TT 13: Transport: Poster Session

We recommend to hang up the posters already during the morning sessions.

Time: Monday 15:00–19:00 Location: Poster B

TT 13.1 Mon 15:00 Poster B

Lab::Measurement — Measurement control and automation with Perl — Florian Olbrich[1], David Kalok[1], Daniela Taubert[2], Daniel Schröer[2], and •Andreas K. Hüttel[1] — [1]Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Department für Physik, LMU München, Geschwister-Scholl-Platz 1, 80539 München, Germany

For quickly setting up varying and evolving complex measurement tasks involving diverse hardware, graphical logic programming quickly reaches practical limits. We present *Lab::Measurement*, a collection of Perl modules designed to control GPIB and serial instruments. It provides an interface to instrumentation control backends as e.g. Linux-GPIB or National Instruments' NI-VISA library. Dedicated instrument driver classes relieve the user from taking care of internal details. Recording a measurement trace, say $I(V_g)$, becomes as easy as programming a single for-loop, and much more complex setups can quickly be implemented. At the same time, the modules provide (live) plotting and metadata handling. *Lab::Measurement* has already been successfully used in several low temperature transport spectroscopy setups. It is free software and available at `http://www.labmeasurement.de/`

TT 13.2 Mon 15:00 Poster B

Possibility of superconductivity due to electron-phonon interaction in graphene — •Matthias Einenkel and Konstantin Efetov — Institut für Theoretische Physik III, Ruhr-Universität Bochum, 44780 Bochum, Germany}

We discuss the possibility of superconductivity in graphene taking into account both electron-phonon and electron-electron Coulomb interactions. The analysis is carried out assuming that the Fermi energy is far away from the Dirac points, such that the density of the particles (electrons or holes) is high. We derive proper Eliashberg equations that allow us to estimate the critical superconducting temperature. The most favorable is pairing of electrons belonging to different valleys in the spectrum. Using values of electron-phonon coupling estimated in other publications we obtain the critical temperature as a function of the electron (hole) density. This temperature can reach the order of 10 K at the Fermi energy of order 1-2 eV. We show that the dependence of the intervalley pairing on the impurity concentration should be weak.

TT 13.3 Mon 15:00 Poster B

Quenching photoluminescence in semiconducting nanorods in contact with epitaxial graphene — •Christian Sorger[1], Daniel Waldmann[1], Johannes Jobst[1], Stefan Hertel[1], Adam Faust[2], Uri Banin[2], and Heiko B. Weber[1] — [1]Lehrstuhl für Angewandte Physik, Universität Erlangen-Nürnberg, 91058 Erlangen, Germany — [2]Institute of Chemistry, The Hebrew University, Jerusalem 91904 Israel

It is well known that the photoluminescence of semiconducting particles can be quenched in close vicinity to a metallic surface. In our experiment we deposit CdSe-nanorods in close contact to epitaxially grown graphene [1] and detect the photoluminescence on large areas. Substantial quenching is observed.

We are targeting the dependence of fluorescence quenching on the charge density in the graphene layer, which is tuned by a bottom gate [2]. Vice versa, the influence of photoexcitation on transport properties is investigated.

[1] K. V. Emtsev et al. , Nature Materials **8**, 203 (2009).
[2] D. Waldmann et al. , Nature Materials **10**, 357 (2011).

TT 13.4 Mon 15:00 Poster B

Symmetries and the conductance of graphene nanoribbons with long-range disorder — Jürgen Wurm[1], •Michael Wimmer[2], and Klaus Richter[1] — [1]Institut für Theoretische Physik, Universität Regensburg, Germany — [2]Instituut-Lorentz, Universiteit Leiden, The Netherlands

We study the conductance of graphene nanoribbons with long-range disorder. Due to the absence of intervalley scattering from the disorder potential, time-reversal symmetry (TRS) can be effectively broken even without a magnetic field, depending on the type of ribbon edge. Even though armchair edges generally mix valleys, we show that metallic armchair nanoribbons possess a hidden pseudovalley structure and effectively broken TRS. In contrast, semiconducting armchair nanoribbons inevitably mix valleys and restore TRS. As a result, in strong disorder metallic armchair ribbons exhibit a perfectly conducting channel, but semiconducting armchair ribbons ordinary localization. TRS is also effectively broken in zigzag nanoribbons in the absence of valley mixing. However, we show that intervalley scattering in zigzag ribbons is significantly enhanced and TRS is restored even for smooth disorder, if the Fermi energy is smaller than the potential amplitude. The symmetry properties of disordered nanoribbons are also reflected in their conductance in the diffusive regime. In particular, we find suppression of weak localization and an enhancement of conductance fluctuations in metallic armchair and zigzag ribbons without valley mixing. In contrast, semiconducting armchair and zigzag ribbons with valley mixing exhibit weak localization behavior.

TT 13.5 Mon 15:00 Poster B

Resonant scattering in graphene with a gate-defined chaotic quantum dot — •Martin Schneider and Piet W. Brouwer — Dahlem Center for Complex Quantum Systems and Institut für theoretische Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

We investigate the conductance of an undoped graphene sheet with two metallic contacts and an electrostatically gated island (quantum dot) between the contacts. Our analysis is based on the Matrix Green Function formalism, which was recently adapted to graphene [1]. We find pronounced differences between the case of a stadium-shaped dot (which has chaotic classical dynamics) and a disc-shaped dot (which has integrable classical dynamics) in the limit that the dot size is small in comparison to the distance between the contacts. In particular, for the stadium-shaped dot the two-terminal conductance shows Fano resonances as a function of the gate voltage, which cross-over to Breit-Wigner resonances only in the limit of completely separated resonances, whereas for a disc-shaped dot sharp Breit-Wigner resonances resulting from higher angular momentum remain present throughout.

[1] M. Titov, P. M. Ostrovskyi, I. V. Gornyi, A. Schuessler, and A. D. Mirlin, Phys. Rev. Lett. **104**, 076802 (2010)

TT 13.6 Mon 15:00 Poster B

Limitations of pulse-gating schemes for extracting relaxation times in graphene quantum dots — •Sebastian Kazarski[1], Christian Volk[1,2], Christoph Neumann[1], Fabian Hassler[3], and Christoph Stampfer[1,2] — [1]JARA-FIT and II. Institute of Physics B, RWTH Aachen, 52074 Aachen, Germany — [2]Institute for Bio- and Nanosystems, Forschungszentrum Jülich, 52425 Jülich, Germany — [3]Institute for Quantum Information, RWTH Aachen, 52074 Aachen, Germany

Solid state quantum dots are interesting candidates for future spin-based quantum information technology. In particular carbon materials, such as graphene and nanotubes are interesting for hosting quantum dots since these materials exhibit weak spin-orbit coupling and weak hyperfine interaction promising long spin coherence times. Here, we present low-temperature pulse-gating transport experiments on a graphene quantum dot, which potentially allow us to estimate relaxation times. The experimental data are compared with a detailed numerical simulation of the pulse-gating experiment to extract relaxation times which arise in a graphene quantum dot considering excited (ES) to ground state (GS) transitions. The simulation is based on solving the involved rate equations, taking into account tunnel coupling rates $\Gamma_{L,R}$, the relaxation rate Γ_τ from ES to GS, and a number different pulse-gate configurations. The average current I through the ES and GS, and the averaged electron number per cycle $\langle n \rangle$ are calculated numerically. We can find reasonable agreement with the experiment and discuss the limits of the used technique.

TT 13.7 Mon 15:00 Poster B

Tuning the electronic structure and transport properties in carbon-based devices — •Hernan L. Calvo[1], Claudia G. Rocha[2,3], Horacio M. Pastawski[4], Stephan Roche[5], Gianaurelio Cuniberti[3], and Luis E.F. Foa Torres[4] — [1]Institut für Theorie

der Statistischen Physik, RWTH Aachen University, 52056 Aachen, Germany — [2]Department of Physics, NanoScience Center, University of Jyväskylä, Jyväskylä 40014, Finland — [3]Institute for Materials Science and Max Bergmann Center of Biomaterials, Dresden University of Technology, Dresden D-01062, Germany — [4]IFEG-CONICET, FaMAF, Universidad Nacional de Córdoba, Argentina — [5]CIN2 (ICN-CSIC), Universidad Autónoma de Barcelona, Campus UAB, 08193 Bellaterra (Barcelona), and ICREA, 08070 Barcelona, Spain

Thanks to their outstanding electrical, mechanical and thermal properties, research in carbon-based materials is one of the most rapidly advancing fronts ever. In this work, we study the effects a time-periodic potential induces on the electronic structure and transport properties in graphene and carbon nanotubes. By combining Floquet theory with Green's function formalism, we describe two different situations: (1) the generation of laser-induced band gaps in graphene and (2) the enhancement of the pumped current in carbon nanotubes. For the first case, we show how the band gaps can be tuned by using the laser polarization and describe a strong suppression in the conductance. For the second case, we observe an enhancement of the pumped current by up to two orders of magnitude when gating the system close to a van Hove singularity (vHs).

TT 13.8 Mon 15:00 Poster B

Metal-to-insulator transition and electron-hole puddle formation in disordered graphene nanoribbons — •Holger Fehske and Gerald Schubert — Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17487 Greifswald

The experimentally observed metal-to-insulator transition in hydrogenated graphene is numerically confirmed for actual sized graphene samples and realistic impurity concentrations. The eigenstates of our tight-binding model with substitutional disorder corroborate the formation of electron-hole-puddles with characteristic length scales comparable to the ones found in experiments. The puddles cause charge inhomogeneities and tend to suppress Anderson localization. Even though, monitoring the charge carrier quantum dynamics and performing a finite-size scaling of the local density of states distribution, we find strong evidence for the existence of localized states in graphene nanoribbons with short-range but also correlated long-range disorder.

TT 13.9 Mon 15:00 Poster B

CVD growth of carbon nanotubes on ultra-flat hexagonal boron nitride — •Lidia Saptsova[1,2], Stephan Engels[1,2], K. Watanabe[3], T. Taniguchi[3], Carola Meyer[2], and Christoph Stampfer[1,2] — [1]JARA-FIT and II. Institute of Physics B, RWTH Aachen, 52074 Aachen, Germany — [2]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [3]Advanced Materials Laboratory, National Institute for Materials Science, 1-1 Namiki, Tsukuba, 305-0044, Japan

Single-walled carbon nanotubes (SWNTs) are promising candidates for hosting high-quality quantum dots (QDs). However, at the present time it is difficult to achieve ultra-clean SWNT QDs on substrates, since the substrate, in particular SiO_2 introduce a significant disorder potential. For graphene devices it was recently shown that placing graphene on hexagonal boron nitride (hBN) significantly improves the device performance. Since hBN is a wide-bandgap insulator, has the graphene-like planar layer structure and is free of dangling bonds and charge traps at the surface, it might be used as a perfect substrate for CNT devices. Here, we present the fabrication technology for making SWNT quantum dots on hBN. We use a Ferritin-based Fe catalyst CVD growth method for obtaining uniformly distributed SWNTs with diameters of about 1.5-2 nm. To study the effect of the substrate material on the disorder in nanotubes, SWNTs lying on both hBN and SiO_2 were chosen using scanning force microscopy. Finally, SWNT QDs on hBN and SiO_2 were obtained by contacting individual 300 nm nanotube sections by metal electrodes.

TT 13.10 Mon 15:00 Poster B

Low temperature transport in carbon nanotubes — •Birgit Kiessig[1,2], Cornelius Thiele[2,3], Ralph Krupke[3], Kai Grube[1], Roland Schäfer[1], and Hilbert v. Löhneysen[1,2] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik — [2]Karlsruher Institut für Technologie, Physikalisches Institut — [3]Karlsruher Institut für Technologie, Institut für Nanotechnologie

We present measurements on gold contacted metallic carbon nanotubes (CNTs) performed in a $^3He/^4He$ dilution refrigerator between base temperature ($\sim 10\,mK$) and 5 K. In addition to the electrodes spaced 300-400 nm apart, side gates were implemented 50-150 nm from the CNTs.

IV curves show Coulomb blockade at low voltages which can be lifted by gating. For higher voltages conductance increases nonlinearly and assymmetrically. Transport modifications induced by gate voltage and magnetic field up to 8 T are characterized.

TT 13.11 Mon 15:00 Poster B

Quantum dots in ultra-clean, suspended single-wall carbon nanotubes — •Peter Stiller, Daniel Schmid, Sabine Kugler, Alois Dirnaichner, Christoph Strunk, and Andreas K. Hüttel — Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany

Single suspended carbon nanotubes, CVD-grown over pre-defined contacts without any further chemical or lithographic processing, can exhibit their unperturbed electronic level structure in transport spectroscopy. We present measurements on the quantum dot forming in such a nanotube in the few carrier limit, characterizing the electronic and mechanical properties and the interaction of both. The measurements show the transition from strong Coulomb blockade to the Kondo regime on the electron conduction side and from Coulomb blockade to Fabry-Perot interference on the hole conduction side. On the electronic side the few carrier spectrum is characterized in detail, as well as the build-up of Kondo correlations towards higher electron numbers.

TT 13.12 Mon 15:00 Poster B

Magnetoresistance measurements on carbon nanotubes with CoPd contacts — •Dominik Metten[1], Caitlin Morgan[1], Claus M. Schneider[1,2], and Carola Meyer[1,2] — [1]Forschungszentrum Jülich, Peter Grünberg Institut (PGI-6) and JARA Jülich Aachen Research Alliance, 52425 Jülich, Germany — [2]Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Carbon nanotubes (CNTs) are expected to show a long spin relaxation length because they exhibit small hyperfine coupling and have small spin-orbit interactions. These properties, along with ballistic electron transport, lead to a high potential for applications in the field of spintronics.

We study spin injection in CNT-based devices using $Co_{50}Pd_{50}$ as contacts. Palladium is known to have low contact resistivity to CNTs and is easily spin-polarized by cobalt. Shape anisotropy is used to ensure in-plane magnetization and to prevent formation of multiple domains in the contacts.

Here we present a magnetic characterization of the contacts including SQUID- and MFM-measurements. First magnetoresistance (MR) measurements show an MR effect of 5% with clear switching behavior. Our devices can be tuned using a backgate. Gate dependent measurements reveal different regimes for the MR effect. Since a potential barrier forms at the interface between the contacts and the CNT, tunneling MR is the expected mechanism.

TT 13.13 Mon 15:00 Poster B

Multiterminal electron transport in a quantum dot lattice — •Christian Morfonios[1], Daniel Buchholz[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Physikalisch-Chemisches Institut, Universität Heidelberg, Im Neuenheimer Feld 229, D-69120 Heidelberg, Germany

The multiterminal transport of electrons through a lattice of coupled quantum dots is studied in terms of the array topology and geometry, the internal features of its nodes, and an applied magnetic flux. The scattering properties of individual dots are addressed through separation of interfering lead-coupled states, boundary guiding and magnetic deflection. By assembling the dots into a lattice of variable spacing, connectivity and terminal positioning, the possibility of mode-resolved control of scattering between input and output lead states is investigated.

TT 13.14 Mon 15:00 Poster B

Liouville space formulation for interacting quantum dots with superconducting leads — •Jacek Swiebodzinski[1], Dirk Schuricht[2], Jürgen König[1], and Herbert Schoeller[2] — [1]Theoretische Physik, Universität Duisburg-Essen and CeNIDE, 47048 Duisburg, Germany — [2]Institut für Theorie der Statistischen Physik, RWTH Aachen, 52056 Aachen, Germany

Following recent advances in nanofabrication, quantum dots in contact with superconducting leads have increasingly moved into the focus of

spintronic related research. A key issue is hereby the occurrence of both superconducting correlations and Coulomb interaction combined with a general non-equilibrium situation. In the following contribution we present a diagrammatic method suitable to describe quantum dots with arbitrarily large interactions coupled to normal and superconducting leads. In the latter case transport can be provided either by quasiparticle or Andreev tunneling giving rise to a rich variety of interesting physical phenomena. The method is based upon a perturbative expansion in the dot-reservoir coupling and formulated in Liouville space. As compared to the standard diagrammatic approach in Keldysh space, in the Liouville formulation the two branches of the Keldysh contour are taken together simplifying the diagrammatic language. Relaxation and dephasing rates can be easily read off from the poles of the Liouvillian. We apply the method to a normal lead - quantum dot - superconductor system discussing some of its properties.

TT 13.15 Mon 15:00 Poster B

Dynamics of a doubly Monitored Charge Qubit — •Christian Nietner, Gernot Schaller, Christina Pöltl, and Tobias Brandes — TU Berlin, Institut für Theoretische Physik, Hardenbergstr. 36, 10623 Berlin

We investigate the electronic transport through two parallel double quantum dots coupled via a perpendicularly aligned charge qubit. In our model, the presence of the qubit leads to a modification of the intrinsic tunnel amplitudes of each double quantum dot. Specifically, the two charge configurations of the qubit are associated with a suppression of the electronic tunneling in the respective double quantum dot. We study the influence of the qubit on the electronic steady state currents through the system. To this end we use a Born-Markov-Secular quantum master equation for the system and apply a full counting statistics ansatz. The obtained currents show signatures of the qubit for all bias regimes. Conversely, the stationary qubit state may be tuned and even rendered pure by applying suitable voltages.

TT 13.16 Mon 15:00 Poster B

Multiply Connected Graph Model for Dephasing in Diffusive Quantum Dots — •Maximilian Treiber, Oleg Yevtushenko, and Jan von Delft — Ludwig Maximilians Universität, Arnold Sommerfeld Center und Center for Nano-Science, München

We propose a model, based on the theory of diffusion in graphs, to study quantum transport through a diffusive quantum dot. The graph consists of a central region composed of many quasi-1d wires describing the dot, and two identical left- and right- wires connected to leads describing contacts. We evaluate the conductance for this model and compare our results to random matrix theory (RMT). An advantage compared to RMT-models is that we can take into account interaction-induced dephasing at finite temperatures. We present results for the temperature dependence of the weak localization correction and discuss the possibility to observe the elusive 0D-regime of dephasing in quantum dots.

TT 13.17 Mon 15:00 Poster B

Thermoelectric performance of quantum pumps — •Federica Haupt[1], Stefan Juergens[1], Michael Moskalets[2], and Janine Splettstoesser[1] — [1]Institut für Theorie der Statistischen Physik, RWTH Aachen University, 52074 Aachen, Germany — [2]Department of Metal and Semiconductor Physics, Kharkiv Polytechnical Institute, 61002 Kharkiv, Ukraine

Prototypical examples of quantum pumps are systems formed by one or a few coupled quantum dots, whose tunneling barriers and/or energy levels are modulated in time by external gate voltages. These devices can be regarded in many respects as quantum engines, with the difference that while classical engines are typically systems working out of equilibrium between hot and cold sources, the phenomenon of quantum pumping becomes especially relevant around equilibrium conditions. This makes a non trivial task the generalization to quantum pumps of concepts such as efficiency, typically used to quantify the performance of classical engines. To address this problem, we investigate in detail charge and energy current in different models of interacting quantum pumps, as well as their thermoelectric properties when brought out of equilibrium. This allows us to identify suitable quantities that permit to characterize the performance of the pump both at and out of equilibrium.

TT 13.18 Mon 15:00 Poster B

Finite Frequency Noise Spectrum of the Anderson Impurity Model — •Christoph Orth[1,2] and Andreas Komnik[1] — [1]Institut für Theoretische Physik, Universität Heidelberg — [2]Department of Physics, University of Basel

Quantum noise is an inherent property for quantum information and nanoscale physics. We analyze the finite frequency current noise spectrum of a quantum dot described by a two-terminal Anderson impurity model at bias voltage V. We focus on the electron-electron interaction effects in the electron-hole symmetric case: (i) perturbatively up to the second order in the interaction strength, and (ii) using a random phase approximation for the two-particle vertex function (screened interaction) to go beyond perturbation theory. Our method is based on a non-equilibrium Keldysh Green's function technique and is exact in tunneling.

An exact analytical formula is found for the non-interacting case which shows a staircase like structure with steps whenever ω reaches a characteristic energy of the system. The electron-electron interaction leads to non-vanishing correlations of currents with opposite spin. For small U we observe that the spectrum develops a distinct threshold at $\omega < -V/2$ and peaks at $\omega \approx V/2$. We expect that our results capture the generic properties of the noise spectra, which is also supported by recent publications.

TT 13.19 Mon 15:00 Poster B

Transport measurements on single Bi nanowires at temperatures below 1 K — •Arnold Seiler[1], Christopher Reiche[1,2], Torben Peichl[1], Sven Müller[3], Maria E. Toimil-Molares[3], Christina Trautmann[3], and Georg Weiss[1,2] — [1]Physikalisches Institut, KIT Karlsruhe — [2]Centrum für funktionelle Nanostrukturen, KIT Karlsruhe — [3]GSI Darmstadt

Bismuth is an interesting semimetal for studies of electronic transport phenomena at low temperatures and reduced dimensions due to its large Fermi wavelength and long mean free path. Previous experiments with bundles of crystalline Bi wires embedded in a polycarbonate membrane show a decrease in resistance below 300 mK. Different measurements of Bi nanowires suggest that this drop is caused by superconductivity. This may be induced by surface oxidation or surface contaminants. Our Bi wires are fabricated by electrodeposition using an ion-track etched membrane as a template. We use an all organic process to extract the nanowires from the membrane without oxidation of the surface and developed various methods to contact single Bi wires in a 4-point geometry. Thus, the transport properties of Bi nanowires were successfully measured down to temperatures below 50 mK. Obtained results indicate that, depending on the growth conditions, the wires have a tendency to become either superconducting or insulating.

TT 13.20 Mon 15:00 Poster B

Electric transport and tunnel measurements on pure copper nanowires — •Maksym Kompaniiets[1], Dirk Klingenberger[1], Fabrizio Porrati[1], Oleksandr Dobrovolskiy[1], Oleksandr Foyevtsov[1], Cornelia Neetzel[2], Markus Rauber[2], Maria Eugenia Toimil-Molares[3], Wolfgang Ensinger[2], Christina Trautmann[3], and Michael Huth[1] — [1]Physikalisches Institut, Goethe Universität, Frankfurt a. M. — [2]Fachbereich Materialwissenschaften, TU Darmstadt, Darmstadt — [3]3GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

Cu and Cu/Fe nanowires of well-defined shape and composition are well-suited for studying the spin-dependent scattering resistance contribution of ferromagnets and Kondo systems. We present first four-probe ac-resistance and tunnel measurements on cross-type junctions of individual nanowires with diameters of about $250 - 300\ nm$ and length of about $30-60\ \mu m$. The nanowires have been prepared by electrochemical deposition in etched heavy-ion-track polycarbonate membranes (templates). For contacting individual nanowires ion beam induced deposits of $W - Ca - Ga - O$ electrodes with the precursor gas $W(CO)_6$ in a dual-beam SEM/FIB were used. Electric transport measurements on pure Cu nanowires reveal a decreasing resistivity with decreasing temperature, as is expected for metallic nanowires. Furthermore, in tunneling spectroscopy measurements we found clear indications of proximity-effect induced superconductivity in the Cu nanowires below $5\ K$, i.e. the critical temperature of the $W-C-Ga-O$ composites electrodes.

TT 13.21 Mon 15:00 Poster B

Weak localization and magnetoresistance in two-chain ladder models — •Michael P. Schneider, Sam T. Carr, Igor V. Gornyi, and Alexander D. Mirlin — Institut für Theorie der kondensierten Materie, KIT, D-76128 Karlsruhe

We study the weak localization correction to the conductivity of a disordered two-chain ladder in the limit of strong dephasing, paying particular attention to magnetoresistance. We observe an anomalous behaviour of the magnetoresistance in a specific range of parameters, due to a competition between an interference effect and the dimensionality of the system, and predict the curious phenomenon of magnetic field enhanced localization.

TT 13.22 Mon 15:00 Poster B

Magnetotransport properties of nanoporouse gold films — •Jaqueline Weissbon, Andreas Gondorf, Martin Geller, and Axel Lorke — Faculty of Physics and CeNIDE, University of Duisburg-Essen, Lotharstraße 1, 47057 Duisburg, Germany

Nanoporous gold layers are prepared by etching thin films of Au/Ag-alloys in HNO_3. The morphology of the nanoporous films is determined by scanning electron microscopy for different etching conditions. The films are patterned into Hall bar geometries and their magnetotransport properties are investigated as a function of temperature. In the magnetic field range $B = 0 - 12\ T$, we find a linear Hall resistance $\rho_{xy}(B)$ and a quadratic longitudinal magnetoresistance $\Delta\rho_{xx}(B) \propto B^2$. In the temperature range between 20 K and 350 K, we find a roughly linearly increasing specific resistance. The results are compared with recent reports in the literature [1,2] and discussed within the Fuchs-Sonderheimer model of scattering in thin films.

[1] T. Fujita, H. Okada, K. Koyama, K. Watanabe, S. Maekawa and M. W. Chen, Physical Review Letters, 101, 166601 (2008)
[2] R. C. Munoz, M. A. Suarez, S. Oyarzun, R. Henrique, A. Espinosa, G. Kremer, L. Moraga, S. Cancino and R. Morales, Physical Review B, 81, 165408 (2010)

TT 13.23 Mon 15:00 Poster B

Spin polarized transport through noncollinear single-electron spin-valve transistors — •Stephan Lindebaum and Jürgen König — Theoretische Physik, Universität Duisburg-Essen and CeNIDE, D-47048 Duisburg

We study the electronic transport through a noncollinear single-electron spin-valve transistor, i.e., a metallic island with a continuous electron density of states tunnel coupled to two ferromagnetic leads. The polarization directions of the ferromagnets enclose an arbitrary angle. In the considered system, charging and spin effects play an important role and influence the transport behavior of the transistor. Furthermore, the interplay of Coulomb interaction and tunnel coupling to spin-polarized leads yields a many-body exchange field, in which the accumulated island spin precesses.

We derive kinetic equations for the island charge and spin within a diagrammatic real-time transport formalism. In our theory we perform a perturbative analysis of the transport properties up to first order in the tunnel-coupling strength (sequential-tunneling limit), which is reasonable due to the weak island-lead coupling.

Our formalism enables to analyze both the linear and nonlinear transport regimes. The electric current through the transistor and the accumulated island spin are considered in detail. In particular, we find that the exchange field can give rise to a high sensitivity of the island's spin orientation on the gate voltage.

[1] S. Lindebaum and J. König, arXiv:1109.5800v1

TT 13.24 Mon 15:00 Poster B

Quantum transport through coupled quantum dots attached to a Large spin — •Klemens Mosshammer, Gerold Kiesslich, and Tobias Brandes — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstrasse 36, 10623 Berlin

We investigate theoretically the magneto-transport through a system of two coupled single level quantum dots, connected to ferromagnetic leads, where the electron spin is coupled to an external (pseudo-)spin via an exchange interaction, introducing non-linear dynamics. The system is examined using a semi-classical technique in combination with a quantum master equation approach to describe the sequential tunneling trough the system. We find regimes where the average current through the quantum dot system displays self-sustained oscillations reflecting limit-cycles behaviour of the transport electrons.

TT 13.25 Mon 15:00 Poster B

Charge transport in molecule-graphene nanojunctions using complex absorbing potentials — •Susanne Leitherer, Ivan Pshenichnyuk, Pedro B. Coto, and Michael Thoss — Institut für Theoretische Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany

Charge transport in molecule-graphene nanojunctions is studied employing the Landauer formalism in combination with complex absorbing potentials (CAPs). Within this approach, the self-energies, which describe molecule-electrode coupling in an extended system, are obtained using absorbing potentials and finite graphene electrodes. The performance of different CAPs is discussed, including CAPs in polynomial form [1] as well as CAPs derived using the WKB approximation [2,3]. The method is applied to molecular junctions consisting of a pentacene molecule and a polyyne chain between graphene electrodes.

[1] A. Kopf and P. Saalfrank, Chem. Phys. Lett. 386, 17 (2004).
[2] D. E. Manolopoulos, J. Chem. Phys. 117, 9552 (2002).
[3] J. A. Driscoll and K. Varga, Phys. Rev. B 78, 245118 (2008).

TT 13.26 Mon 15:00 Poster B

Statistical model for the effects of phase and momentum randomization on electron transport — •Thomas Stegmann[1], Matías Zilly[1], Orsolya Ujsághy[2], and Dietrich E. Wolf[1] — [1]Department of Physics, University of Duisburg-Essen and CeNIDE, Duisburg, Germany — [2]Department of Theoretical Physics and Condensed Matter Research Group of the Hungarian Academy of Sciences, Budapest University of Technology and Economics, Budapest, Hungary

Recently, we have introduced a statistical model for the effects of dephasing on the transport properties of large systems [1]. This model has been applied successfully on the conduction of DNA molecules [2] and the dephasing-induced conductivity in the 1D Anderson model [3]. Now, we present an extension of our model which allows to adjust the degree of phase and momentum randomization independently.

As a first result, we demonstrate that the resistance of an ordered tight-binding chain is independent of the chain length and the degree of phase randomization if the dephasing is momentum conserving. In contrast, the resistance increases if the dephasing is momentum randomizing.

[1] M. Zilly, O. Ujsághy and D. E. Wolf, Eur. Phys. B, **68**:237 (2009)
[2] M. Zilly, O. Ujsághy and D. E. Wolf, Phys. Rev. B, **82**:125125 (2010)
[3] M. Zilly, O. Ujsághy, M. Wölki and D. E. Wolf, Phys. Rev. B, arXiv:1111.6014

TT 13.27 Mon 15:00 Poster B

Decoherence-induced conductivity in the 1D Anderson model: Resistivity, generalized Lyapunov exponents and localization length — •Matías Zilly[1], Orsolya Ujsághy[2], Marko Woelki[3], Thomas Stegmann[1], and Dietrich E. Wolf[1] — [1]Fakultät für Physik und CeNiDE, Universität Duisburg-Essen, Duisburg, Germany — [2]Department of Theoretical Physics and Condensed Matter Research Group of the Hungarian Academy of Sciences, Budapest University of Technology and Economics, Budapest, Hungary — [3]Theoretische Physik, Universität des Saarlands, Saarbrücken, Germany

A recently proposed statistical model for the effects of decoherence on electron transport [1] manifests a decoherence-driven transition from quantum-coherent localized to ohmic behavior when applied to the Anderson model. Here [2] we derive the resistivity in the ohmic case and study the critical decoherence density at which the transition takes place. This density is shown to be related to the second-order generalized Lyapunov exponent, which under the assumption of a Gaussian limiting distribution for the logarithm of the transmission $\ln T$ allows to determine the localization length.

[1] M. Zilly, O. Ujsághy, and D. E. Wolf. Eur. Phys. J. B **68**, 237 (2009)
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TT 13.28 Mon 15:00 Poster B

Attenuated total reflection (ATR)-study of the reversible switching of immobilized ring-opening/ring-closure molecular switches — •Katharina Luka-Guth[1], Dmytro Sysoiev[2], Youngsang Kim[1], Johannes Boneberg[1], Paul Leiderer[1], Jannic Wolf[2], Thomas Huhn[2], Ulrich Groth[2], and Elke Scheer[1] — [1]Fachbereich Physik, Universität Konstanz — [2]Fachbereich Chemie, Universität Konstanz

We study the conformational changes of the photochromic difurylperfluorocyclopentene molecules induced by optical switching by attenuated total reflection (ATR) measurements.

A single layer of molecules is chemisorbed on a 40-nm thin layer of gold. We measure the reflected intensity of near infrared-light that is coupled-in from the rear side of the molecular layer on gold on a glass

substrate (Kretschmann geometry) and observe the reflection decrease due to the excitation of surface plasmons at the interface between gold and the determine the atmosphere. Upon irradiation with UV and red light, respectively, the molecules are switched between the open, low-conducting and the closed, highly conducting state. We detect the change of the ATR signal while switching for a series of molecules in lock-in technique and discuss their potential applications in molecular electronics devices.

TT 13.29 Mon 15:00 Poster B

Electrical characterization of single molecules in liquid environments — Matthias Wieser, •Torsten Sendler, Jochen Grebing, and Artur Erbe — Helmholtz-Zentrum Dresden-Rossendorf

We have developed the mechanical controllable break junction technique for the use in liquid environments in order to characterize the electrical properties of single molecules in their solvents. The metallic electrodes, which form the contacts for the molecular structures, are produced on an insulating substrate in order to reduce all spurious effects coming from parallel conduction through the liquid. We present first electrical characterization of such junctions in dry and in liquid environments. The solvents range from aqueous buffer, which will be used for measurements of DNA fragments, to toluene and THF, which are typical solvents for short, conjugated organic molecules.

TT 13.30 Mon 15:00 Poster B

Large shot noise levels in single-molecule junctions due to electronic-vibrational coupling — •Christian Schinabeck, Rainer Härtle, and Michael Thoss — Institut für Theoreti-sche Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany

We investigate shot noise in transport through single-molecule junctions using a master equation approach that is based on a second order expansion in the molecule-lead coupling [1]. Recently, large shot noise levels have been reported for a variety of single-molecule junctions with different molecular species [2]. This indicates that electrons are tunneling through these contacts in avalanches rather than in statistically uncorrelated tunneling events. Such a transport behaviour was found by Koch et al. for a model comprising a single electronic state that is very strongly coupled to a single vibrational mode [3]. In this contribution, we show that a weak to moderate coupling of the electrons to a multitude of vibrational modes may also give rise to large shot noise levels, as observed in experiments [2].

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[3] J. Koch *et al.*, Phys. Rev. B 74, 205438 (2006).

TT 13.31 Mon 15:00 Poster B

Time-dependent transport through fluctuating molecular wires — •Bogdan Popescu and Ulrich Kleinekathöfer — Jacobs University Bremen, Germany

In the present study, the electron transport through a quantum wire, modeled as a linear chain of tight-binding sites and coupled to external fermion leads, is investigated using several distinct formalisms: nonequilibrium Green's functions [1], the hierarchical equations of motion approach [2] and by a perturbation expansion [3]. The first two methods are known to be exact for noninteracting fermions. Several accuracy and performance tests involving all three methods have been carried out for different configurations (site energy differences, voltages, temperatures). The propagation schemes are suited to be applied to investigate time-dependent transport through molecular wires, e.g., DNA molecules, where the on-site energies and next-neighbour couplings are time-dependent due to solvent fluctuations. First tests in this direction will be demonstrated.

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TT 13.32 Mon 15:00 Poster B

Vibration induced memory effects in molecular nanojunctions — •Abdullah Yar, Andrea Donarini, and Milena Grifoni — Institute for Theoretical Physics, University of Regensburg, D-93040 Regensburg, Germany

We investigate the bistability and memory effects for a single molecule weakly coupled to metallic leads subject to time-dependent voltage. The system is described by an Anderson-Holstein model and its dynamics is calculated via a master equation approach. Particular emphasis is given to the role played by the excited vibronic states in the bistability and hysteretic switching dynamics as a function of the voltage sweeping rates. We discuss how the hysteretic behavior depends on the asymmetry of the voltage drop through the junction as well as on the time scales of voltage sweeping and quantum switching rates between metastable states.

TT 13.33 Mon 15:00 Poster B

The role of the tip symmetry on the STM topography of π-conjugated molecules — •Benjamin Siegert, Sandra Sobczyk, Andrea Donarini, and Milena Grifoni — Institute of Theoretical Physics, University of Regensburg, Germany

Motivated by recent STM experiments, where either Cu tips or CO-functionalized tips have been adopted [1], we compare theoretically the influence of s-, p- and d-wave tip states on the current maps of π-conjugated molecules. Our theory is based on the density matrix formalism and it is sufficiently general to be applied to any STM device consisting of a π-conjugated molecule weakly coupled to the substrate and the tip. Here we concentrate on the study of the topography of benzene, pentacene and hydrogen phthalocyanine. Our formalism is able to mirror experimental results quite well showing that the shape of the recorded images is strongly related to the orbital structure of the tip.

[1] L. Gross, *et al.*, Phys. Rev. Lett. **107**, 086101 (2011)

TT 13.34 Mon 15:00 Poster B

Current fluctuations in capacitively coupled double quantum dots — •Robert Hussein and Sigmund Kohler — Instituto de Ciencia de Materiales de Madrid, CSIC, Cantoblanco, 28049 Madrid, Spain

Based on a recent work [1], we study a coherent quantum ratchet that is driven by tunnel oscillations. It is realised by two capacitively coupled double quantum dots — the driving circuit is biased but undetuned, while the ratchet circuit is detuned but unbiased. We investigate the full counting statistics (FCS) of both subsystems and compare the results to those of an effective master equation in which the driving circuit is eliminated. While higher order cumulants exhibit discrepancies, Fano factor, skewness and kurtosis are in good agreement.

[1] M. Stark and S. Kohler, EPL 91, 20007 (2010)

TT 13.35 Mon 15:00 Poster B

Induced thermal gradient and quantum shot noise cross-talk in neighboring nanodevices — •Johannes Buelte[1], Federica Haupt[2], and Wolfgang Belzig[1] — [1]Fachbereich Physik, Universität Konstanz, D-78457, Germany — [2]Institut für Theoretische Physik A, RWTH Aachen, D-52074 Aachen, Germany

Motivated by recent experimental results showing strong modifications of the current through a carbon nanotube quantum dot (QD) due to the bias voltage applied to a close-by graphene constriction, we investigate theoretically the cross-talk between neighboring nanodevices. We first show that several of the observed features can be understood assuming that a temperature gradient across the QD develops as the bias applied to the graphene constriction is increased. Next, we consider a model where the biased graphene constriction is treated as non-equilibrium electromagnetic environment for the quantum dot, and use such a model to a) draw a clear connection between the voltage applied to the former and the effective temperature gradient across the QD; b) investigate the dependence of the current in the QD on the spectral properties of the electromagnetic environment itself.

TT 13.36 Mon 15:00 Poster B

Light emission of tunneling electrons interacting via a localized plasmon — •Fei Xu[1], Federica Haupt[2], Cecilia Holmqvist[1], and Wolfgang Belzig[1] — [1]Fachbereich Physik, Universität Konstanz, Konstanz, Germany — [2]Institut für Theorie der Statistischen Physik, RWTH Aachen, Aachen, Germany

Photon emission in electron tunneling can be related to current noise, which is an important tool to investigate quantum many-body effects in electron transport in a non-equilibrium mesoscopic conductor. Recent experiments on photon emission from atomic-size tunnel junctions formed by an STM tip and a metallic surface showed a considerable intensity of photons emitted with a frequency larger than the applied bias voltage $\hbar\omega > eV$ [1,2]. This is a fingerprint of electronic correlations involving electromagnetic plasmonic modes involving both the surface and the tip apex. We address the problem of this over-bias

photon emission in terms of non-equilibrium current fluctuations in a conductor interacting with an electromagnetic environment. The latter can mediate tunneling processes, resulting in two electrons teaming up to cross the junction and emitting a single photon with energy higher than eV [3]. We model the plasmon resonance as an electrical RLC circuit and find that non-Gaussian noise yields one-photon emission with over-bias energy.

[1] G. Schull et al., Phys. Rev. Lett. 102, 057401 (2009).
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[3] J. Tobiska et al., Phys. Rev. Lett. 96, 096801 (2006).

TT 13.37 Mon 15:00 Poster B

Effects of Synchronisation and Noise in Coupled Optomechanical Arrays — •Michael Schneider[1], Georg Heinrich[1], and Florian Marquardt[1,2] — [1]Institute for Theoretical Physics, Universität Erlangen-Nürnberg, Staudtstr. 7, 91058 Erlangen, Germany — [2]Max Planck Institute for the Science of Light, Günther-Scharowsky-Str. 1/Bau 24, 91058 Erlangen, Germany

Optomechanical systems couple light stored inside an optical resonator to the motion of a mechanical mode. Recent experiments have demonstrated setups, such as photonic crystal structures, that in principle allow one to confine several optical and vibrational modes on a single chip. For an array of several coupled optomechanical cells interesting nonlinear behaviour, especially synchronisation, arises. Here we investigate these dynamics and the effects of external noise thereupon. In particular we show how synchronisation affects phase stability.

TT 13.38 Mon 15:00 Poster B

Microcantilevers for Torque Magnetometry — •Stefanos Chalkidis, Stephan Albert, Benedikt Rupprecht, Marc Wilde, and Dirk Grundler — James-Franck-Straße 1, 85747 Garching, Deutschland

Torque magnetometry has proven to be powerful to measure magnetic oscillations of two-dimensional electron systems (2DES) at low temperature. For conventional 2DES in, e.g., semiconductor heterostructures, corresponding cantilevers supported 2DES of 1 mm2. Graphene, the first truly 2D crystal, is an intriguing candidate for examination by torque magnetometry. Our calculations show that magnetic oscillations in exfoliated high-mobility graphene are roughly four orders of magnitude smaller than for the conventional 2DES due to small sample size. This necessitates the development of miniaturized cantilevers. We report our calculation and the progress in the preparation of such cantilevers by reactive-ion-etching from the device layer of a silicon-on-insulator wafer. We will discuss different sensor designs that we analyze either analytically or by finite element simulations. Financial support by the DFG via project no. WI3320/1-1 in the priority programme "Graphene" is gratefully acknowledged as well as experimental support by the Nanosystems Initiative Munich.

TT 13.39 Mon 15:00 Poster B

Dynamics and decoherence in the Gaudin model — •Daniel Stanek, Carsten Raas, and Götz S. Uhrig — Technische Universität Dortmund, Lehrstuhl für Theoretische Physik I, 44221 Dortmund

The Gaudin or central spin model describes a single qubit which interacts with a bath of non-interacting spins 1/2, e.g., nuclear spins in a quantum dot. The model is widely applied in the fields of nuclear magnetic resonance and quantum information processing.

Using time-dependent density matrix renormalization group (tDMRG), we calculate the time-evolution of the qubit which is initialized in a well-defined state out of equilibrium. A detailed analysis of the longitudinal as well as of the transverse relaxation of the qubit for various distributions of the couplings between bath and qubit is presented. In addition, we discuss different initial states of the bath and their influence on the decoherence of the qubit.

TT 13.40 Mon 15:00 Poster B

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 considered 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 theory of "noise of noise" and analyze some microscopic models that could explain these experiments. Special attention is paid to RKKY interaction.

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[2] S. Sendelbach et al., Phys. Rev. Lett. 100, 227006 (2008).
[3] H. Bluhm et al., Phys. Rev. Lett. 103, 026805 (2009).
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[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 13.41 Mon 15:00 Poster B

Full Counting Statistics applied to dissipative Cooper Pair Pumps — •Philip Wollfarth[1], Ingo Kamleitner[1], and Alexander Shnirman[1,2] — [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

We investigate geometric charge pumping in superconducting Josephson devices [1,2] using the method of Full Counting Statistics [3]. In previous studies the expectation value of the current operator was calculated and a very delicate handling of the dissipative master equation [4] governing the dynamics of the system was required. E.g., the rotating wave (secular) approximation turned out to be non-charge-conserving [5]. We include the counting field (charge measuring device) into the master equation and investigate the influence of voltage fluctuation on the pumping process.

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TT 13.42 Mon 15:00 Poster B

Quantum metamaterials with superconducting flux qubits — •Pascal Macha[1], Gregor Oelsner[1], Markus Jerger[2], Uwe Hübner[1], Susanne Butz[2], Evgeni Il'ichev[1], Alexev V. Ustinov[2], and Hans-Georg Meyer[1] — [1]Institute of Photonic Technology, PO Box 100239, D-07702 Jena, Germany — [2]Physikalisches Institut, Karlsruhe Institute of Technology and DFG-Center for Functional Nanostructures (CFN), D-76128 Karlsruhe, Germany

In recent years superconducting qubits have opened up a new route to explore the physics of quantum metamaterials. Artificial materials, formed by many qubits, can potentially exhibit unusual and controllable refraction (transmission) coefficients in the microwave range. We have fabricated cavities and transmission lines containing 20 flux qubits and more. We experimentally investigate the transmission of electromagnetic waves through these new types of media. First experimental results will be presented and discussed.

TT 13.43 Mon 15:00 Poster B

The Back Action of Josephson Photomultipliers — •Luke C.G. Govia[1,2], Emily J. Pritchett[2], Seth T. Merkel[2], Deanna Pineau[3], and Frank K. Wilhelm[2] — [1]Institute for Quantum Computing and Department of Physics and Astronomy, University of Waterloo, Ontario, Canada — [2]Theoretical Physics, Universität des Saarlandes, Saarbrücken, Germany — [3]Department of Physics and Astronomy, University of Victoria, British Columbia, Canada

We describe the Josephson photomultiplier, a photon counter applicable to circuit QED. We show that its backaction is described by the regular photon annihilation operator at short interaction times and approaches a variant of the photon subtraction operator at long times. Understanding this backaction opens the opportunity to use multiplexed photomultipliers for, e.g., state tomography with few preparations.

TT 13.44 Mon 15:00 Poster B

A strategy to measure the Lamb shift in a superconducting two-level system embedded in a thermal broadband reservoir — •Vera Gramich[1], Paolo Solinas[2,3], Mikko Möttönen[2,3], Jukka Pekola[3], and Joachim Ankerhold[1] — [1]Institut für Theo-

retische Physik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm, Germany — [2]Department of Applied Physics/COMP, Aalto University, P.O. Box 14100, FI-00076 Aalto, Finland — [3]Low Temperature Laboratory, Aalto University, P.O. Box 13500, FI-00076 Aalto, Finland

Realistic quantum systems are never completely isolated. Even a single atom in zero-temperature vacuum is influenced by the zero-point fluctuations of the electromagnetic field which in turn induces a shift of its transition frequencies known as the Lamb shift. Cavity quantum electrodynamics (QED) provides a particularly convenient setup to observe this shift since the restricted geometries of the cavities allow the atoms to interact only with the fluctuations of single harmonic fields. In contrast to single-frequency environments, typical reservoirs for mesoscopic solid-state devices are characterized by broadband spectral distributions in thermal equilibrium. Within weak-coupling master equations even explicit expressions for the reservoir-induced frequency shifts can be derived, while associated experimental observations are still missing. To fill this gap, we discuss and analyze a theoretical proposal to retrieve the Lamb shift for a superconducting two-level system embedded in an ohmic environment. Moreover, we present a possible way to measure the Lamb shift in a circuit containing a Cooper pair sluice.

TT 13.45 Mon 15:00 Poster B

Compact superconducting coplanar microwave beam splitters — •Alexander Baust[1,2], Norbert Kalb[2], Max Haeberlein[1,2], Jan Goetz[1,2], Elisabeth Hoffmann[1,2], Edwin P. Menzel[1,2], Manuel J. Schwarz[1,2], Friedrich Wulschner[1,2], Ling Zhong[1,2], Thomas Losinger[2], Frank Deppe[1,2], Achim Marx[1,2], and Rudolf Gross[1,2] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, Garching, Germany — [2]Physik-Department, TUM, Garching, Germany

The recent evolution of circuit quantum electrodynamics systems making use of standing-wave microwave modes towards setups for propagating quantum microwaves has triggered the need for low-loss superconducting microwave beam splitters. Such a device should have ports compatible with the coplanar geometry relevant for circuit QED and, at the same time, be compact allowing for scalability. This combination presents fundamental and technological challenges. In this work, we present the fabrication and characterization of various compact superconducting coplanar microwave beam splitters. In addition, we discuss efforts towards a tunable beam splitter.

This work is supported by the DFG via SFB631 and by the German Excellence Initiative via NIM.

TT 13.46 Mon 15:00 Poster B

Strong coupling of paramagnetic spins to a superconducting microwave resonator — •Moritz Greifenstein[1], Christoph Zollitsch[1], Johannes Lotze[1], Fredrik Hocke[1], Rudolf Gross[1,2], Sebastian T.B. Goennenwein[1], and Hans Huebl[1] — [1]Walther-Meissner-Institut (WMI), Garching, Germany — [2]Physik-Department, TU München, Garching, Germany

Under application of an external magnetic field, non-interacting electron spins behave as an ensemble of identical two-level-systems with tuneable transition frequency. When such an ensemble collectively interacts with a single mode of an electromagnetic resonator, the entire system can be described as two coupled quantum harmonic oscillators. The criterion for the observation of the so-called strong coupling regime is that the collective coupling strength g exceeds both the loss rate of the resonator κ and of the spin ensemble γ.

In our experiment we realize a coupled spin-photon-system by introducing the spin marker DPPH (2,2-diphenyl-1-picrylhydrazyl) into the mode volume of a superconducting coplanar microwave resonator and investigate the interaction at 2.5, 5.0 and 7.5 GHz. For tuning the resonance, we apply an in-plane magnetic field and observe interaction at around ± 90, ± 180 and ± 270 mT. While the coupling with the fundamental mode and the first harmonic mode of the resonator is identified as weak, the second harmonic shows $g = 21$ MHz, $\kappa = 6$ MHz and $\gamma = 5$ MHz, i.e. the strong coupling regime. We further investigate the dependence of g on temperature and on microwave input power. This work is financially supported by DFG via SFB 631.

TT 13.47 Mon 15:00 Poster B

Master Equation Description of Subsystem and Subspace Qubits — •Sebastian Mehl[1,2] and David P. DiVincenzo[1,2] — [1]Peter Grünberg Institute: Theoretical Nanoelectronics, Research Center Jülich, D-52428 Jülich — [2]Institute for Quantum Information, RWTH Aachen, D-52056 Aachen

It is possible to implement and control qubits in a higher dimensional Hilbert space. Especially for spin based solid state qubits this approach is widely used to improve phase coherence properties. Encoded qubits are currently experimentally analyzed in double and triple quantum dot setups [1, 2].

We present the idea to encode qubits in a subspace and a subsystem of a Hilbert space [3]. Starting from a simple model describing the dissipative evolution of the density matrix in the full Hilbert space we develop a master equation description for the subsystem and subspace approach. Particular attention is paid to the influence of the chosen approach on the memory kernel of the Master equation.

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[3] J. Kempe et al., PRA, 63, 042307 (2001)

TT 13.48 Mon 15:00 Poster B

Perfect state transfer in XX chains induced by boundary magnetic fields — •Thorben Linneweber, Joachim Stolze, and Götz S. Uhrig — Institut für Physik, TU Dortmund, Germany

A recent numerical study of short chains found near-perfect quantum state transfer between the boundary sites of a spin-1/2 XX chain if a sufficiently strong magnetic field acts on these sites. We show that the phenomenon is based on a pair of states strongly localized at the boundaries of the system and provide a simple quantitative analytical explanation.

TT 13.49 Mon 15:00 Poster B

Enhancing the hyperfine spin decoherence time of holes in quantum dots by strain — •Franziska Maier and Daniel Loss — Department of Physics, University of Basel, 4056 Basel, Switzerland

In this work we theoretically examine the effect of strain on the single spin decoherence time T_2 of a heavy hole confined to a cylindrical InAs semiconductor quantum dot. To this end, we include strain in the **k·p**-Hamiltonian describing the states in the lowest conduction bands (CB) and the heavy hole (HH), light hole (LH) and split-off (SO) bands of the dot. For non-zero strain we find a modification of the existing confinement-induced hybridization of the HH states [1] which strongly depends on explicit values of the strain tensor components. Hyperfine interaction between the hybridized HH states and the surrounding nuclear spin bath leads to a reduction of the hole spin decoherence time T_2. Our results reveal that T_2 cannot only be tuned by external parameters such as nuclear polarization or external magnetic fields as it has been previously shown, but also by choosing different strain configurations.

[1] J. Fischer and D. Loss, Phys. Rev. Lett. **105**, 266603 (2010)

TT 13.50 Mon 15:00 Poster B

A Superconducting Quantum Register with Multiplexed Readout — •Markus Jerger[1], Stefano Poletto[1], Pascal Macha[1,2], Uwe Hübner[2], Jürgen Lisenfeld[1], Alexander Lukashenko[1], Evgeni Il'ichev[2], and Alexey V. Ustinov[1] — [1]Physikalisches Institut, Karlsruhe Institute of Technology, D-76128 Karlsruhe, Germany — [2]Institute of Photonic Technology, PO Box 100239, D-07702 Jena, Germany

A resonant circuit coupled to a qubit experiences a shift of its resonance frequency that depends on the quantum state of the qubit. By coupling every qubit to an individual readout resonator, the state of a quantum register of many qubits can be read out through a single transmission line connected to all resonators. The readout of all qubits can be performed simultaneously using digital modulation and de-modulation techniques. We experimentally demonstrate the simultaneous multiplexed readout of up to seven qubits through a single line. We integrated this readout system into a circuit QED architecture consisting of qubits interacting via a quantum cavity bus. Our latest measurements aiming at the demonstration of quantum gates will be presented.

TT 13.51 Mon 15:00 Poster B

Topological insulators in cold-atom gases with non-Abelian gauge fields: the role of interactions — •Peter Philipp Orth[1], Daniel Cocks[2], Stephan Rachel[3], Michael Buchhold[2], Karyn Le Hur[4,3], and Walter Hofstetter[2] — [1]Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie, 76128 Karlsruhe, Germany — [2]Institut für Theoretische Physik, Goethe Universität, 60438 Frankfurt/Main, Germany — [3]Department of Physics, Yale University, New Haven, Connecticut 06520, USA — [4]Center for Theoretical Physics, Ecole Polytechnique, 91128 Palaiseau Cedex,

France

With the recent technological advance of creating (non)-Abelian gauge fields for ultracold atoms in optical lattices, it becomes possible to study the interplay of topological phases and interactions in these systems. Specifically, we consider a spinful and time-reversal invariant version of the Hofstadter problem. In addition, we allow for a hopping term which does not preserve S_z spin symmetry and a staggered sublattice potential. Without interactions, the parameters can be tuned such that the system is a topological insulator. Using a combination of analytical techniques and the powerful real-space dynamical mean-field (R-DMFT) method, we discuss the effect of interactions and determine the interacting phase diagram.

TT 13.52 Mon 15:00 Poster B

Magnetic impurities on edges of topological insulators — •Florian Goth and Fakher F. Assaad — Institut für Theoretische Physik und Astrophysik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany

The realization of the Spin-Hall-Effect in quantum wells has led to a plethora of studies regarding the properties of the edge states of a 2D topological insulator. These edge states constitute a class of one-dimensional liquids, called the helical liquid, where an electron's spin direction is coupled to its direction of movement. In contrast to one dimensional conductors, magnetic impurities – below the Kondo temperature – cannot block transport and one expects the current to circumvent the impurity. To study this phenomenon, we consider the single impurity Anderson model embedded into an edge of a Kane-Mele ribbon and use numerically exact continuous time QMC methods to study the Kondo effect. We will present results on the temperature dependence of the double occupancy as well as on the local spin susceptibility. To track the edge state we equally compute the temperature dependence of the local spectral function.

TT 13.53 Mon 15:00 Poster B

Topological Superconductivity in the Kitaev-Heisenberg model and the effect of impurities — •Lukas Kimme, Timo Hyart, and Bernd Rosenow — Institut für Theoretische Physik, Universität Leipzig, D-04103, Leipzig, Germany

The Kitaev-Heisenberg (KH) model describes the transition between a spin liquid and an antiferromagnet, and it is expected to be realised in iridates on the honeycomb lattice [1]. Viewing the Kitaev spin model as a Mott insulator at half filling, we investigate the competing interactions away from that limit by applying a slave boson theory. Contrary to the Heisenberg interaction the Kitaev interaction prefers topologically interesting p-wave superconductivity, which in the doped regime is robust against a comparatively strong Heisenberg coupling [2]. In the context of d-wave superconductors, understanding the effect of an isolated impurituy has contributed valuable insights into the nature of the superconducting state. In addition to scattering quasi-particles, an impurity is expected to lead to a local disruption of the strongly correlated ground state, which breaks triplet correlations in the KH model. As this effect cannot be captured in a T-matrix approach for quasi-particles, we perform a fully self-consistent numerical study of the local density of states in the vicinity of an impurity, including the modification of local superconducting order by the impurity.
[1] G. Jackeli and G. Khaliullin, Phys. Rev. Lett. 102, 017205 (2009).
[2] T. Hyart, A.R. Wright, G. Khaliullin and B. Rosenow, preprint arXiv:1109.6681 (2011).

TT 13.54 Mon 15:00 Poster B

Weyl superconductors — •Tobias Meng[1] and Leon Balents[2] — [1]Institut für Theoretische Physik, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany — [2]Kavli Institute for Theoretical Physics, University of California, Santa Barbara, CA, 93106-4030, U.S.A.

We study the physics of the superconducting variant of Weyl semimetals, which may for instance be realized in multilayer structures comprising topological insulators and superconductors. We show how superconductivity splits each Weyl node into two. The resulting Bogoliubov Weyl nodes can be pairwise independently controlled, allowing to access a set of phases characterized by different numbers of bulk Bogoliubov Weyl nodes and chiral Majorana surface modes. We analyze the physics of vortices in such systems, which trap zero energy Majorana modes only under certain conditions. We finally comment on possible experimental probes, thereby also exploiting the similarities between Weyl superconductors and 2-dimensional $p + ip$ superconductors.