Journal Club, Christoph Orth, 10.07.2012

Luttinger liquid physics from infinite-system DMRG
C. Karrasch, J. E. Moore
arXiv:1207.0011v1
We study one-dimensional spinless fermions at zero and finite temperature T using the density matrix renormalization group. We consider nearest as well as next-nearest neighbor interactions; the latter render the system inaccessible by a Bethe ansatz treatment. Using an infinite-system alogrithm we demonstrate the emergence of Luttinger liquid physics at low energies for a variety of static correlation functions as well as for thermodynamic properties. The characteristic power law suppression of the momentum distribution n(k) function at T = 0 can be directly observed over several orders of magnitude. At finite temperature, we show that n(k) obeys a scaling relation. The Luttinger liquid parameter and the renormalized Fermi velocity can be extracted from the density response function, the specific heat, and/or the susceptibility without the need to carry out any finite-size analysis. We illustrate that the energy scale below which Luttinger liquid power laws manifest vanishes as the half-filled system is driven into a gapped phase by large interactions.

Pseudospin-Resolved Transport Spectroscopy of the Kondo Effect in a Double Quantum Dot
S. Amasha, A. J. Keller, I. G. Rau, A. Carmi, J. A. Katine, H. Shtrikman, Y. Oreg, D. Goldhaber-Gordon
arXiv:1207.0526v1v1
We report measurements of the Kondo effect in a double quantum dot (DQD), where the orbital states act as pseudospin states whose degeneracy contributes to Kondo screening. Standard transport spectroscopy as a function of the bias voltage on both dots shows a zero-bias peak in conductance, analogous to that observed for spin Kondo in single dots. Breaking the orbital degeneracy splits the Kondo resonance in the tunneling density of states above and below the Fermi energy of the leads, with the resonances having different pseudospin character. Using pseudospin-resolved spectroscopy, we demonstrate the pseudospin character by observing a Kondo peak at only one sign of the bias voltage. We show that even when the pseudospin states have very different tunnel rates to the leads, a Kondo temperature can be consistently defined for the DQD system.

Topological blockade and measurement of topological charge
B. van Heck, M. Burrello, A. Yacoby, A. R. Akhmerov
arXiv:1207.0542v1
The fractionally charged quasiparticles appearing in the 5/2 fractional quantum Hall plateau are predicted to have an extra non-local degree of freedom, known as topological charge. We show how this topological charge can block the tunnelling of these particles, and how such topological blockade can be used to readout their topological charge. We argue that the short time scale required for this measurement is favorable for the detection of the non-Abelian anyonic statistics of the quasiparticles. We also show how topological blockade can be used to measure braiding statistics, and to couple a topological qubit with a conventional one.

Quantum dot admittance probed at microwave frequencies with an on-chip resonator
T. Frey, P. J. Leek, M. Beck, J. Faist, A. Wallraff, K. Ensslin, T. Ihn, M. Büttiker
arXiv:1207.0945v1
We present microwave frequency measurements of the dynamic admittance of a quantum dot tunnel coupled to a two-dimensional electron gas. The measurements are made via a high-quality 6.75 GHz on-chip resonator capacitively coupled to the dot. The resonator frequency is found to shift both down and up close to conductance resonance of the dot corresponding to a change of sign of the reactance of the system from capacitive to inductive. The observations are consistent with a scattering matrix model. The sign of the reactance depends on the detuning of the dot from conductance resonance and on the magnitude of the tunnel rate to the lead with respect to the resonator frequency. Inductive response is observed on a conductance resonance, when tunnel coupling and temperature are sufficiently small compared to the resonator frequency.

Kondo-like behavior near the metal-to-insulator transition of nano-scale granular aluminum
N. Bachar, S. Lerer, S. Hacohen-Gourgy, B. Almog, G. Deutscher
arXiv:1207.0970v1
We show that transport properties of nano-scale granular Aluminum films near the metal to insulator transition are similar to those of Kondo systems. This similarity implies the existence of a spin-flip scattering mechanism related to the small grain size. We propose that a shell electronic structure in at least a fraction of the grains may be at the origin of this mechanism. Degenerate states of this shell structure may also contribute to an elevated superconducting critical temperature.

$\mathbb{Z}_2$ Green's function topology of Majorana wires

Jan Carl Budich, Björn Trauzettel

arXiv:1207.1104v1

We calculate the $\mathbb{Z}_2$ topological invariant characterizing a one dimensional topological superconductor using a Wess-Zumino-Witten dimensional extension. The invariant is formulated in terms of the single particle Green's function which allows to classify interacting systems. Employing a recently proposed generalized Berry curvature method, the topological invariant is represented independent of the extra dimension requiring only the single particle Green's function at zero frequency of the interacting system. Furthermore, a modified twisted boundary conditions approach is used to rigorously formulate the topological invariant for disordered systems.

Zero-bias anomaly in a nanowire quantum dot coupled to superconductors

Eduardo J. H. Lee, Xiaocheng Jiang, Ramon Aguado, Georgios Katsaros, Charles M. Lieber, Silvano de Franceschi

arXiv:1207.1259v1

We studied the low-energy states of spin-1/2 quantum dots defined in InAs/InP nanowires and coupled to aluminium superconducting leads. By varying the superconducting gap, Δ, with a magnetic field, B, we investigated the transition from strong coupling, $\Delta \ll T_K$, to weak coupling, $\Delta \gg T_K$, where T_K is the Kondo temperature. Below the critical field, we observe a persisting zero-bias Kondo resonance that vanishes only for low B or higher temperatures, leaving the room to more robust sub-gap structures at bias voltages between Δ and 2Δ. For strong and approximately symmetric tunnel couplings, a Josephson supercurrent is observed in addition to the Kondo peak. We ascribe the coexistence of a Kondo resonance and a superconducting gap to a significant density of intra-gap quasiparticle states, and the finite-bias sub-gap structures to tunneling through Shiba states. Our results, supported by numerical calculations, own relevance also in relation to tunnelspectroscopy experiments aiming at the observation of Majorana fermions in hybrid nanostructures.

Hedgehog spin texture and Berry's phase tuning in a magnetic topological insulator

Su-Yang Xu, Madhab Neupane, Chang Liu, Duming Zhang, Anthony Richardella, L. Andrew Wray, Nasser Alidoust, Mats Leandersson, Thiagarajan Balasubramanian, Jaime Sánchez-Barriga, Oliver Rader, Gabriel Landolt, Bartosz Slomski, Jan Hugo Dil, Jürg Osterwalder, Tay-Rong Chang, Horng-Tay Jeng, Hsin Lin, Arun Bansil, Nitin Samarth, M. Zahid Hasan

Nature, DOI:10.1038/NPHYS2351

Understanding and control of spin degrees of freedom on the surfaces of topological materials are key to future applications as well as for realizing novel physics such as the axion electrodynamics associated with time-reversal (TR) symmetry breaking on the surface. We experimentally demonstrate magnetically induced spin reorientation phenomena simultaneous with a Dirac-metal to gapped-insulator transition on the surfaces of manganese-doped Bi_2Se_3 thin films. The resulting electronic groundstate exhibits unique hedgehog-like spin textures at low energies, which directly demonstrate the mechanics of TR symmetry breaking on the surface. We further show that an insulating gap induced by quantum tunnelling between surfaces exhibits spin texture modulation at low energies but respects TR invariance. These spin phenomena and the control of their Fermi surface geometrical phase first demonstrated in our experiments pave the way for the future realization of many predicted exotic magnetic phenomena of topological origin.

Crossover from Coulomb Blockade to Quantum Hall Effect in Suspended Graphene Nanoribbons

Dong-Keun Ki, Alberto F. Morpurgo

PRL 108, 266601

Suspended graphene nanoribbons formed during current annealing of suspended graphene flakes have been investigated experimentally. Transport measurements show the opening of a transport gap around charge neutrality due to the formation of "Coulomb islands", coexisting with quantum Hall conductance plateaus appearing at moderate values of the magnetic field B. Upon increasing B, the transport gap is rapidly suppressed, and is taken over by a much larger energy gap due to electronic correlations. Our observations show that suspended nanoribbons allow the investigation of phenomena that could not so far be accessed in ribbons on SiO_2 substrates.