3}Ni_{0.7}$ electrodes.

TT 36.14 Thu 14:00 Poster A

Transport through a Molecular Bridge: Comparison of Different Truncation Schemes for Non-Equilibrium Green Functions — •Brendan Coughlin, Sabine Tornow, and Gertrud Zwicknagl — Institut fuer Mathematische Physik, TU Braunschweig, 38106 Braunschweig, Germany

We present a detailed model study of electron transport through a molecular bridge using analytical methods. Employing an extended Hubbard model for the molecular bridge which is contacted to leads we calculate non-equilibrium Green functions. A scheme of coupled equation of motion is set up with the help of computer algebra systems. To calculate the conductivity higher order decoupling schemes in different parameter regimes are systematically tested and compared with numerical methods.

TT 36.15 Thu 14:00 Poster A

Multiple-charge transfer and trapping in DNA dimers — •Sabine Tornow[1], Ralf Bulla[2], Frithjof Anders[3], and Gertrud Zwicknagl[1] — [1]Institut fuer Mathematische Physik, TU Braunschweig, 38106 Braunschweig, Germany — [2]Institut fuer Theoretische Physik, Universitaet zu Koeln, 50937 Koeln, Germany — [3]Theoretische Physik II, TU Dortmund, 44221 Dortmund, Germany

We investigate the transfer characteristics of multiple charges in a DNA base-pair dimer using a model Hamiltonian approach. It comprises different Coulomb matrix elements which where calculated recently by Starikov [E. B. Starikov, Phil. Mag. Lett. 83, 699 (2003)] as well as the dissipative environment which is modeled by a bosonic bath. In the nuclear tunneling regime we employ the Numerical Renormalization Group method whereas in the thermal activation regime a scheme of kinetic equations and Marcus rates is used to calculate the time-dependent population probabilities. We find that the mobility of two excess charges depends strongly on the Coulomb-matrix elements which differ for the different base pairs. Starting with two electrons on the donor, the Coulomb matrix elements determine, if, e.g, both electrons are self-trapped, transferred as a pair or only one of the electrons is transferred. The latter can be even activation-less when the difference of the on-site and inter-site Coulomb matrix element is equal to the reorganization energy which is the case in a GC-GC dimer. Whereas two excess electrons in AT-AT, dependent on the temperature and spectral function of the environment, are either self-trapped or are oscillating as a pair.

TT 36.16 Thu 14:00 Poster A

Interference in transport through single molecules in a STM set-up — •Sandra Kolmeder, Andrea Donarini, and Milena Grifoni — Institute of Theoretical Physics, University of Regensburg, Germany

We theoretically study the transport properties of single molecules in a STM configuration. The focus is on STM experiments, which measure electronic properties of individual molecules deposited on ultrathin insulating films on metal substrates. The insulating film allows to electronically decouple the molecule from the matallic surface. We model this geometry as a double-barrier tunneling set-up where we account for angular momentum selection rules governing tunneling processes from the tip to the molecule and from the molecule to the substrate. In turn this might lead to interference effects in transport, like selective conductance and current blocking, because of involved orbitally degenerate states.

TT 36.17 Thu 14:00 Poster A

Electrical contacting of vertical nanostructures — •Matthias Wieser[1], Jochen Grebing[1], Marcel Höwler[1], Kerstin Bernert[1], Artur Erbe[1], Jürgen Fassbender[1], and Bertram Schmidt[2] — [1]Forschungszentrum Dresden-Rossendorf e. V., D-01328 Dresden — [2]Otto-von-Guericke-Universität Magdeburg, D-39106 Magdeburg

The aim of this new approach is the contacting and characterization of small vertical nanostructures. Therefore, in contrast to conventional lateral contacting a vertical pillar with a height of about 70nm and an elliptic size of 100nm × 150nm is contacted using a bottom electrode, a via with the same height as the pillar and two top electrodes for tip-contacting of measurement devices. The structuring of the different layers is done using electron beam lithography (EBL). A resist layer is used as an insulator between the bottom and the top electrodes. In the center of the pillar an Al_2O_3 tunnel barrier will be integrated. The current voltage (IV) characteristics of the system will be investigated and compared to the direct tunneling and the Fowler-Nordheim tunneling model. Using this technique we will characterize the electrical properties of oxides with varying thickness.

TT 36.18 Thu 14:00 Poster A

Nonequilibrium quantum transport in the local Holstein model — •Roland Hützen[1], Stephan Weiss[2], Michael Thorwart[3], and Reinhold Egger[1] — [1]Heinrich-Heine Universität Düsseldorf — [2]Niels Bohr Institute & Nano-Science Center, University of Copenhagen — [3]FRIAS, Albert-Ludwigs Universität Freiburg

The local Holstein model serves as a basic model to study quantum transport through a single molecule. We employ the Keldysh path integral formalism to describe the system under nonequilibrium conditions. Free fermionic fields are integrated out and the coupling between the dot electron and the phonon mode is disentangled exactly by introducing auxiliary spin fields ($S_j = 0, \pm 1$) on every Trotter slice. Those interact with each other over finite memory times, whereas free bosonic fields are integrated out as well. The remaining functional integration over the discrete spins is performed by means of the deterministic ISPI method [1]. We calculate the generating function for the tunneling current at finite bias voltages. For small electron-phonon coupling strengths λ we have checked our results against perturbation theory at finite temperature. In addition we have studied the regime of slow and fast phonon modes.

[1] S. Weiss, J. Eckel, M. Thorwart, and R. Egger, Phys. Rev. B **77**, 195316 (2008).

TT 36.19 Thu 14:00 Poster A

Formation of metallic electrodes for molecular transport measurements by electromigration — •Birgit Kiessig[1,2], Wanyin Cui[1,2], Kai Grube[1], Regina Hofmann[2], Dominik Stöffler[2], and Roland Schäfer[1] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen — [2]Karlsruher Institut für Technologie, Physikalisches Institut, Wolfgang-Gaede-Straße 1, 76128 Karlsruhe

Molecular transport measurements require the fabrication of conductive electrodes spaced only a few nm apart. Electromigration of metallic nanostructures is a tool to achieve this aim which by now has been approved by several groups around the world.

We report on our own experience with electromigration of various materials, namely Au, Al and AuPd, using a feedback controlled electromigration process.

A dependence of the size of the resulting gaps on substrate and structure material as well as ambient temperature is observed. We mainly attribute this to different mechanisms and magnitude of heat transport from the nanostructures to the surroundings which results in different temperature profiles in the devices.

Furthermore we monitore structure thinning during electomigration in situ with a scanning electron microscope. At the same time resistance is measured and a simple model is used to explain the observed dependence of resistance on geometry.

TT 36.20 Thu 14:00 Poster A

Inter-System Crossing in a Dissipative Three-Spin System — •Sabine Tornow[1], Frithjof Anders[2], and Gertrud Zwicknagl[1] — [1]Institut fuer Mathematische Physik, TU Braunschweig, 38106 Braunschweig, Germany — [2]Theoretische Physik II, TU Dortmund, 44221 Dortmund, Germany

We present an extended Hubbard model with dissipation (dissipative Hubbard model) for analyzing the spin and electron dynamics of a donor-acceptor system representing a chromophore coupled to a radical in a solvent. The latter is modeled by a bosonic bath. After photoexcitation, the initial local singlet state on the chromophore can perform a transition to a local triplet state (inter-system crossing) dependent on the coupling to the dissipative environment, Coulomb interactions, exchange interactions, on-site-energies and hopping parameters. We investigate the rate of local triplet formation and calculate the time-dependent population probabilities of all electronic states with the Time-Dependent Numerical Renormalization Group. The investigation of the role of different parameters can help to tailor appropriate molecules and solvents, to study fundamental questions about controlling molecular spin-systems.

TT 36.21 Thu 14:00 Poster A

Electron Transport through Molecular Junctions — Dirk Brossell, •Ole Pfoch, and Barbara Sandow — Freie Universität Berlin, Institut für Experimentalphysik, Arminallee 14, 14195 Berlin

Molecular switches with characteristic conductance attributes are highly favoured as new generation of nanoelectronic devices. Switching between stable isomers occurs by interaction with light, by current and magnetic field. Using mechanically controllable break junction we can fabricate stable metal-molecule-metal junctions. We present our newly developed break junction experiment which has been used to study the transport and switching properties of a gold-molecule-gold junction or a copper-molecule-copper junction, i.e. with a molecular switch like azobenzene.

TT 36.22 Thu 14:00 Poster A

Inelastic Electron Tunneling Spectroscopy of a Single-Molecule Break Junction — •Youngsang Kim[1], Hyunwook Song[2], Hans-Fridtjof Pernau[1], Takhee Lee[2], and Elke Scheer[1] — [1]Department of Physics, University of Konstanz, D-78457 Konstanz, Germany — [2]Department of Materials Science and Engineering, Gwangju Institute of Science and Technology, Gwangju 500-712, Korea

We report the inelastic electron tunneling (IET) spectra of an 1,6-hexanedithiol (HDT) single-molecule junction using a mechanically controllable break junction (MCBJ) technique. We measure the completely assigned IET spectra of the HDT junction. All of the spectral features are attributable to vibrational modes associated with the molecular species, providing a clear evidence of the existence of the component molecule through which tunneling is occurring. In addition, we discuss the effect of the junction elongation by changing the separation between two electrodes in MCBJ, which gives rise to changes in the configuration in the single-molecule junction.

TT 36.23 Thu 14:00 Poster A

Entanglement transfer from electrons to photons in quantum dots: An open quantum system approach — •Jan Carl Budich and Björn Trauzettel — Institut für Theoretische Physik, 97074 Würzburg, Deutschland

We investigate entanglement transfer from a system of two spin-entangled electron-hole pairs, each placed in a separate single mode cavity, to the photons emitted during their recombination process. Dipole selection rules and a splitting between the light-hole and the heavy-hole subbands are the crucial ingredients establishing a one-to-one correspondence between electron spins and circular photon polarizations. To account for the measurement of the photons as well as dephasing effects, we choose a stochastic Schrödinger equation and a conditional master equation approach, respectively. The influence of interactions with the environment as well as asymmetries in the coherent couplings on the photon-entanglement is analyzed for two concrete measurement schemes. The first one is designed to violate the Clauser-Horne-Shimony-Holt (CHSH) inequality, while the second one employs the visibility of interference fringes to prove the entanglement of the photons. Because of the spatial separation of the entangled electronic system over two quantum dots, a successful verification of entangled photons emitted by this system would imply the detection of nonlocal spin-entanglement of massive particles in a solid state structure.

TT 36.24 Thu 14:00 Poster A

Experiments with Double-SQUID Qubits — •Bernhard Dörling[1], Stefano Poletto[1], Maria Gabriella Castellano[2], Fabio Chiarello[2], and Alexey V. Ustinov[1] — [1]Karlsruher Institut für Technologie — [2]Instituto Fotonica e Nanotecnologie - CNR, Roma, Italy

A double-SQUID qubit (flash-qubit) allows the manipulation of quantum states by very short pulses of magnetic flux, without using microwaves [1]. It consists of an rf-SQUID with a dc-SQUID replacing the single Josephson junction.

The energy potential profile is controllable by dc bias fluxes threading the two loops. The initial qubit state in a double well is prepared by applying a dc flux pulse to one loop, thereby tilting the double well so that only one of the two states remains stable. To manipulate the state of the qubit a dc flux pulse is applied to the other loop to change the potential into a single well, where coherent Larmor oscillations between the two lowest eigenstates take place. Reading out the state is once again performed in the double well situation, where our readout dc-SQUID is able to discriminate between the two computational states due to their flux difference.

We hope to present measurements done on a new sample, fabricated using shadow evaporation of aluminium and silicon nitride as the dielectric.

[1] Stefano Poletto et al., New J. Phys. **11**, 013009 (2009)

TT 36.25 Thu 14:00 Poster A

Dissipative dynamics of a qubit coupled to a nonlinear undriven or driven oscillator — •Carmen Vierheilig, Johannes Hausinger, and Milena Grifoni — Universität Regensburg, 93040 Regensburg, Germany

Coupling a qubit to a nonlinear readout device, for example a DC-SQUID in the nonlinear regime or a Josephson junction bifurcation amplifier, lead to advantages in several measurement schemes and to new physical observations. In this poster we consider the case of a qubit coupled to a nonlinear, driven or undriven, oscillator. The oscillator is in turn coupled to a thermal bath, which thus indirectly induces dissipation and dephasing in the qubit's dynamics.

In the undriven situation focus is on the regime where the frequency of the linear oscillator nearly equals the qubit's energy splitting. This yields a multiplicity of quasi-degenerate states of the coupled qubit-nonlinear oscillator system, reflected in a complex dynamics of the qubit towards equilibrium [1].

When an additional ac-field is included, resonant transitions between the multiplets can be induced.

[1] C. Vierheilig, J. Hausinger, and M. Grifoni, Phys. Rev. A **80**, 052331 (2009)

TT 36.26 Thu 14:00 Poster A

Bifurcation Readout of a Josephson Phase Qubit — •Tobias Wirth, Jürgen Lisenfeld, Alexander Lukashenko, and Alexey V. Ustinov — Karlsruhe Institute of Technology (KIT), Physikalisches Institut, Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

The standard method to read out a Josephson phase qubit is using a dc-SQUID to measure the state-dependent magnetic flux of the qubit by switching to the non-superconducting state. This process generates heat directly on the qubit chip and quasi-particles in the circuitry. Both effects require a relatively long cool-down time after each switching event. This, together with the time needed to ramp up the bias current of the SQUID limits the repetition rate of the experiment. In our ongoing experiments we replace the standard readout scheme by a SQUID shunted by a capacitor. This nonlinear resonator is operated close to its bifurcation point between two oscillating states which depend on the qubit flux. The measurement is done by detecting either the resonance amplitude or phase shift of the reflected probe signal. We verified that our SQUID resonator works as linear resonator for low excitation powers and observed the periodic dependence of the resonance frequency on the externally applied magnetic flux. For higher excitation powers the device shows a hysteretic behavior between the two oscillating states. Current experiments are focused on a pulsed rf-readout to measure coherent evolution of the qubit states. We hope to achieve longer coherence times, perform faster measurements, and test non-destructive measurement schemes with Josephson phase qubits.

TT 36.27 Thu 14:00 Poster A

Galvanic coupling of two superconducting microwave resonators — Thomas Weissl[1], •Elisabeth Hoffmann[1], Frank Deppe[1], Edwin P. Menzel[1], Achim Marx[1], Rudolf Gross[1], David Zueco[2], Georg M. Reuther[2], Juan J. Garcia-Ripoll[3], and Enrique Solano[4] — [1]Walther-Meissner-Institut and TU München, Garching, Germany — [2]Universität Augsburg, Augsburg, Germany — [3]Instituto de Fisica Fundamental, CSIC, Madrid, Spain — [4]Universidad del País Vasco-Eurskal Herriko Unibertsitatea, Spain

Thermal entanglement, e.g. in a system of two degenerate coupled superconducting microwave resonators, is achieved just by lowering the temperature below a critical temperature T_c and can be detected via suitable correlation measurements. T_c depends on the coupling strength of the two resonators. To obtain a critical temperature of about 100 mK in an actual experiment, a coupling strength of the order of 1 GHz is required. For superconducting flux quantum circuits, such a large coupling can be realized by making use of the kinetic inductance: the circuits have to be galvanically connected and form a single entity. Nevertheless, the physics can often be described by two separate modes with an enhanced coupling constant. Our experiments show that the mode structure of two coupled superconducting microwave resonators changes discontinuously when connecting them galvanically instead of just placing them very close to each other. This is explained within a simple toy model. This work is supported by the DFG within SFB 631 and NIM.

TT 36.28 Thu 14:00 Poster A

Dual-path measurements of the noise properties of Josephson parametric amplifiers — •Alexander Baust[1], Edwin P. Menzel[1], Matteo Mariantoni[1], Frank Deppe[1], Miguel Angel Araque Caballero[1], Elisabeth Hoffmann[1], Thomas Niemczyk[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

Phase sensitive amplifiers, e.g. Josephson parametric amplifiers (JPA), in principle allow for the amplification of one signal quadrature without adding noise. In practice however, internal losses introduce noise. In experiments, the JPA output signal usually is further amplified by HEMT amplifiers, which obscure the noise properties of the JPA by their much larger noise. We show that splitting the signal and utilizing two amplification chains allows one to eliminate the noise contribution of the HEMT amplifiers. In this way, the first two signal moments can be analyzed by correlation measurements. We study two possible applications of our dual-path method. First, we investigate the noise properties of a superconducting JPA. Second, we address the measurement of squeezed states generated by the latter and discuss to what extent squeezing can be observed in our samples.

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TT 36.29 Thu 14:00 Poster A

Back-action on the flux-qubit from a driven non-linear detector — •Vicente Ancelmo Leyton Ortega[1], Vittorio Peano[1], Michael Thorwart[1], and John Henrry Reina[2] — [1]Freiburg Institute for Advanced Studies (FRIAS), Albert-Ludwigs Universität Freiburg, 79104 Freiburg — [2]Universidad del Valle, Departamento de Física, A.A. 25360, Cali-Colombia.

We consider a superconducting flux qubit inductively coupled to a driven SQUID, acting as a detector, in presence of weak dissipation and close to the optimal working point. We study the nonlinear response of the detector to the drive and the population difference of the qubit state. By varying the external magnetic field piercing the SQUID, we access two different regimes: i) For vanishing external flux, the SQUID acts as a Josephson bifurcation amplifier, however, operated here with few energy quanta rather than in its classical regime. In this regime, we show that the back-action of the detector on the qubit is small, rendering the driven SQUID an ideal detector. ii) When the external flux is close to half a flux quantum, the combined qubit-oscillator system implements the two-photon Jaynes-Cummings model. We study multiphoton (anti-)resonances in the two-photon transition regime.

TT 36.30 Thu 14:00 Poster A

Characterization of non-Gaussian quantum noise via dephasing of qubits — •Stefan Kessler and Florian Marquardt — Department of Physics, Arnold Sommerfeld Center for Theoretical Physics, and Center for NanoScience, Ludwig-Maximilians-Universität München, Theresienstr 37, D-80333 München, Germany

Until now, a major restriction of solid state qubits as quantum memories is their small coherence times due to the unavoidable coupling to their noisy environment. On the other hand the decoherence of the qubit can be used as unique probe for the time correlations of the environmental noise fluctuations.

While most of the previous work on decoherence has been based on environments modeled by Gaussian fluctuators or ensembles of classical fluctuators, we address here genuine quantum non-Gaussian noise. Features of quantum non-Gaussian noise have been observed in recent experiments in mesoscopic physics, where strong coupling between the system and few environmental fluctuators is dominant.

In this work, we consider the pure dephasing of a two level system due to its quantum environment and introduce an effective quantum noise spectrum based on the time evolution of the qubit coherence. We show that this spectrum provides a convenient way to distinguish experimentally between Gaussian and non-Gaussian noise and can be used to characterize the non-Gaussianity of the noise. The results are illustrated by different models of non-Gaussian environments. We discuss the implications for experimental setups measuring quantum noise.

TT 36.31 Thu 14:00 Poster A

Gradiometric superconducting flux qubit with tunable gap — •Manuel Johannes Schwarz[1], Tomasz Niemczyk[1,2], Frank Deppe[1], Achim Marx[1], and Rudolf Gross[1,2] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meissner-Str. 8, 85748 Garching — [2]Physics Department, TU München, 85748 Garching

One promising candidate for the implementation of scalable quantum information processing is a superconducting flux qubit. In its gradiometric version, it consists of two galvanically coupled superconducting loops with three or four nanoscale Josephson junctions, one of them being slightly smaller than the others, placed on the shared line. In principle, the qubit transition frequency can be controlled by applying an external flux to the loop. However, in order to maintain long phase coherence time, the qubit must be operated at a certain optimal flux bias. Nevertheless, tunability can be obtained by replacing the smaller junction with a DC SQUID loop acting as an effective junction, whose critical current can be varied via an additional flux line without changing the flux bias in the qubit loop [1]. Using electron beam lithography, two-angle shadow evaporation and Al technology, we have fabricated such a device together with a readout SQUID. At 30 mK, we observe a clear qubit signature in the switching current of the readout SQUID. Furthermore, we show the results of spectroscopic measurements and discuss to which extent an additional flux through the small SQUID loop affects this data. This work is supported by the DFG via SFB631 and NIM.

[1] F.G. Paauw et al., Phys. Rev. Lett. 102, 090501 (2009)

TT 36.32 Thu 14:00 Poster A

Multiplexing Qubit Readout using Microwave Resonators — •Markus Jerger, Stefano Poletto, and Alexey V. Ustinov — Physikalisches Institut, Karlsruher Institut für Technologie (KIT), Wolfgang-Gaede-Str. 1, 76131 Karlsruhe, Germany

We investigate the coupling of quantum bits to transmission line resonators. A set of resonators around 10 GHz with short decay times is used for a fast measurement of the qubit states. Distinct resonances enable frequency-domain multiplexing readout of several qubits. An additional resonator with a long decay time is used to entangle the states of selected qubits and transfer information between them. We explore situations where the coupling is dominated by either the magnetic or the electric fields of the resonators.

The qubit we use is a Josephson phase qubit, consisting of a superconducting loop interrupted by a Josephson junction with a well-defined phase difference across the junction. Under certain conditions, the loop forms a two-level system with eigenfrequencies in the gigahertz range that evolves according to the laws of quantum mechanics.

In this session we will present our latest measurements.

TT 36.33 Thu 14:00 Poster A

Towards Quantum Experiments in Electromechanical Systems — •Fredrik Hocke[1], Stefan Weis[2], Xiaoqing Zhou[2], Thomas Niemczyk[1], Edwin P. Menzel[1], Georg Wild[1], Hans Huebl[1], Achim Marx[1], Tobias Kippenberg[2,3], and Rudolf Gross[1] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Max Planck Institut für Quantenoptik, Garching , Germany — [3]Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

During the last years optomechanics has developed into a wide playground, allowing the study of quantum mechanics in a literal sense. Here, a light field is coupled to the mechanical motion of a resonator and exploited to cool down the mechanical mode eventually to its quantum mechanical ground state. In our case, the light field is realized in form of microwave photons in a superconducting on-chip cavity and the mechanical oscillator as freely suspended, nanometer-sized beam. This on-chip layout allows implementing experiments at low temperatures in a straightforward way. We present first experimental results on the characterization of nanometer-sized beams and beam-resonator hybrids. This work is supported by the Excellence Cluster "Nanosystems Initiative Munich (NIM)".

TT 36.34 Thu 14:00 Poster A

Feedback and Rate Asymmetry of the Josephson Junction Noise Detector — •Daniel Urban[1] and Hermann Grabert[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany — [2]Freiburg Institute for Advanced Studies, Albert-Ludwigs-Universität, D-79104 Freiburg, Germany

The Josephson junction noise detector measures the skewness of non-Gaussian noise via the asymmetry of the rate of escape from the zero-voltage state upon reversal of the bias current. The feedback of this detector on the noise generating device is investigated in detail [1]. Concise predictions are made for a second Josephson junction as noise generating device. The strong nonlinearity of this component implies particularly strong feedback effects, including a change of sign of the rate asymmetry as the applied voltage approaches twice the superconducting gap.

[1] D. F. Urban and H. Grabert, Phys. Rev. B **79**, 113102 (2009).