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Zero-voltage conductance peak from weak antilocalization in a Majorana nanowire

D. I. Pikulin *et al.*, arxiv: 1206.6687 (2012)

We show that weak antilocalization by disorder competes with resonant Andreev reflection from a Majorana zero-mode to produce a zero-voltage conductance peak of order e^2/h in a superconducting nanowire. The phase conjugation needed for quantum interference to survive a disorder average is provided by particle-hole symmetry - in the absence of time-reversal symmetry and without requiring a topologically nontrivial phase. We identify methods to distinguish the Majorana resonance from the weak antilocalization effect.

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

E. J. H. Lee *et al.*, arxiv: 1207.1259 (2012)

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, \Delta, with a magnetic field, B, we investigated the transition from strong coupling, \Delta << T_{K}, to weak coupling, \Delta >> 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 \Delta and 2\Delta. 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 tunnel-spectroscopy experiments aiming at the observation of Majorana fermions in hybrid nanostructures.

Subsystem surface codes with three-qubit check operators

S. Bravyi *et al.*, arxiv:1207.1443 (2012)

We propose a simplified version of the Kitaev's surface code in which error correction requires only three-qubit parity measurements for Pauli operators XXX and ZZZ. The new code belongs to the class of subsystem stabilizer codes. It inherits many favorable properties of the standard surface code such as encoding of multiple logical qubits on a planar lattice with punctured holes, efficient decoding by either minimum-weight matching or renormalization group methods, and high error threshold. The new subsystem surface code (SSC) gives rise to an exactly solvable Hamiltonian with 3-qubit interactions, topologically ordered ground state, and a constant energy gap. We construct a local unitary transformation mapping the SSC Hamiltonian to the one of the ordinary surface code thus showing that the two Hamiltonians belong to the same topological class. We describe error correction protocols for the SSC and determine its error thresholds under several natural error models. In particular, we show that the SSC has error threshold approximately 0.6% for the standard circuit-based error model studied in the literature. We also consider a model in which three-qubit parity operators can be measured directly. We show that the SSC has error threshold approximately 0.97% in this setting.

Near-zero-energy end states in topologically trivial spin-orbit coupled superconducting nanowires with a smooth confinement

G. Kells, D. Meidan, and P. W. Brouwer, arxiv:1207.3067 (2012)

A one-dimensional spin-orbit coupled nanowire with proximity-induced pairing from a nearby s-wave superconductor may be in a topological nontrivial state, in which it has a zero energy Majorana bound state at each end. We find that the topological trivial phase may have fermionic end states with an exponentially small energy, if the confinement potential at the wire's ends is smooth. The possible existence of such near-zero energy levels implies that the mere observation of a zero-bias peak in the tunneling conductance is not an exclusive signature of a topological superconducting phase even in the ideal clean single channel limit.

Weak localization and antilocalization in topological insulator thin films with coherent bulk-surface coupling

I. Garate and L. Glazman, Phys. Rev. B **86**, 035422 (2012).

We evaluate quantum corrections to conductivity in an electrically gated thin film of a three-dimensional topological insulator. We derive approximate analytical expressions for the low-field magnetoresistance as a function of bulk doping and bulk-surface tunneling rate. Our results reveal parameter regimes for both weak localization and weak antilocalization, and include diffusive Weyl semimetals as a special case.

Relaxation dynamics of the Kondo lattice model

P. Werner and M. Eckstein, Phys. Rev. B **86**, 045119 (2012)

We study the relaxation properties of the Kondo lattice model using the nonequilibrium dynamical mean-field formalism in combination with the noncrossing approximation. The system is driven out of equilibrium either by a magnetic field pulse, which perturbs the local singlets, or by a sudden quench of the Kondo coupling. For relaxation processes close to thermal equilibrium (after a weak perturbation), the relaxation time increases substantially as one crosses from the local moment regime into the heavy Fermi liquid. A strong perturbation, which injects a large amount of energy, can rapidly transform the heavy Fermi liquid into a local moment state. Upon cooling, the heavy Fermi liquid reappears in a two-stage relaxation, where the first step opens the Kondo gap and the second step corresponds to a slow approach of the equilibrium state via a nonthermal pathway.

Geometric proof of the equality between entanglement and edge spectra

B. Swingle and T. Senthil, Phys. Rev. B **86**, 045117 (2012)

The bulk-edge correspondence for topological quantum liquids states that the spectrum of the reduced density matrix of a large subregion reproduces the thermal state of a physical edge. This correspondence suggests an intricate connection between ground state entanglement and physical edge dynamics. We give a simple geometric proof of the bulk-edge correspondence for a wide variety of physical systems. Our unified proof relies on geometric techniques available in Lorentz invariant and conformally invariant quantum field theories. These methods were originally developed in part to understand the physics of black holes, and we now apply them to determine the local structure of entanglement in quantum many-body systems.

Strong and tunable mode coupling in carbon nanotube resonators

A . Castellanos-Gomez et al., Phys. Rev. B **86**, 041402(R) (2012).

The nonlinear interaction between two mechanical resonances of the same freely suspended carbon nanotube resonator is studied. We find that, in the Coulomb-blockade regime, the nonlinear modal interaction is dominated by single-electron-tunneling processes and that the mode-coupling parameter can be tuned with the gate voltage, allowing both mode-softening and mode-stiffening behaviors. This is in striking contrast to tension-induced mode coupling in strings where the coupling parameter is positive and gives rise to a stiffening of the mode. The strength of the mode coupling in carbon nanotubes in the Coulomb-blockade regime is observed to be 6 orders of magnitude larger than the mechanical-mode coupling in micromechanical resonators.