TT 103: Transport: Poster Session

Time: Thursday 15:00–18:00 Location: Poster B

TT 103.1 Thu 15:00 Poster B

Currents in a chain of quantum dots — •Klaus Morawetz — Münster University of Applied Sciences,Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics (IIP)Av. Odilon Gomes de Lima 1722, 59078-400 Natal, Brazil — Max-Planck-Institute for the Physics of Complex Systems, 01187 Dresden, Germany

Using the quantum kinetic equation analytical expressions for the currents in chains of quantum dots are derived. During the transient behaviour non-dissipative quantum correlations lead to a decay of the initial correlations. After this short time behaviour the total current for homogeneous electric fields is ballistic. For wavelength-modulated electric fields, effective capacitance, inductance and Ohmic resistance can be produced.

TT 103.2 Thu 15:00 Poster B

Phonon-induced spintronics and spin cooling in quantum dots — •Stephan Weiss[1], Jochen Brueggemann[2], Peter Nalbach[2], and Michael Thorwart[2] — [1]Theoretische Physik, Universität Duisburg-Essen and CENIDE, 47048 Duisburg, Germany — [2]I. Institut für Theoretische Physik, Universität Hamburg, Jungiusstraße 9, 20355 Hamburg

In the presence of spin dependent tunnel couplings, vibrations in quantum dots or single molecule transistors induce exchange fields which give rise to spin-accumulation and -precession for confined electrons. The effective exchange field is calculated to lowest order in the dot-lead coupling for a nonequilibrium transport setup. For realistic parameters, an effective spin-phonon coupling driven by many-body interactions, either electron-phonon or Coulomb-like, emerges [1]. We investigate the precession- and accumulation-effects of the confined spins as function of bias- and gate-voltages. In addition, we investigate the cooling of a vibrational mode of a magnetic quantum dot by a spin-polarized tunneling charge current, exploiting the interaction between the magnetization and the vibration[2]. We determine parameter regimes for the *cooling* of the vibration below the lead temperature.

[1] S. Weiss, J. Brueggemann, and M. Thorwart, (submitted).
[2] J. Brueggemann, S. Weiss, P. Nalbach, and M. Thorwart, Phys. Rev. Lett. **113**, 076602 (2014).

TT 103.3 Thu 15:00 Poster B

Lab::Measurement — Measurement control and automation with Perl — Christian Butschkow, Alexei Iankilevitch, Alois Dirnaichner, Stefan Geissler, and •Andreas K. Hüttel — Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, 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 instruments connected by as various means as GPIB, USB, serial cable, Oxford Instruments IsoBus, or Ethernet. Internally, backends as e.g. Linux-GPIB or National Instruments' NI-VISA library are used as well as direct operating system calls. Dedicated instrument driver classes relieve the user from taking care of internal details. An additional layer, Lab::XPRESS, enables fast and flexible creation of nested measurement loops, where e.g. several input variables are varied and one or several output parameters are read for each setting. Metadata and device parameters are automatically protocolled. *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 103.4 Thu 15:00 Poster B

Monitoring quantum transport: Backaction and measurement correlations — •Robert Hussein, Jorge Gómez-García, and Sigmund Kohler — Instituto de Ciencia de Materiales de Madrid, CSIC, Cantoblanco, 28049 Madrid, Spain

We investigate a tunnel contact that is capacitively coupled to a double quantum dot and employed as charge monitor for the latter. We consider both the quantum regime and the classical limit characterized by the absence of quantum coherence. In the classical case, we derive measurement correlations from conditional probabilities, which yields quantitative statements about the parameter regime in which the detection scheme works well. Moreover, we demonstrate that not only the occupations of the double quantum dot may exhibit strong correlations with the detector current but also the corresponding current. The quantum mechanical solution shows that the backaction of the measurement tends to localize the electrons on the double quantum dot and, thus, significantly reduces the corresponding current. Furthermore, it provides the effective parameters of the classical treatment. It turns out that already the classical description is adequate for most operating regimes.

[1] R. Hussein, J. Gómez-García, and S. Kohler, Phys. Rev. B 90, 155424 (2014).

TT 103.5 Thu 15:00 Poster B

Long-range transfer of spin qubits — •Rafael Sánchez[1], Ghislain Granger[2], Louis Gaudreau[2], Fernando Gallego-Marcos[1], Michel Pioro-Ladrière[3], Sergei A. Studenikin[2], Andrew S. Sachrajda[2], and Gloria Platero[1] — [1]Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC), Spain — [2]NRC, Ottawa, Canada — [3]Université de Sherbrooke, Canada

Quantum mechanics allows for superpositions of indirectly coupled states even if the intermediate states are far in energy. In transport, this enables long-range charge transfer through quantum dot chains [1,2]. We present the first evidence of long-range transfer of a spin qubit in a triple quantum dot [3]. This process is detected via a very narrow resonance in the current through the system at the degeneracy point of three-electron charge configurations (2,0,1) and (1,0,2). There, an electron is delocalized between the two dots without ever occupying the center dot. Of the two electrons forming a spin singlet in one dot, only the one with a spin opposite to that of the electron in the other edge dot will be allowed to tunnel. The emptiness of the centre dot warranties the conservation of the spin of the tunneling electron. Thus, the long-range electron tunneling between edges enables the long-range transfer of an arbitrary spin state (the qubit) in the opposite direction.

[1] M. Busl et al., Nature Nanotech. 8, 261 (2013).
[2] R. Sánchez et al., Phys. Rev. B 89, 161402(R) (2014).
[3] R. Sánchez et al., Phys. Rev. Lett. 112, 176803 (2014)

TT 103.6 Thu 15:00 Poster B

Conductance hysteresis during forming and breaking of single-atom contacts on Pb(111) — •Martin Müller[1], Nicolas Néel[1], Carlos Salgado[2], Juan Jose Palacios[2], and Jörg Kröger[1] — [1]Institut für Physik, TU Ilmenau, D-98693 Ilmenau — [2]Departamento de Física de la Materia Condensada, Universidad Autónoma de Madrid, Cantoblanco, 28049 Madrid, Spain

Single-atom junctions were fabricated from Pb-coated W tips of a scanning tunneling microscope and a Pb(111) surface. Conductance traces were simultaneously recorded with tip approach up to contact and retraction. A pronounced hysteresis was observed between the abrupt formation of the contact and its gradual breaking. The hysteresis width and the conductance in contact depend on the tip geometry and contact position. Supporting ab initio calculations reproduce contact conductances and hysteresis widths and highlight the importance of the junction geometry. Financial support by the Carl Zeiss foundation is acknowledged.

TT 103.7 Thu 15:00 Poster B

Charge and Energy Transport through Quantum Dots — •Christian Schiegg, Michael Dzierzawa, and Ulrich Eckern — Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

We consider a model of interacting spinless fermions coupled to non-interacting leads. Initially a non-equilibrium situation is imposed by applying a bias voltage and temperature gradient across the system. The time-evolution of the density matrix leads to a quasi-stationary state from which charge and energy currents can be extracted. Numerical results based on the time-dependent Hartree-Fock approximation are compared with exact currents obtained from discrete Hubbard-Stratonovich decoupling of the interaction for small systems. For a wide range of parameters the time-evolution of the currents is reasonably well described within the Hartree-Fock approach.

TT 103.8 Thu 15:00 Poster B

Scattering of two-dimensional Dirac fermions on gate-defined oscillating quantum dots — •Christian Schulz, Rafael L. Heinisch, and Holger Fehske — Universität Greifswald, Greifswald, Deutschland

Within an effective Dirac-Weyl theory we solve the scattering problem for massless chiral fermions impinging on a cylindrical time-dependent potential barrier. The set-up we consider can be used to model the electron propagation in a monolayer of graphene with harmonically driven quantum dots. For static small-sized quantum dots scattering resonances enable particle confinement and interference effects may switch forward scattering on and off. In addition to these phenomena, an oscillating quantum dot may cause the excitation of partial waves belonging to high energy states. This essentially modifies the resonance structures. For example, the scattering efficiency of an around the Dirac energy symmetric oscillating dot remains finite in the limit of low particle energies and small potential amplitudes. For an asymmetric oscillating dot, the partial wave resonances at higher energies are smeared out for small frequencies or large oscillation amplitudes, thereby dissolving the dot-bound states.

TT 103.9 Thu 15:00 Poster B

DC transport measurements of aluminium-oxide nanowire arrays — •Marco Pfirrmann[1], Sebastian T. Skacel[1], Jan N. Voss[1], Julian Münzberg[1], Martin Weides[1,2], Hannes Rotzinger[1], Hans E. Mooij[1,3], and Alexey V. Ustinov[1,4] — [1]Physikalisches Institut, Kalsruhe Institut of Technology, Wolgang-Gaede-Straße 1, D-76131 Karlsruhe, Germany — [2]Institute of Physics, Johannes Gutenberg University Mainz, Staudinger Weg 7 D-55128 Mainz, Germany — [3]Kavli Institute of Nanoscience, Delft University of Technology, 2628 CJ Delft, The Netherlands — [4]Russian Quantum Center, 100 Novaya St., Skolkovo, Moscow region, 143025, Russia

We experimentally investigate superconducting aluminium-oxide nanowires with a focus on coherent quantum phase slips. In duality to the Josephson effect where two superconductors are weakly coupled through the tunneling of Cooper pairs, the tunneling of the phase across a nanowire leads to the quantum phase slip effect. We are interested in the DC transport properties of arrays of aluminium-oxide nanowires, where we expect to see spurs of quantum vortex dynamics in the I-V characteristics in dependence on the applied magnetic field. The high-resistive aluminium-oxide thin films are deposited by precise control of a reactive Al sputter plasma in oxygen atmosphere. Electron-beam lithography and reactive ion etching is used to define the nanowires. We present fabrication details and first measurement results of the parallel arrays of nanowires at mK temperatures.

TT 103.10 Thu 15:00 Poster B

Light-induced changes of the electronic transport of atomic-sized contacts — •Matthias Bädicker, Daniel Benner, Golaleh Ghafoori, Johannes Boneberg, and Elke Scheer — Universität Konstanz, Germany

We investigate the influence of laser light onto the electrical transport of atomic sized Au contacts realized by the mechanically controllable break junction (MCBJ) technique. Experiments on MCBJs showed light-induced conductance changes, which have been interpreted as photo-assisted transport due to the excitation of high-energetic quasiparticles and collective effects such as surface plasmon excitation. Also optical near field enhancement caused by antenna effects as well as thermal expansion and thermo power may contribute to the signal [1-4]. The influence of surface plasmons is of particular interest for this work, because they provide a way to bring light to the contact without illuminating it directly. To excite and detect surface plasmons we fabricated grating couplers at either side of the constriction. Optical measurements carried out simultaneously with the transport measurements confirm the excitation and transmission of surface plasmons through the constriction [5,6]. In this work we concentrate on time-resolved transport experiments to distinguish between heating effects [7] and influences due to the electric field modulation of the plasmons.

[1] J.K. Viljas et al., PRB 75, 075406(2007).
[2] D. Guhr et al., PRL 99, 086801 (2007).
[3] N. Ittah et al., Nano Lett. 11, 2 (2011).
[4] Nano Lett. 9, 4 (2009).
[5] D. Benner et al., New J. Phys. 15 113014.
[6] Nano Lett., 14(9) (2014).
[7] A. Ganser et al., APL 105, 191119 (2014).

TT 103.11 Thu 15:00 Poster B

Probing Molecular Transport by Multiple Andreev Reflections — •David Weber and Elke Scheer — Universität Konstanz, Konstanz, Germany

The properties of molecular transport can be analyzed by measuring the conductance G or its derivatives, giving first insights to molecular levels and coupling to the electrodes [1]. Yet, the information of the intrinsic composition of conduction channels in a molecular contact is very limited. A Pt-H_2-Pt junction with a conductance of 1 G_0 was shown to accommodate indeed a single perfectly transmitted channel by measurements of the shot noise [2]. For Au-1,4-Benzenedithiol-Au junctions it has been proposed that despite of an enormous variability of G from 0.001 G_0 to almost 1 G_0, the transport would be maintained by a single channel [3]. We test this proposition by coupling the junction to superconducting leads and analyzing the non-linear current-voltage characteristics [4]. We present first results obtained with a low temperature Mechanically Controlled Break Junction setup.

[1] L. Zotti et al., Small **6**, 1529-1535 (2010)
[2] R. H. M. Smit et al., Nature **419**, 906-909 (2002)
[3] Y. Kim et al., Nano Lett. **11**, 3734-3738 (2011)
[4] J. C. Cuevas et al., Phys. Rev. B **54**, 7366-7379 (1996)

TT 103.12 Thu 15:00 Poster B

Transport Calculations for Si_4 Clusters with Gold single Atom Contacts — •Jeffrey Kelling[1], Jochen Kerbusch[1,2], Artur Erbe[1], Rainer Dietsche[3], Gerd Ganteför[3], Elke Scheer[3], Peter Zahn[1], and Sibylle Gemming[1,4] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Center for Advancing Electronics Dresden (CFAED), Technische Universität Dresden, Dresden, Germany — [3]Physics Department, University of Konstanz, Konstanz, Germany — [4]Institute of Physics, TU Chemnitz, Chemnitz, Germany

We present results for electronic transport through Si_4 clusters contacted by single-atom gold contacts attached to <111> fcc-gold leads. The calculations were performed using density functional theory and the non-equilibrium Green's function approach for transport. The simulation setup mimics contacts in mechanically controllable break-junction experiments, which provide data for comparison.

TT 103.13 Thu 15:00 Poster B

Enhanced thermoelectric figure of merit in polycrystalline carbon nanostructures — •Thomas Lehmann[1,2,3], Dmitry Ryndyk[1,2,3], and Gianaurelio Cuniberti[1,2,3] — [1]Institute for Materials Science and Max Bergmann Center of Biomaterials, TU Dresden, 01062 Dresden, Germany — [2]Dresden Center for Computational Materials Science (DCCMS), TU Dresden, 01062 Dresden, Germany — [3]Center for Advancing Electronics Dresden, TU Dresden, 01062 Dresden, Germany

Grain boundaries are commonly observed in carbon nanostructures, but their influence on thermal and electronic properties are still not completely understood. Using a combined approach of density functional tight-binding theory and non-equilibrium Green functions we investigate electron and phonon transport in carbon based systems. In this work, quantum transport and thermoelectric properties are summarized for graphene sheets, graphene nanoribbons and carbon nanotubes with a variety of grain boundary types in a large temperature range. Motivated by previous findings that disorder scatters phonons more effectively than electrons, a significant improvement in the thermoelectric performance for polycrystalline systems is expected. While the effect depends on the grain boundary type, we demonstrate that grain boundaries are a viable tool to greatly enhance the thermoelectric figure of merit, paving the way for the design of new thermoelectric materials.

TT 103.14 Thu 15:00 Poster B

Electron transport in Diarylethene Switches: A combined theoretical and experimental approach — •Lokamani Lokamani[1], Torsten Sendler[1], Peter Zahn[1], Sibylle Gemming[1,2], and Artur Erbe[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf e.V., Germany — [2]SKALMOD, Institute of Physics, TU-Chemnitz, Germany

Diarylethene, a class of photosensitive molecules which exhibit photochoromism, can be switched optically between open- and closed-ring isomers. The open-ring isomer is non-planar with the pi-system localized on two aryl groups. On the other hand, the closed-ring iso-

mer is highly planar with the pi-conjugated-system extending over the whole molecule. In break-junction experiments diarylethene in open and closed-ring isomeric form can be distinguished by a low or high conductance state with a difference in current levels of about an order of magnitude. Moreover, these molecules exhibit stable current-voltage characteristics in both the conductance states.

Here, we study the electronic transport properties of such derivatives at the level of single molecules using density functional theory and non-equilibrium greens function. In particular, we analyse the effect of strongly electrophillic groups on conductance properties of single molecules attached to gold electrodes. A comparison to break junction experimental results is also presented.

TT 103.15 Thu 15:00 Poster B

Switching a Molecular Junction using a Proton Transfer Reaction — •Chriszandro Hofmeister, Pedro B. Coto, and Michael Thoss — Institut für Theoretische Physik und Interdisziplinäres Zentrum für Molekulare Materialien (ICMM), Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstr. 7/B2, D-91058 Erlangen, Germany

The possibility of utilizing single molecules as switches in electronic circuits has motivated intensive experimental and theoretical research on bistable molecular systems [1]. In this contribution, we present a theoretical model for the switching of a molecular junction based on a ground state proton transfer reaction triggered by an external electrostatic field [2,3]. The dynamics of the proton translocation and the electron transport across the junction is described within the framework of quantum master equations. The results show that the proton transfer induces a significant change in the current for low bias voltages. The underlying mechanisms are analyzed in some detail.

[1] S.J. van der Molen *et al.*,
J. Phys.: Condens. Matter 22, 133001 (2010)
[2] A.L. Sobolewski, Phys. Chem. Chem. Phys. 10, 1243 (2008)
[3] C. Hofmeister *et al.*, J. Mol. Model. 20, 1 (2014)

TT 103.16 Thu 15:00 Poster B

Magneto resistance measurements on ultra clean CNT devices with ferromagnetic contacts — •Michael Schafberger, Nicola Paradiso, Michael Görtler, Helmut Körner, Tobias Weindler, Matthias Kronseder, Andreas K. Hüttel, and Christoph Strunk — Institute of Exp. and Appl. Physics, University of Regensburg, Germany

Our goal is the realization of a spin-valve device based on ultra-clean single wall carbon nanotubes (SWNTs). In order to grant defect free and unperturbed SWNTs , chemical vapor deposition (CVD) growth is performed as last nanofabrication step. The achievement of ferromagnetic contacts that can sustain the CVD conditions remains to date elusive. We investigate bilayers of Rhenium and Cobalt (20/40 nm), which form an alloy during the CVD. The Re/Co contacts have been characterized by vibrating sample and SQUID magnetometry in order to demonstrate the persistence of ferromagnetic behavior after CVD. Optimized devices have then been used for transport measurements in the Coulomb blockade regime at 20 mK. The results of magnetoresistance experiments will be discussed together with recently proposed alternative fabrication approaches.

TT 103.17 Thu 15:00 Poster B

Effect of geometrical Langevin forces on magnetic dynamics — •Tim Ludwig[1] and Alexander Shnirman[1,2] — [1]Institut für Theorie der Kondensierten Materie, Karlsruher Institut für Technologie, Karlsruhe, Germany — [2]DFG-Center for Functional Nanostructures (CFN), Karlsruher Institut für Technologie, Karlsruhe, Germany

Stochastic Landau-Lifshitz-Gilbert (LLG) equations with Langevin forces are a standard tool to describe the magnetic dynamics of ferromagnetic single-domain particles. In the classical regime, i.e. for temperatures much higher than the precession frequency, the results of Brown [1] can be used. Recently, it was predicted that, at low temperatures, the Langevin forces are influenced by the geometrical phases [2]. We analyzed the LLG-type Langevin equations with the geometrical Langevin forces for the situation of ferromagnetic resonance. At low temperatures, we found that the stationary distribution of the magnetization is governed by an effective geometric temperature rather than by the bath temperature.

[1] W. F. Brown, Phys. Rev. **130**, 1677 (1963).
[2] A. Shnirman, Y. Gefen, A. Saha, I. S. Burmistrov, M. N. Kiselev, and A. Altland, arXiv:1409.0150v1.

TT 103.18 Thu 15:00 Poster B

Emerging Magnetism in transition metal atomic contacts — •Martin Keller[1], Amin Karimi[1], Florian Strigl[1], Bernat Olivera[2], Carlos Untiedt[2], Elke Scheer[1], and Torsten Pietsch[1] — [1]Department of Physics, University of Konstanz, 78467 Konstanz, Germany — [2]Department of Applied Physics, University of Alicante, 03690 Alicante, Spain

Transition metals which are a strong paramagnet (Pd, Pt) or have only weak magnetic order (Gd) show fascinating magnetic properties in reduced dimensions. For Pd nanowires anisotropic magnetotransport magnetic effects are theoretically predicted [1,2], while, as we show, Gd exhibits large magnetostriction in atomic contacts. These properties can be examined by investigating the magnetoconductance (MC) of controlled atomic-size junctions of these materials. Additional a study of the shot noise of such atomic junctions provides information that cannot be easily obtained by other means, such as the determination of the transmission probability and the number of electronic conductance channels [3]. Here we show a comprehensive experimental study of MC and shot noise of atomic contacts of these metals. We also develop a minimal model for magnetic configuration of the contatcs to account for the complex MC behavior.

[1] Delin et al., Phys. Rev. Lett. 92, 057201 (2004).
[2] Smelova et al., Phys. Rev. B. 77, 033408 (2008).
[3] Brom et al., Phys. Rev. Lett. 82, 1526 (1999).

TT 103.19 Thu 15:00 Poster B

Coherent Dynamics of Quantum Spins in Magnetic Environments — •Lars-Hendrik Frahm, Christoph Hübner, Benjamin Baxevanis und Daniela Pfannkuche — 1. Institut für Theoretische Physik, Universität Hamburg, Hamburg, Germany

We investigate equilibration and transport effects of a quantum spin that is exchange coupled to two electron reservoirs. We include an effective crystal field, which arises from the substrate the spin is living on and gives the spin an easy axis for alignment. First, we determine stationary states using a quantum master equation and compare our results to a semi-classical approach using a rate equation. Second, we consider a spin-polarized electron reservoir that breaks the rotation symmetry around the spin quantization axis. This system requires to consider the complete density operator, where its knowledge allows to calculate magnetization dynamics and transport properties on an equal footing. We discuss the electron transport through the spin system by especially focusing on the non-linear influence of the spin torque effect.

TT 103.20 Thu 15:00 Poster B

Nanomechanics and strain engineering in 2d materials — •Alexander Croy[1], Daniel Midtvedt[1], and Caio H. Lewenkopf[2] — [1]Max-Planck-Institute for the Physics of Complex Systems, Dresden, Germany — [2]Universidade Federal Fluminense, Niterói, Brazil

We investigate the electromechanical coupling in two-dimensional materials. To this end we put forward a systematic approach to relate the macroscopic strain tensor to microscopic atomic displacements. This strain-displacement relation depends non-trivially on the lattice structure and the parameters of the force field model. Implications for nanomechanical properties and electromechanical coupling in two-dimensional materials are discussed. Using graphene as a study case, we combine a tight binding and a valence force-field model to calculate the electronic (DOS, band energy) and mechanical properties (elastic modulus, Poisson ratio) of graphene nanoribbons under strain. We then compare those calculations with results obtained from the Dirac equation coupled to continuum mechanics. In this long wave-limit effective theory we find a renormalization correction to the strain-induced pseudo-magnetic fields which is connected to the strain-displacement relation.

TT 103.21 Thu 15:00 Poster B

Emulation of the Fermi-Hubbard Model in One Dimension — •Jan-Michael Reiner, Michael Marthaler, and Gerd Schön — Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

For every qubit system which allows for σ_z and σ_x coupling between the qubits, it is possible to realize a Hamiltonian which is similar to the Fermi-Hubbard model in 1D. This way one can design a quantum emulator for this model.

We discuss a specific implementation of such an emulator for superconducting qubits. We consider tunable Transmon qubits, where the

σ_z coupling is realized via inductive coupling and the σ_x coupling is realized via capacitive coupling. We then discuss the possible errors through disorder and how confidence in the emulation results can be established through measurements of local operators.

TT 103.22 Thu 15:00 Poster B

Towards a room temperature 2D quantum platform on diamond — •Nathan Chejanovsky[1,2] and Jörg Wrachtrup[1,2] — [1]3rd Physics Institute and Research Center SCoPE, University of Stuttgart, 70569 Stuttgart, Germany — [2]Max Planck Institute for Solid State Research, 70174 Stuttgart, Germany

The nitrogen vacancy (NV) in diamond has been on the fore front of research for room temperature quantum computation applications. Polarization of nuclear spins using the NV center electron spin as a quantum bus for read/write has been demonstrated [1]. For material residing on top of the diamond lattice, a suitable platform is needed for nuclei spin polarization. It has been proposed that graphene, covalently bonded to other non-zero spin nuclei, could be a starting point for this platform [2]. However, graphene alone contains a zero band gap which quenches the NV- state, rendering it useless for optical read out.

We propose here a different approach using 2D hexagonal boron-nitride (h-BN) monolayer instead. These monolayers have shown a band gap from 4.6 to 7.0 eV [3]. In addition, all atoms composing the monolayer already have none zero spin: Boron*s isotope natural abundance is 80.1% spin 3/2 and 19.9% spin 3, for Nitrogen the abundance is 99.6% spin 1 and 0.4% spin 1/2. These properties make h-BN an excellent choice for a starting 'playground' platform for NV controlled quantum applications.

[1] Taminiau, T. H. et al. Nature Nanotechnology 9, 171-176 (2014)
[2] Cai, J. et al. Nature Physics 9, 168-173 (2013)
[3] Nagashima, A. et al. Physical Review B 51, 4606-4613 (1995).

TT 103.23 Thu 15:00 Poster B

Decoherence in Two-Level Systems — •Sebastian Zanker[1], Jürgen Lisenfeld[2], Michael Marthaler[1], Gerd Schön[1], Alexey Ustinov[2], and Georg Weiss[2] — [1]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, D-76131 Karlsruhe, Germany — [2]Physikalisches Institut, Karlsruhe Institute of Technology , D-76131 Karlsruhe, Germany

We study decoherence of two level systems (TLS) living inside the amorphous AlOx layer of a phase qubit's Josephson junction. We discuss TLS coupling to phonons, tunneling quasiparticles and other TLS as possible sources of decoherence and compare theoretical decoherence behavior with experimental data. The experiment suggests strong improvements in dephasing times using spin echo protocol as compared to Ramsey dephasing, $\Gamma_{\mathrm{Ramsey}}/\Gamma_{\mathrm{echo}} \sim 3-55$ which indicates a divergent noise spectral density at low frequencies best matched by either other TLS or quasiparticles.

TT 103.24 Thu 15:00 Poster B

Nonequilibrium spin noise and noise of susceptibility — •Pablo Schad[1], Boris N. Narozhny[1,2], Gerd Schön[3,4], and Alexander Shnirman[1] — [1]Institut für Theorie der Kondensierten Materie, Karlsruhe Institute of Technology, D-76131 Karlsruhe, Germany — [2]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe shosse 31, 115409 Moscow, Russia — [3]Institut für Theoretische Festkörperphysik, Karlsruhe Institute of Technology, D-76131 Karlsruhe, Germany — [4]Institut für Nanotechnologie, Karlsruhe Institute of Technology, D-76021 Karlsruhe, Germany

We analyze out-of-equilibrium fluctuations in a driven spin system and relate them to the noise of spin susceptibility. In the spirit of the linear response theory we further relate the noise of susceptibility to a 4-spin correlation function in equilibrium. We show that, in contrast to the second noise (noise of noise), the noise of susceptibility is a direct measure of non-Gaussian fluctuations in the system. We develop a general framework for calculating the noise of susceptibility using the Majorana representation of spin-1/2 operators. We illustrate our approach by a simple example of noninteracting spins coupled to a dissipative (Ohmic) bath.

[1] P. Schad, B. N. Narozhny, G. Schön, and A. Shnirman, Phys. Rev. B 90, 205419 (2014).

TT 103.25 Thu 15:00 Poster B

Influence of strong noise on coupled qubit systems — •Philipp Rudo, Michael Marthaler, and Gerd Schön — Institut für Theoretische Festkörperphysik, KIT, Karlsruhe

We investigate the influence of the environment on systems with coupled qubits. For this we assume that the coupling between the qubits as well as the coupling of the qubit to its environment is strong. In our model we are especially interested in the choice of basis when the qubit undergo an adiabatic evolution while the noise is static. To do so we introduced an rotation angle connecting the different bases of the adiabatic evolution and investigate its behavior over time.

TT 103.26 Thu 15:00 Poster B

Transmon qubits coupled to lumped element LC-readout-resonators — •Joel Cramer[1], Peter Fehlner[1], Jochen Braumüller[1], Steffen Schlör[1], Lucas Radtke[1], Hannes Rotzinger[1], Martin Weides[2,1], and Alexey V. Ustinov[3,1] — [1]Physikalisches Institut, KIT, Wolfgang-Gaede-Straße 1, 76131 Karlsruhe, Germany — [2]Institut für Physik, JGU, Staudingerweg 7, 55128 Mainz, Germany — [3]Russian Quantum Center, 100 Novaya St., Skolkovo, Moscow, 143025, Russia

Superconducting qubits are among the most promising approaches for unit cells of a quantum computer or simulator. In this work, we investigated capacitively shunted Cooper pair boxes, so-called transmon qubits, each of them coupled to a superconducting readout resonator. Significant detuning of resonator and qubit enables non-demolition readout of the qubit state. Transmon qubits offer simple design and, in principle, large coherence time. In this work quasi-lumped element LC-resonators have been employed,which allow a compact qubit-resonator design of about $400 \times 600\,\mu\mathrm{m}^2$. In total one chip contains 12 qubit-resonator pairs, each linked to its own fast-flux bias line. To implement and test these circuits, we have chosen simple optical lithography of aluminum films deposited on sapphire substrates. This approach results in relatively large junction sizes and reduced lifetimes due to large number of parasitic two-levels states within the tunnel barrier. Time domain measurements of the fabricated system revealed T1 lifetime of about $0.5\,\mu$s, long enough to explore quantum phenomena like multi-level dressing.

TT 103.27 Thu 15:00 Poster B

Tunable Nb resonators for resonant coupling with ultracold atomic gases — •Benedikt Ferdinand, Daniel Bothner, Dominik Wiedmaier, Dieter Koelle, and Reinhold Kleiner — Physikalisches Institut and Center for Collective Quantum Phenomena in LISA$^+$, Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

We intend to investigate a hybrid quantum system where ultracold atomic gases play the role of a long-living quantum memory, coupled to a superconducting qubit via a transmission line resonator. As a first step towards this goal we develop a tunable superconducting resonator-chip containing a Z-shaped trapping wire for the atoms. Schemes for trapping the atoms in close vicinity of the resonator gap for maximum coupling are presented. We forthermore show how one can retain the full microwave performance despite these additional wire structures. For resonant coupling it is beneficial to have a tunable resonator which is insensitive to applied magnetic fields. Therefore we add a ferroelectric tunable capacitance with small dimensions compared to the resonator length. Experimental results of the controlled tunability are shown.

TT 103.28 Thu 15:00 Poster B

Circuit QED with 3D cavities — •Edwar Xie[1,2,3], Gustav Anderson[1,2], Lujun Wang[1,2], Alexander Baust[1,2,3], Peter Eder[1,2], Michael Fischer[1,2], Jan Goetz[1,2], Max Haeberlein[1,2], Manuel Schwarz[1,2], Karl Friedrich Wulschner[1,2], Ling Zhong[1,2,3], Frank Deppe[1,2], Kirill Fedorov[1,2], Hans Hübl[1,2], Achim Marx[1], Edwin Menzel[1,2], and Rudolf Gross[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, TU München, 85748 Garching, Germany — [3]Nanosystems Initiative Munich (NIM), 80799 München, Germany

In typical circuit QED systems on-chip superconducting qubits are coupled to integrated coplanar microwave resonators. Due to the planar geometry, the resonators are often a limiting factor regarding the total coherence of the system. Alternatively, similar hybrid systems can be realized using 3D microwave cavities.

Here, we present design considerations for the 3D microwave cavity as well as the superconducting transmon qubit. Moreover, we show

experimental data of a high purity aluminum cavity demonstrating quality factors above 1.4 $\cdot 10^6$ at the single photon level and a temperature of 50 mK. Our experiments also demonstrate that the quality factor is less dependent on the power compared to planar resonator geometries. Furthermore, we present strategies for tuning both the cavity and the qubit individually.

This work is supported by the DFG via SFB 631 and the EU projects CCQED and PROMISCE.

TT 103.29 Thu 15:00 Poster B

Circuit QED with transmon qubits — •Karl Friedrich Wulschner[1,2,3], Javier Puertas[1,2,3], Alexander Baust[1,2,3], Peter Eder[1,2,3], Michael Fischer[1,2,3], Jan Goetz[1,2,3], Max Haeberlein[1,2,3], Manuel Schwarz[1,2,3], Edwar Xie[1,2,3], Ling Zhong[1,2,3], Frank Deppe[1,2,3], Kirill Fedorov[1,2,3], Hans Hübl[1,3], Achim Marx[1,2,3], Edwin Menzel[1,2,3], Martin Weides[4], and Rudolf Gross[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, TU München, 85748 Garching, Germany — [3]Nanosystems Initiative Munich (NIM), 80799 München, Germany — [4]Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

Superconducting quantum bits are basic building blocks for circuit QED systems. Applications in the fields of quantum computation and quantum simulation require long coherence times. We have fabricated and characterized superconducting transmon qubits which are designed to operate at a high ratio of Josephson energy and charging energy. Due to their low sensitivity to charge noise transmon qubits show good coherence properties. We couple transmon qubits to coplanar waveguide resonators and coplanar slotline resonators and characterize the devices at mK-temperatures. From the experimental data we derive the qubit-resonator coupling strength, the qubit relaxation time and calibrate the photon number in the resonator via Stark shifts.

This work is supported by the DFG via SFB 631 and the EU projects CCQED and PROMISCE.

TT 103.30 Thu 15:00 Poster B

Implementation of a time domain measurement setup for circuit QED experiments — •Miriam Müting[1,2], Jan Goetz[1,2], Alexander Baust[1,2,3], Peter Eder[1,2], Michael Fischer[1,2], Max Haeberlein[1,2], Manuel Schwarz[1,2], Karl Friedrich Wulschner[1,2], Ling Zhong[1,2,3], Frank Deppe[1,2], Kirill Fedorov[1,2], Hans Hübl[1,2], Achim Marx[1], Edwin Menzel[1,2], and Rudolf Gross[1,2,3] — [1]Walther-Meißner-Institut, Bayerische Akademie der Wissenschaften, 85748 Garching, Germany — [2]Physik-Department, TU München, 85748 Garching, Germany — [3]Nanosystems Initiative Munich (NIM), 80799 München, Germany

For many experiments and applications of circuit QED systems the time evolution of the quantum system plays an important role. Therefore, studies of the quantum dynamics in the time domain are essential. Here, we present a time domain excitation and readout scheme, which allows us to investigate the quantum behavior of coupled qubit-resonator systems. We apply this scheme to perform Rabi and echo measurements to fully characterize our systems. Additionally, we investigate the decoherence properties at various operation points definded by the applied magnetic flux. Our readout scheme is promising for future simulation experiments of relativistic quantum systems.

This work is supported by the DFG via SFB 631 and the EU projects CCQED and PROMISCE.

TT 103.31 Thu 15:00 Poster B

The two classes of low energy spectra in finite carbon nanotubes — •Magdalena Marganska[1], Piotr Chudzinski[1,2], and Milena Grifoni[1] — [1]Institute for Theoretical Physics, Regensburg University, 93 053 Regensburg, Germany — [2]Institute for Theoretical Physics, Leuvenlaan 4, 3584 CE Utrecht, The Netherlands

Electrons in carbon nanotubes (CNTs) possess spin and orbital degrees of freedom. The latter is inherited from the bipartite graphene lattice with two inequivalent Dirac points. The electronic spectra obtained in several transport experiments on CNT quantum dots in parallel magnetic field often show an anticrossing of spectral lines assigned to the opposite Dirac valleys. So far this valley mixing has been attributed to the disorder, with impurity induced scattering with large momentum transfer. We show that this effect can arise also in ultraclean armchair-like CNTs, where it is caused solely by the presence of the boundaries. In zigzag-like CNTs it does not occur due to the angular momentum conservation - there the two valleys indeed correspond to different values of orbital angular momentum. In the armchair-like CNTs the orbital angular momentum in both valleys is zero and the degeneracy between valley states is removed. The magnitude of the level splitting depends in a non-monotonous way on the energy of the levels involved.

TT 103.32 Thu 15:00 Poster B

Effect of Hydrogen on Spin-Transport in Graphene — •Fedor Tkatschenko, Jan Bundesmann, Denis Kochan, Jaroslav Fabian, and Klaus Richter — Institut für Theoretische Physik, Universität of Regensburg, 93053 Regensburg Germany

The impact of hydrogen on the spin lifetime is expected to be huge, as it leads to resonant scattering near the charge neutrality point [1] and to the formation of local magnetic moments in the vicinity of the hydrogen. This situation strongly enhances the spin flip probability of electrons and holes when passing through a graphene sample.

Here we aim to explain the experimental results [2], which seem to contradict the theoretical predictions, by taking into account the formation of hydrogen clusters, which reduce the effect on the spin lifetime compared to isolated hydrogen atoms. We calculate the electronic structure of hydrogenated graphene and perform quantum transport calculations based on a tight-binding model. Adopting the parameters from ab initio calculations, we find that clustering affects both, the formation of the resonant state and the magnetic moments. We show that the exact configuration, such as the sublattice occupation of each cluster is essential, as it decides for example if local magnetic moments are formed and determines the position of the resonant state.

[1] D. Kochan, M. Gmitra and J. Fabian PRL **112**, 116602 (2014)
[2] M. Wojtaszeck, I. J. Vera-Marun, T. Massen and B. J. van Wees PRB **87**, 081402(R) (2013)

TT 103.33 Thu 15:00 Poster B

Dirac Electrons in a Photon Cavity — •Lisa Hesse and Klaus Richter — Institut für Theoretische Physik, Universität Regensburg, 93040 Regensburg, Germany

We consider low energy excitations of monolayer graphene embedded in an optical cavity and exposed to a perpendicular constant magnetic field. The influence of an additional radiation field can yield resonant cyclotron transitions of the Dirac fermions of graphene which can be studied using techniques known from cavity quantum electrodynamics. The coupling of cavity photons with condensed matter has been realized in the context of electron gases[1] and recently also proposed for graphene[2, 3] and therefore opens a new subfield of research in graphene. Based on a realistic tight-binding model, we consider the interaction of cavity photon modes with Landau quantized states in graphene and study the spectral properties of this hybrid system.

[1] G. Scalari, C. Maissen, D. Turčinková, D. Hagenmüller, S. De Liberato, C. Ciuti, C. Reichl, D. Schuh, W. Wegscheider, M. Beck, and J. Faist, Science 335, 1323 (2012).
[2] D. Hagenmüller and C. Ciuti, Phys. Rev. Lett. 109, 267403 (2012).
[3] L. Chirolli, M. Polini, V. Giovannetti and A. H. MacDonald, Phys. Rev. Lett. 109, 267404 (2012).

TT 103.34 Thu 15:00 Poster B

Charge transport through structurally well-defined graphene nanoribbons — •Nils Richter[1], Akimitsu Narita[2], Andrea Candini[3], Xinliang Feng[4], Klaus Müllen[2], and Mathias Kläui[1] — [1]Institut für Physik, Johannes Gutenberg Universität, Mainz, Germany — [2]Max Planck Institute for Polymer Research, Mainz, Germany — [3]Centro S3, Istituto Nanoscienze CNR, Modena, Italy — [4]TU Dresden, Dresden, Germany

Graphene nanoribbons are ultra narrow stripes of graphene, a monolayer material of carbon atoms. Such ribbons are of particular interest because of the new physical phenomena that arise due to their geometrical confinement. Theory predicts a band gap that is dependent on width and edge structure of the ribbons [1]. In chemically synthesized graphene nanoribbons the edge structure is perfect on the atomic level [2]. For the investigation of the charge and spin transport properties we rely on fabricating contacts to the ribbons using the electromigration technique. Nanoribbons that are dispersed in a solvent can then be drop cast on top of these nanojunctions. Besides junctions formed in normal metals we explore graphitic electrodes [3] and ferromagnetic metal electrodes [4]. Using ribbons with different widths and edge geometries, we probe the exciting unconventional properties that have been predicted for these nano-structures [5].

[1] K. Nakada et al. Phys. Rev. B, 54, 24 (1996).
[2] A. Narita et al., Nature Chem. 6, 126 (2014).
[3] A. Candini et al.,
Beilstein Journal of Nanotechnology, submitted (2014).
[4] A. Bieren et al., Phys. Rev. Lett. 110, 067203 (2013).
[5] O. Yazyev, Rep. Prog. Phys. 73, 056501 (2010).

TT 103.35 Thu 15:00 Poster B

Transport measurements in graphite-like C_3B and C_3P — •Philip Brown[1], Timothy King[2], Peter Matthews[2], Dominic Wright[2], and Malte Grosche[1] — [1]Dept. of Physics, 19 J J Thomson Ave, Cambridge CB3 0HE, United Kingdom — [2]Dept. of Chemistry, Lensfield Road, Cambridge CB2 1EW, United Kingdom

Heavily-doped graphitic materials are of both fundamental and practical interest. Pure bulk graphite is a semimetal exhibiting unusual linear magnetoresistance at low temperatures, and the Dirac point in monolayer graphene leads to a plethora of interesting physics. The effects of boron doping have been investigated theoretically in some detail.

$C_{1-x}B_x$ is predicted to dramatically improve upon the already high Li ion storage of graphite, and may also have relevance as a functional material for fusion reactor cladding. The $x = 0.25$ compound C_3B has been synthesised experimentally, and found to possess graphite's hexagonal lattice and an ordered 2D structure. Despite extensive theoretical study, little experimental data is available on the properties of these heavily doped graphitic materials.

We report magnetotransport measurements on bulk samples of C_3B and C_3P, in temperatures down to 2 K and fields up to 9 T. We find both materials are semiconducting. The resistivity exhibits a non-Arrhenius temperature dependence over a wide range. At low temperatures, the dependence of resistivity on field is nearly linear and does not saturate in fields up to 9 T. Our findings are discussed in the context of current theoretical models of these novel materials.

TT 103.36 Thu 15:00 Poster B

Transport measurements on epitaxial $Bi_{1-x}Sb_x$ thin films grown on Si(111) — •Julian Koch, Philipp Kröger, Herbert Pfnür, and Christoph Tegenkamp — Leibniz Universität Hannover, Inst. für Festkörperphysik, Appelstr. 2, 30167 Hannover

The alloy $Bi_{1-x}Sb_x$ is a 3D topological insulator for concentrations between x = 0.04 and 0.22 [1]. Thus it has topologically protected metallic surface states and an insulating bulk at these concentrations, making it interesting for transport measurements. In this study thin films are used to reduce bulk contributions and to provide the possibility of nanostructuring. The films are grown by in-situ co-deposition on Si(111) substrates. The morphology has been controlled by means of low energy electron diffraction. Temperature dependent transport measurements for temperatures from 12 to 300 K were performed for films of different stoichiometry ranging from $x = 0.14 - 0.22$ and thicknesses of 10, 20, 40 and 60 BL. Besides variable range hopping and activated bulk transport, metallic surface transport channels have been identified. At 10 BL the surface transport is strongly suppressed in accordance with measurements on Bi_2Se_3 [2]. Furthermore, magnetotransport measurements up to 4 T were performed in order to determine carrier concentrations, mobilities and scattering times. A 30 BL film with a concentration of x = 0.18 was found to have carrier concentrations of $n = 1 \cdot 10^{13}$ cm^{-2} and $p = 2 \cdot 10^{13}$ cm^{-2} with mobilities of $\mu_n = 2.6 \cdot 10^2$ cm^2(Vs)$^{-1}$ and $\mu_p = 1.9 \cdot 10^2$ cm^2(Vs)$^{-1}$. Compared to Bi(111)-films the spin-orbit scattering rate is reduced by one order of magnitude.

[1] PRB **83**, 201104(R).
[2] PRL **109**, 066803

TT 103.37 Thu 15:00 Poster B

First investigations of the sputter deposited topologically non-trivial ternary Heusler YPdBi — •Robin Klett[1], Jan Krieft[1], Benedikt Ernst[2], Daniel Ebke[2], Claudia Felser[2], and Günter Reiss[1] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany

A large number of ternary Heusler compounds have been recently proposed as three-dimensional topological insulators with tunable physical properties. However, no transport measurements associated with the topological surface states have been observed in these candidates due to the dominating conduction contribution from bulk. In this work, we investigate the physical properties of sputter deposited topologically non-trivial half-Heusler non-centrosymmetric semimetal YPdBi thin films. First measurements indicate fingerprints of Weak Antilocalization effects and a superconducting phase transition at roughly 4K.

TT 103.38 Thu 15:00 Poster B

Pd/PtBi based topological insulators prepared by sputter deposition — •Benedikt Ernst[1], Daniel Ebke[1], Stanislav Chadov[1], Robin Klett[2], Günter Reiss[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Thin Films and Physics of Nanostructures, Bielefeld University, Germany

Heusler compounds have exhibited manifold physical properties in the recent years and attracted a lot of interest in the field of spintronic applications due to their half-metallic properties.

In this work, we have prepared Heusler materials such as LaPdBi, LaPtBi and YPtBi for which a topological insulating behavior was predicted. In a combinatorial approach we used a mixture of Pd and Pt to tune the band gap. Co-deposition by DC- and RF magnetron sputtering was used to prepare corresponding thin films. To realize an epitaxial film growth in the crystallographic $C1_b$ structure on MgO-substrates, a buffer layer was applied and optimized. Initial transport properties will be discussed with regard to the film composition and the crystallographic properties.

TT 103.39 Thu 15:00 Poster B

High quality thin films of $BaBiO_3$ on $SrTiO_3$ grown by pulsed laser deposition — •Michael Zapf[1], Martin Stübinger[1], Gang Li[2], Michael Sing[1], and Ralph Claessen[1] — [1]Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Germany — [2]Institut für Theoretische Physik und Astronomie, Universität Würzburg, Germany

Recently, $BaBiO_3$ (BBO) has been predicted to be a possible candidate for a large gap topological insulator. However, DFT calculations show that the protected surface states are located 2 eV above the Fermi level. To populate these states heavy electron doping is necessary. Conceivable ways to achieve such a doping are, for example, the deposition of alkali metal atoms on thin BBO films or electrostatic doping by applying a gate voltage. As a first step we have been able to fabricate phase-pure BBO on Nb-doped $SrTiO_3$ (STO) by pulsed laser deposition. High energy electron diffraction (RHEED) shows an island-like growth mode after formation of a wetting layer on the STO substrate, which may be due to the large lattice misfit of BBO and STO. A sharp low energy electron diffraction (LEED) pattern and X-ray diffraction evidence the epitaxial growth of crystalline BBO. In angle integrated photoemission experiments the samples reveal the valence band structure of cleaved undoped BBO single crystals. To our knowledge it is the first time that this could be shown on BBO thin films. Further experiments will elucidate the feasibility of doping electrons into these samples.

TT 103.40 Thu 15:00 Poster B

THz magneto-optics and FIR spectroscopy on topological insulators — •Nick Borgwardt[1], Gregor Mussler[2], Malte Langenbach[1], Joachim Hemberger[1], and Markus Grüninger[1] — [1]1 II. Physikalisches Institut, Universität zu Köln, Cologne, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, Germany

Topological insulators are one of the most discussed areas of current research in condensed matter physics. Topological insulators show outstanding electromagnetic properties. One example is the Faraday rotation angle, which in the quantum Hall state is expected to be given by the fine structure constant. We report on optical data in the THz and FIR range measured on thin films of (Bi,Sb)2Te3 grown on high-resistive Si (111) wafers by MBE. For magneto-optical measurements in the THz range, we employ two photomixers placed inside a magneto-cryostat with magnetic fields B of up to 8T. Phase-sensitive detection of circularly polarized light allows for a direct determination of the Faraday rotation angle without any mechanically moving components in the THz path. We studied the transmittance and phase change as a function of temperature and magnetic field for thin films of various thicknesses.

TT 103.41 Thu 15:00 Poster B

XMCD of 3*d* adatoms on Bi_2Te_3 and Bi_2Te_2Se: experiment and *ab-initio* theory — Martin Vondráček[1], Malte Schüler[5], Markus Dunst[7], Cinthia Piamonteze[2], Jonas

Warmuth[4], Matteo Michiardi[3], Lucas Barreto[3], Alexander Ako Khajetoorians[4,6], Jian-Li Mi[3], Bo B. Iversen[3], Philip Hofmann[3], Jens Wiebe[4], Tim Wehling[5], Jan Minár[7,8], Hubert Ebert[7], Roland Wiesendanger[4], and •Jan Honolka[1] — [1]Inst. of Physics ASCR, Prague, CZ — [2]PSI, CH — [3]iNano, Aarhus Univ., DK — [4]INF, Univ. of Hamburg, DE — [5]Inst. of Theo. Physics, Univ. of Bremen, DE — [6]Radboud Univ. Nijmegen, Inst. for Molec. and Mat., NL — [7]LMU München, DE — [8]Univ. of West Bohemia, CZ

The chalcogenide 3D topological insulator Bi_2Te_3 obeys time-reversal symmetry and hosts a linear dispersive, topological surface state around the Gamma point. It is predicted that magnetic adatoms can break time-reversal symmetry, thereby generating an energy gap at the Dirac point of the otherwise topologically protected surface states [1].

Here we summarize experimental XAS and XMCD results of single $3d$ adatoms Ni, Fe, and Cu on Bi_2Te_3 and Bi_2Te_2Se surfaces. While Cu shows a d^{10} electronic configuration, we find a significant resonant Ni $L_{2,3}$ intensity in XAS, however no magnetic dichroism within the detection limit. The results are compared to *ab-initio* theory. Calculated equilibrium positions of adatoms and their host structure show strong relaxation effects. d-shell occupancies and magnetic properties are extracted. Moreover, we present simulated resonant spectral shapes.

[1] Y. L. Chen et al., Science 329, 659 (2010).

TT 103.42 Thu 15:00 Poster B

Transport measurements on selective area grown Te-based topological insulator thin films — •Christian Weyrich[1,2], Melissa Schall[1,2], Jörn Kampmeier[1,2], Martin Lanius[1,2], Gregor Mussler[1,2], Thomas Schäpers[1,2], and Detlev Grützmacher[1,2] — [1]Peter Grünberg Institute (PGI- 9) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Virtual Institute for Topological Insulators (VITI), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany

We present magnetotransport measurements on Bi_2Te_3 and Sb_2Te_3 thin films, grown on prepatterned structures atop silicon-on-insulator substrates by molecular beam epitaxy. The substrates contain Si mesa fabricated from the 70nm thick Si(111) top layer on a 300nm thick SiO_2 buried oxide layer. Therefore, we were able to utilize the difference in surface configuration between the Si(111) and the amorphous SiO_2, since only the hexagonal silicon surface supports growth of the tellurides. Using transport we show that films of comparable or even higher quality can be achieved using this method which furthermore evades the need of any additionally ex-situ patterning of the layers. With this, we pave the road to a simple fabrication method for nanometer sized structures that circumvents common problems of conventional methods like ion etching including hardened remains of photo resist and the like.

TT 103.43 Thu 15:00 Poster B

Individual tuning of the top and bottom surface states on a three dimensional topological insulator — •David Mahler, Jonas Wiedenmann, Cornelius Thienel, Kalle Bendias, Christopher Ames, Christoph Brüne, Hartmut Buhmann, and Laurens W. Mohlenkamp — Experimentelle Physik 3, Institut für Physik und Astronomie, Universität Würzburg

It has been shown, that the semimetal HgTe grown on a CdTe substrate becomes a three dimensional topological insulator due to its inverted band structure and the strain induced band gap of approximately 20 meV [1]. By using a top gate the dominance of the surface states in magneto transport data over a wide density range was observed and has been explained by the Dirac-screening of the surface states [2].

We demonstrate that the introduction of a back gate created by epitaxial growth on an n-doped gallium arsenide substrate allows us to independently change the occupation of the upper and lower surface state. This can be shown by transport measurements at low temperatures and high magnetic fields. Therefore the occupation of the upper and lower surface state can be varied by the applied top and back gate voltages leading to different quantum hall sequences.

[1] C. Brüne et al., Phys. Rev. Lett. 106, 126803 (2011).
[2] C. Brüne et al., PRX to be published.

TT 103.44 Thu 15:00 Poster B

Quantum Anomalous Hall Effect in the presence of Rashba spin-orbit interaction — •Christoph Kleiner, Jan Boettcher, and Ewelina M. Hankiewicz — Universität Würzburg, Faculty for Physics and Astronomy

We study the quantum anomalous Hall (QAH) effect in $Hg_{1-y}Mn_yTe$ quantum wells. Here, the QAH effect occurs due to spin splitting in the presence of an intrinsic magnetisation which originates from the manganese atoms [1]. We use an effective four-band model (BHZ) in the tight-binding approximation to study the development of the spin splitting for the edge states and the bulk states. Increasing linearly the energy gap caused by the spin splitting leads to a non-linear behaviour for the bulk bands of one spin direction. Additionally, we observe, that the remaining edge state is shifted into the bulk bands of the opposite spin direction. Since there is no coupling between these two spin blocks in the BHZ model, there are crossings between these bulk bands and the edge states. Furthermore, we study the behaviour of the remaining edge state in the presence of Rashba spin-orbit interaction originating from an inversion breaking potential in the out of plane direction[2] which couples both spin blocks.

[1] Liu et al. PRL 101, 146802(2008).
[2] Rothe et al. New J. Phys. 12, 065012 (2010).

TT 103.45 Thu 15:00 Poster B

Transport at the edge of a 2D topological insulator — •Eslam Khalaf and Pavel Ostrovsky — Max Planck institute for solid state research, Stuttgart, Germany

We consider transport characteristics of the 2D topological insulator edge states in the presence of disorder. Two general setups are studied: a junction of the two quantum-Hall insulators and a relatively thick HgTe quantum well. In the first setup, an imbalance between the number of left- and right propagating modes (n_L and n_R) may occur at the interface if the filling factor is different on both sides of the junction. In this case, $|n_L - n_R|$ edge modes are topologically protected while all other states get eventually localized by disorder. If an edge of a thick HgTe quantum well carries an odd number of modes, one of them is also topologically protected from localization while others are localized at sufficiently long scales. For both systems, we compute the distribution of transmission probabilities and mesoscopic conductance fluctuations. Technically, this requires solving the one-dimensional non-linear sigma model with a topological term and source terms. The transfer-matrix formalism is employed which maps the problem to the problem of finding the eigenfunctions of Laplace operator on a symmetric superspace. For the quantum-Hall edge, the main effect of topology is the development of a gap in the transmission probability distribution around unit transmission for all length scales. In the case of HgTe quantum well, the probability distribution is also suppressed close to unit transmission but does not exhibit a hard gap.

TT 103.46 Thu 15:00 Poster B

Transport in topological insulator thin films: weak localization and universal conductance fluctuations — •Hristo Velkov[1,2], Georg Schwiete[1], and Tobias Micklitz[3] — [1]Institut für Physik, Johannes Gutenberg Universität Mainz, 55128 Mainz, Germany — [2]Dahlem Center for Complex Quantum Systems and Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany — [3]Centro Brasileiro de Pesquisas Físicas, Rua Xavier Sigaud 150, 22290-180 Rio de Janeiro, Brazil

Motivated by the experimental difficulty to produce topological insulators with pure surface-state conduction, we study the effect that the bulk can have on the transport properties of the system. In particular, we focus on the weak localization (WL) and universal conductance fluctuations (UCF) physics in a topological insulator of the Bi_2Se_3 family, modelled by an effective low-energy Hamiltonian. Utilizing diagrammatic perturbation theory techniques we analyse the bulk and the surface separately and subsequently discuss WL and UCF when a tunneling-based coupling is introduced.

TT 103.47 Thu 15:00 Poster B

Microwave readout of Majorana qubits — •Christoph Ohm and Fabian Hassler — JARA Institute for Quantum Information, RWTH Aachen University, 52056 Aachen, Germany

Majorana qubits offer a promising way to store and manipulate quantum information in a topologically protected way. Being immune to local noise the information is inherently hard to access rendering a measurement of the qubit state a challenging task. Here, we propose a readout scheme for Majorana qubits relying on the basic effect that voltage-biased Josephson junctions hosting Majorana fermions emit and absorb microwave photons at half of the Josephson frequency. Using standard tools from microwave engineering we show that in the dispersive regime our setup allows to perform a quantum non-demolition

measurement and to reach the quantum limit. An appealing feature of our setup is that the interaction of the Majorana qubit with the measurement device can be turned on and off at will by changing the dc bias of the junction.

TT 103.48 Thu 15:00 Poster B

Magnetic order on a topological insulator surface with warping and proximity-induced superconductivity — •Daniel Mendler, Panagiotis Kotetes, and Gerd Schön — Institut für theoretische Festkörperphysik, Karlsruher Institut für Technologie

We determine the nature of the magnetic order on the surface of a topological insulator (TI) which develops due to hexagonal warping and the resulting Fermi surface (FS) nesting. By investigating the spin susceptibility and a microscopically-derived Landau theory, we explore the magnetic phases driven by a repulsive Hubbard interaction. We find that the magnetic ground state is formed by a superposition of three helical spin density waves which preserves C_3 symmetry. For a nearly hexagonal FS the magnetic ground state is topologically nontrivial with a non-zero skyrmionic charge. We show that the magnetic phase and the value of the skyrmionic charge can be controlled using magnetic fields and supercurrents. In addition, we explore the possibility of engineering a topological superconductor (TSC) when the TI is in proximity to a conventional SC and confirm the feasibility of an artificial C_3 symmetric TSC. We propose a technique to indirectly demonstrate the underlying skyrmion structure in the TSC, namely by measuring an induced multipolar distribution of supercurrents.

TT 103.49 Thu 15:00 Poster B

Majorana fermions from Shiba states in an antiferromagnetic chain on top of a superconductor — •Andreas Heimes, Panagiotis Kotetes, and Gerd Schön — Karlsruhe Institute of Technology

We propose a new mechanism for topological superconductivity based on an antiferromagnetically ordered chain of magnetic atoms on the surface of a conventional superconductor [1]. In a weak Zeeman field, a supercurrent in the substrate generates a staggered spin-current, which converts the preexisting topologically-unprotected Shiba states into Majorana fermions (MFs). The two experimental knobs can be finely tuned providing a platform with enhanced functionality for applications. Remarkably, the electronic spin-polarization of the arising edge MF wavefunctions depends solely on the parity of the number of magnetic moments, which can serve as a distinctive signature of the MFs. We introduce the basic concepts within a minimal model and make contact with experiments by a microscopic analysis based on the Shiba states.

[1] A. Heimes, P. Kotetes, and G. Schön,
Phys. Rev. B 90, 060507(R) (2014).

TT 103.50 Thu 15:00 Poster B

Majorana bound state coupled to helical edge states — •Daniel Frombach, Benedikt Probst, and Patrik Recher — Institut für Mathematische Physik, TU Braunschweig, 38106 Braunschweig, Germany

We investigate the coupling of a Majorana bound state (MBS) to helical edge states at the boundary of a two-dimensional topological insulator. We show that the transport properties of the helical edge states directly reflect the spin-direction of the MBS. We further investigate the reduced density matrix of a quantum bit built from four MBS coupled to helical edge states and discuss the influence of the different system parameters.

TT 103.51 Thu 15:00 Poster B

Optical detection of Majorana fermions via a quantum dot — •Luzie Weithofer, Anders Ström, and Patrik Recher — Institute of Mathematical Physics, TU Braunschweig, 38106 Braunschweig, Germany

The search for Majorana bound states (MBS) in condensed matter systems is currently in the center of attention for theorists and experimentalists alike. Shortly after MBS have been predicted to emerge in "Majorana nanowires" [1,2], several experiments have indeed reported potential signatures of MBS. While these experiments concentrate on conductance measurements, here, we discuss the novel possibility of detecting MBS optically via their coupling to a quantum dot with a sufficiently strong dipole moment.

[1] Y. Oreg *et al.*, PRL **105**, 177002 (2010).
[2] J.D. Sau *et al.*, PRL **104**, 040502 (2010).

TT 103.52 Thu 15:00 Poster B

Correlations of weak measurements in a non-Markovian detection scheme — •Johannes Buelte[1], Adam Bednorz[2], and Wolfgang Belzig[1] — [1]Fachbereich Physik, Universität Konstanz, D-78457, Germany — [2]Faculty of Physics, University of Warsaw, Hoza 69, PL-00681 Warsaw, Poland

Generalized quantum measurement schemes are described by positive operator-valued measures going beyond the projection postulate, which predicts the instantaneous collapse of the systems wave function. This allows to take the noninvasive limit and investigate the correlations of such weak measurements. We propose a scheme in which the detector is coupled to the measured system for a finite time, as it is the case in many real setups. This leads to non-Markovian effects, in accordance to the previous conjectures [1]. For the measured correlations this scheme predicts memory functions, which are related to symmetric and antisymmetric correlators of the detector variables. We investigate the memory functions under different general assumptions: (a) equilibrium detectors, (b) relation to the linear response Kubo formalism, (c) the role of non-equilibrium detectors and how they could realize the standard Markovian measurement. The latter scheme leads to the symmetrized operator order (aka Keldysh ordering), which is widely used in quantum measurement discussions.

[1] A. Bednorz , C. Bruder, B. Reulet, and W. Belzig,
Phys. Rev. Lett. 110, 250404 (2013)

TT 103.53 Thu 15:00 Poster B

Time-dependent factorial cumulants in quantum dots coupled to ferromagnetic leads — •Philipp Stegmann[1], Björn Sothmann[2], and Jürgen König[1] — [1]Theoretische Physik, Universität Duisburg-Essen and CENIDE, 47048 Duisburg, Germany — [2]Départment de Physique Théorique, Université de Genève, CH-1211 Genève 4, Switzerland

Recently, theoretical studies have shown that factorial cumulants provide a useful tool to probe interaction in electronic transport through nanostructures [1, 2]. Sign changes of factorial cumulants as function of time indicate interaction, whereas in the absence of such sign changes the system can be described by an (effective) noninteracting Hamiltonian. We demonstrate this behavior for a quantum dot and for a mesoscopic Stoner particle [3] weakly tunnel coupled to two ferromagnetic leads.

[1] D. Kambly, C. Flindt, and M. Büttiker,
Phys. Rev. B **83**, 075432 (2011).
[2] D. Kambly and C. Flindt, J. Comput. Electron. 12, 331 (2013).
[3] B. Sothmann, J. König, and Y. Gefen,
Phys. Rev. Lett. **108**, 166603 (2012).

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Highly resistive states in TiN wires induced by a high-impedance environment — •Ina Schneider[1], Tatyana Baturina[1,2], Klaus Kronfeldner[1], and Christoph Strunk[1] — [1]Institute for Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]A.V. Rzhanov Institute of Semiconductor Physics SB RAS, Russia

We investigate different wires with similar aspect ratios, fabricated from a superconducting TiN thin film, at low temperatures and magnetic fields up to 15 T. The width of the wires varies between 20 nm and 1 μm. For the largest wires, we observe a typical superconducting behavior with a drop to zero resistance at sufficiently low temperatures and zero magnetic field. The medium sized wires show qualitatively similar $I(V)$- and $R(T)$-characteristics as the wide wires. However, their resistance does not drop to zero but saturates at finite values. For the smallest wire, the $R(T)$-characteristics reveal a slight increase of the resistance at zero field already.

By embedding the wires into a high impedance environment, we can induce a highly resistive state for the 80 nm wide wire, that manifests as a flat region in the $I(V)$-characteristics at very low bias voltages. This region starts to establish at magnetic fields where one could still observe a decrease of the resistance in the low-impedance environment measurements. At the peak of the magnetoresistance, this region corresponds to a resistance value which is by three orders of magnitude higher than that in the low-impedance environment.