TT 16: Transport: Quantum Dots, Quantum Wires, Point Contacts

Time: Monday 15:00–17:45 Location: H21

TT 16.1 Mon 15:00 H21

Suppression and break-down of Kondo screening in asymmetric double-quantum-dot systems — •Ammar Nejati, Katinka Ballmann, and Johann Kroha — Physikalisches Institut and Bethe Center for Theoretical Physics, Universität Bonn, Germany

Due to recent advances in semiconductor device technology, it is possible to investigate the Kondo effect in presence of magnetic correlations with fully-controllable double-quantum-dot (qdot) systems. Here we present a renormalization group (RG) method which can describe the different regimes observed in a highly-tunable semiconductor device with 2 qdots coupled to 3 leads ; especially, the principal observation which was the formation of a Kondo state for one qdot along with suppression of the Kondo resonance in the other, in presence of RKKY exchange interaction. The RG method is developed to consider local spin screening in multi-impurity Kondo systems in presence of magnetic fluctuations due to the carrier-mediated RKKY interaction. We calculate the beta-function for the Kondo coupling J between a localized spin (of the impurity/qdot) and conduction electrons in 1-loop order, taking into account that J is modified by the RKKY coupling to the neighbouring impurities/qdots. This leads to a suppression of T_K as a function of the dimensionless RKKY coupling parameter y, and ultimately, break-down of Kondo screening at a maximal RKKY coupling y_{max} which depends on the bare parametres only. In the 2-impurity case, the dependence of the renormalized Kondo temperature of each dot is drastically different if there is an asymmetry in the bare Kondo couplings.

TT 16.2 Mon 15:15 H21

Signatures of nonlocal Cooper pair transport in the critical current of a double dot Josephson junction — •Benedikt Probst[1], Fernando Domínguez[2], Alexander Schroer[1], Alfredo Levy Yeyati[2], and Patrik Recher[1,3] — [1]Institut für Mathematische Physik, Technische Universität Braunschweig, D-38106 Braunschweig, Germany — [2]Departamento de Física Teórica de la Materia Condensada, Condensed Matter Physics Center (IFIMAC), and Instituto Nicolás Cabrera, Universidad Autónoma de Madrid, E-28049 Madrid, Spain — [3]Laboratory for Emerging Nanometrology Braunschweig, D-38106 Braunschweig, Germany

We study the critical Josephson current flowing through a double quantum dot weakly coupled to two superconducting leads. We use analytical as well as numerical methods to investigate this setup in the entire range of its microscopic parameters, where we account for on-site interactions exactly. The characteristic behavior we find does not rely on a tunable magnetic field through the structure. Instead, we identify groundstate transitions as the unifying mechanism which gives rise to the rich phenomenology we observe, and which provide clear indications of nonlocal spin-entangled pairs that are consistent with recent experiments [1].

[1] S. Deacon *et al.*, Nat. Commun. **6**, 7446 (2015)

TT 16.3 Mon 15:30 H21

Current cross-correlations in double quantum dot Cooper pair splitter. — •Kacper Wrześniewski, Piotr Trocha, and Ireneusz Weymann — Faculty of Physics, Adam Mickiewicz University, 61-614 Poznań, Poland

We investigate theoretically transport properties of a quantum dot (QD) system working as a Cooper pair splitter.[1] The device is coupled to one superconducting and two ferromagnetic leads. Presented results are calculated using real-time diagrammatic technique in the sequential tunneling approximation with respect to the coupling to ferromagnetic leads. The transport properties are evaluated within the superconductor subgap regime taking into account Andreev reflection processes solely.[2]

We focus on the analysis of current and current cross-correlations, both in linear and nonlinear responses. Current cross-correlations give additional information about dynamics of transport processes. We identify both positive and negative signs of current cross-correlations and discuss mechanisms leading to those results. Strong negative cross-correlations are found when the occupation number of QD system becomes degenerate and near the emergence of the triplet blockade, while positive ones occur in the most range where current flows due to crossed Andreev processes. Finally, we consider ferromagnetic leads polarization and temperature influences on aforementioned features.

[1] L. Hofstetter, S. Csonka, J. Nygård, and C. Schönenberger, Nature **461**, 960 (2009).
[2] P. Trocha and I. Weymann, PRB **91**, 235424 (2015).

TT 16.4 Mon 15:45 H21

Odd triplet superconductivity in ultrasmall quantum dots — •Stephan Weiss[1], Björn Sothmann[2], and Jürgen König[1] — [1]Theoretische Physik, Universität Duisburg-Essen & CENIDE — [2]Institut für Theoretische Physik und Astrophysik, Universität Würzburg

We report on the possibility to create odd frequency Cooper pairs in proximized interacting quantum dots attached to ferromagnetic leads. Spin blockade effects together with induced superconductivity allow electron pairs with same spin at different times to carry superconducting correlations. Besides the conventional finite singlet pairing amplitude on the dot, only odd frequency triplet pairing is possible here. This is in contrast to the double dot case [1]. We demonstrate how the order parameter for odd-frequency triplet pairing as well as the differential Andreev conductance are influenced when tuning gate and/or bias voltages, the angle of magnetizations of the leads and the coupling to the nearby superconductor.

[1] B. Sothmann, S. Weiss, M. Governale and J. König, PRB **90**, 220501 (2014).

TT 16.5 Mon 16:00 H21

Dynamical Properties of the 0.7-Anomaly in Quantum Point Contacts — •Dennis Schimmel and Jan von Delft — Ludwig-Maximilians-Universitaet Muenchen, Arnold-Sommerfeld-Center for theoretical physics

The 0.7-anomaly in the first conductance step of a quantum point contact is believed to arise from an interplay of geometry, spin dynamics and interaction effects. Previously [Bauer2014] it was shown that a one-dimensional tight-binding model with short-range interactions of intermediate strength reproduces the characteristic phenomenology of the 0.7-anomaly for the linear conductance at zero temperature and in equilibrium. Within these studies static quantities were computed using the functional renormalization group (fRG), formulated in terms of imaginary (Matsubara) frequencies. To gain access to real-frequency properties, we have formulated our fRG-scheme on the Keldysh-contour and used it to calculate dynamical quantities of a QPC, such as the local density of states, dynamical spin correlation functions, and transmission times. We have also used our Keldysh-fRG scheme to study the nonlinear conductance for a small bias voltage and discuss the effects of interactions on non-equilibrium transport.

15 min. break

TT 16.6 Mon 16:30 H21

Gauge freedom in pumping: interaction-induced geometric phases, adiabatic-response, and counting statistics — •Thilo Plücker[1], Maarten Wegewijs[2], and Janine Splettstoesser[3] — [1]Institute for Quantum Information, RWTH Aachen, 52056 Aachen, Germany — [2]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [3]Department of Microtechnology and Nanoscience (MC2), Chalmers University of Technology, SE-41298 Göteborg, Sweden

In open quantum systems, adiabatic transport of various quantities such as charge, spin or energy can be realized by the slow and cyclic variation of two or more system parameters. An interesting example is offered by a quantum dot coupled to electrodes. Modulating in time its prime control parameters - the gate and bias voltage - a pumping current is generated, which is entirely due to the strong onsite Coulomb interaction [1].

In this contribution, we will show how to identify the geometric nature of this interaction-induced pumping of various quantities as a consequence of a generic gauge freedom of observables in open quantum systems using Landsberg's approach [2] to dissipative systems with symmetry. We present a general adiabatic pumping formula that shows that any interacting multilevel quantum dot in the wide-band limit exhibits an interaction-induced geometric phase. Our approach also sheds new light on Sinitsyn's [3] counting statistics approach to

pumping.
[1] F. Reckermann, J. Splettstoesser, and Maarten R. Wegewijs, PRL **104**, 226803 (2010)
[2] A. S. Landsberg, PRL **69**, 865 (1992)
[3] N. A. Sinitsyn, J. Phys. A **42**, 193001 (2009)

TT 16.7 Mon 16:45 H21

Gate-tunable Andreev bound states in InSb Nanowire Josephson junction — •Ning Kang[1], Sen Li[1], Dingxun Fan[1], Philippe Caroff[2], and Hongqi Xu[1] — [1]Key Laboratory for the Physics and Chemistry of Nanodevices, Department of Electronics, Peking University, Beijing 100871, P. R. China. — [2]Division of Solid State Physics, Lund University, P. O. Box 118, S-221 00 Lund, Sweden

Hybrid InSb nanowire-superconductor devices are promising candidates for investigating Majorana modes in solid-state devices and future technologies of topological quantum manipulation. Here, we report low-temperature transport measurements on an individual InSb nanowire quantum dot coupled to superconducting contacts that exhibit an interplay between the Kondo effects and uperconductivity. We observed two types of subgap resonance states within the superconudcting gap, which can be attributed to gate-tunable Andreev bound states in Coulomb valleys with different Kondo temperatures. The presence of the gate-tunable 0 and pijunction allow us to invetigate the fundamental 0- pi transition. Detailed magnetic field and temperature evolution of level spectroscopy demonstrate different behavior of two types of the Andreev bound states. Our results exhibit that the InSb nanowires can provide a promising platform for exploring phase coherence transport and the effect of spin-orbit couping in semiconductor nanowire-superconductor hybird device.

TT 16.8 Mon 17:00 H21

Spin-dependent scattering in a nanowire — •Alba Pascual[1], Vitaly N. Golovach[1,2,3], Dario Bercioux[2,3], Juan José Sáenz[2,3], and Sebastián Bergeret[1,2] — [1]Centro de Física de Materiales (CFM-MPC) Centro Mixto CSIC-UPV/EHU,E-20018 Donostia-San Sebastián, Spain — [2]Donostia International Physics Center (DIPC), E-20018 Donostia-San Sebastián, Spain — [3]IKERBASQUE, Basque Foundation of Science, E-48011 Bilbao, Spain

We study a quasi-one-dimensional quantum wire in the presence of an impurity and spin-orbit interaction. We solve the problem using a perturbative approach in order to obtain an effective Hamiltonian for the scattering problem. We solve that the scattering problem via the Lippmann-Schwinger equation at the leading order in spin-orbit. We focus on the scattering matrix of a spin-dependent transport setup and elucidate what we believe to be a suitable set of experiments aimed at a scattering matrix tomography.

TT 16.9 Mon 17:15 H21

Functional Renormalization Group Approach for Inhomogeneous One-Dimensional Fermi Systems with Finite-Ranged Interactions — •Lukas Weidinger, Florian Bauer, Jan Heyder, and Jan von Delft — LMU München, Arnold Sommerfeld Center for Theoretical Physics

We use the functional renormalization group (fRG) to study transport through quantum point contacts (QPCs) described by a one-dimensional lattice model with either on-site or finite-ranged interactions. In previous work on this model [Bauer2014], the so-called coupled-ladder approximation (CLA) was shown to admit a consistent fRG treatment for the case of a purely onsite interaction. We introduce an extended version of this scheme, called the extended coupled ladder approximation (eCLA), which includes a spatially extended feedback between the individual interaction channels, measured by a feedback length L. We applied a static version of this scheme to our QPC model, finding that for on-site interactions, this scheme converges to the third-order-truncated fRG when L is increased beyond the characteristic length l_x of the QPC. Additionally, it turns out that the enhanced feedback stabilizes the fRG flow. Furthermore, it allows us to also treat a finite-ranged interaction with a range of up to L sites. Studying our QPC model with a screened Coulomb interaction, we find that in certain parameter regimes (in particular interaction range $\gtrsim l_x$), the density shows the onset of crystaline features in the QPC region, accompanied by oscillatory behavior of the conductance as function of gate voltage.

TT 16.10 Mon 17:30 H21

Transport through strongly correlated Hubbard chains — •Junichi Ozaki and Yoshihiro Asai — AIST, Tsukuba, Japan

Strong correlation effect on the electric conductance of a wire at zero bias voltage was discussed a lot in the literatures mostly a decade ago by using the Luttinger model and/or some numerical methods. In some cases, the finite size effect of the single chain is not taken into account very well. Moreover, the effect of the thermalized Landauer*s electrode has not been taken into account quite unfortunately. Here, we put our priorities on these unresolved problems in discussing the strong correlation effect on the charge transport. The electric current in the strong correlation regime under the finite bias voltage is investigated in terms of a finite length single chain Hubbard model connected to non-interacting electrodes. The on-site Coulomb repulsion and the length are the variables. We use the time-dependent density matrix renormalization group (t-DMRG), which describes the many-body electron dynamics accurately. The zero-bias conductance and the current versus voltage (I-V) characteristics are examined at zero temperature. The conductance oscillation as a function of the length accompanies a damping. The non-linear behavior due to the strong correlation effect is found in the I-V curve. In the both cases, inelastic contribution from the Coulomb repulsion is clear in the strong correlation regime.