Interaction-induced backscattering in short quantum wires

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We study interaction-induced backscattering in clean quantum wires with adiabatic contacts exposed to a voltage bias. Particle backscattering relaxes such systems to a fully equilibrated steady state only on length scales exponentially large in the ratio of bandwidth of excitations and temperature. Here we focus on shorter wires in which full equilibration is not accomplished. Signatures of relaxation then are due to backscattering of hole excitations close to the band bottom which perform a diffusive motion in momentum space while scattering from excitations at the Fermi level. This is reminiscent to the first passage problem of a Brownian particle and, regardless of the interaction strength, can be described by an inhomogeneous Fokker-Planck equation. From general solutions of the latter we calculate the hole backscattering rate for different wire lengths and discuss the resulting length dependence of interaction-induced correction to the conductance of a clean single channel quantum wire.

The viscoelastic response of topological tight-binding models in 2D and 3D

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arXiv:1505.03868
The topological response to external perturbations is an effective probe to characterize different topological phases of matter. Besides the Hall conductance, the Hall viscosity is another example of such a response that measures how electronic wave functions respond to changes in the underlying geometry. Topological (Chern) insulators are known to have a quantized Hall conductance. A natural question is how the Hall viscosity behaves for these materials. So far, most of studies on the Hall viscosity of Chern insulators have focused on the continuum limit. The presence of lattice breaks the continuous translational symmetry to a discrete group and this causes two complications: it introduces a new length scale associated with lattice constant, and makes the momentum periodic. We develop two different methods of how to implement a lattice deformation: (1) lattice distortion is encoded as a shift in the lattice momentum; (2) lattice deformation is treated microscopically in the gradient expansion of the hopping matrix elements. After establishing the method of deformation we can compute the Hall viscosity through a linear response (Kubo) formula. We examine these methods for three models: the Hofstadter model, the Chern insulator, and the surface of a 3D topological insulator. Our results in certain regimes of parameters, where the continuum limit is relevant, are in agreement with previous calculations. We also provide possible experimental signatures of the Hall viscosity by studying the phononic properties of a single crystal 3D topological insulator.

Morphology control of the magnetization reversal mechanism in Co80Ni20 nanomagnets

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Nanowires with very different size, shape, morphology and crystal symmetry can give rise to a wide ensemble of magnetic behaviors whose optimization determines their applications in nanomagnets. We present here an experimental work on the shape and morphological dependence of the magnetization reversal mechanism in weakly interacting Co80Ni20 hexagonal-close-packed nanowires. Non-agglomerated nanowires (with length L and diameter d) with a controlled shape going from quasi perfect cylinders to diabolos, have been studied inside their polyol solution in order to avoid any oxidation process. The coercive field HC was found to follow a standard behavior and to be optimized for an aspect ratio $L/d > 15$. Interestingly, an unexpected behavior was observed as function of the head morphology leading to the strange situation where a diabolo shaped nanowire is a better nanomagnet than a cylinder. This paradoxical behavior can be ascribed to the growth-competition between the aspect ratio L/d and the head morphology ratio d/D (D being the head width). Our experimental results clearly show the importance of the independent parameter (t = head thickness) that needs to be considered in addition to the shape aspect ratio (L/d) in order to fully describe the nanomagnets magnetic behavior. Micromagnetic simulations well support the experimental results and bring important insights for future optimization of the nanomagnets morphology

Bound states of charges on top of graphene in magnetic field

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arXiv:1505.03935
Charges put on top of graphene can move at elevated temperatures or if these charges are the intrinsic electron or hole states in the surface band of substrate such as SiC. We show that in the external magnetic field like charges on top of graphene may be mutually attracted to form macro-molecules. The size of the resulting macro-molecules is of the order of the magnetic length. Tuning the doping of graphene or the magnetic field, the binding of impurities can be turned on and off and the macro-molecule size may be tuned. We classify all the possible stable macro-molecules that unit charges can form on graphene in magnetic field. We argue that the binding survives the high temperatures. This opens the perspective to nanoscopic manipulation of ions on graphene by using macroscopic tools.

Quantum interference and structure-dependent orbital-filling effects on the thermoelectric properties of quantum dot molecules

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arXiv:1505.03944
The Quantum interference and orbital filling effects on the thermoelectric (TE) properties of quantum dot molecules with high figure of merit are illustrated via the full solution to the Hubbard- Anderson model in the Coulomb blockade regime. It is found that under certain condition in the triangular QD molecule (TQDM), destructive quantum interference (QI) can occur, which leads to vanishing small electrical conductance, while the Seebeck coefficient is modified dramatically. When TQDM is in the charge localization state due to QI, the Seebeck coefficient is seriously suppressed at low temperature, but highly enhanced at high temperature. Meanwhile, the behavior of Lorenz number reveals that it is easier to block charge transport via destructive QI than the electron heat transport at high temperatures. The maximum power factor (PF) in TQDM occurs at full-filling condition. Nevertheless, low-filling condition is preferred for getting maximum PF in serially coupled triple QDs in general. In double QDs, the maximum PF can be achieved either with orbital-depletion or orbital-filling as a result of electron-hole symmetry. Our theoretical work provides a useful guideline for advancing the nanoscale TE technology.

Phase Diagram of the Interacting Majorana Chain Model

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arXiv:1505.03966
The Hubbard chain and spinless fermion chain are paradigms of strongly correlated systems, very well understood using Bethe ansatz, Density Matrix Renormalization Group (DMRG) and field theory/renormalization group (RG) methods. They have been applied to one-dimensional materials and have provided important insights for understanding higher dimensional cases. Recently, a new interacting fermion model has been introduced, with possible applications to topological materials. It has a single Majorana fermion operator on each lattice site and interactions with the shortest possible range that involve 4 sites. We present a thorough analysis of the phase diagram of this model in one dimension using field theory/RG and DMRG methods. It includes a gapped supersymmetric region and a novel gapless phase with coexisting Luttinger liquid and Ising degrees of freedom. In addition to a first order transition, three critical points occur: tricritical Ising, Lifshitz and a novel generalization of the commensurate-incommensurate transition. We also survey various gapped phases of the system that arise when the translation symmetry is broken by dimerization and find both trivial and topological phases with 0, 1 and 2 Majorana zero modes bound to the edges of the chain with open boundary conditions.

Impurity Effects on Bound States in the Vortex Core of Topological S-wave Superconductor

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arXiv:1505.03975
We study the impurity effects on the Caroli-de Gennes-Matricon (CdGM) states, particularly on the level spacings in a vortex core in topological s-wave superconductor (SC) by two means, numerically and analytically. The topological s-wave SC belongs to the same class as a chiral p-wave SC and thus there are two inequivalent vortices in terms of any symmetry operation. We take into account this inequivalence and numerically calculate the scattering rates based on an improved version of Kopnin-Kravtsov

(iKK) scheme, which enables us to treat the discrete levels in the presence of white-noise disorder. We also construct the Andreev equation for the topological s-wave SC and obtain the Andreev bound states analytically. We use a correspondence between the wave functions for the Bogoliubov-de Gennes equation and the Andreev equation in the iKK scheme and deduce the formula of scattering rates described by the wave function for the Andreev equation. With this formula, we discuss the origin of impurity scattering rates for CdGM states of topological s-wave SC and the dependence on the types of vortices related to the inequivalence.