arXiv:1308.0017 [cond-mat.mes-hall]

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We theoretically study the superconducting proximity effect in silicene, which features massive Dirac fermions with a tunable mass (band gap), and compute the conductance across a normal/superconductor (N/S) silicene junction, the non-local conductance of an N/S/N junction, and the supercurrent flowing in an S/N/S junction. It is demonstrated that the transport processes consisting of local and non-local Andreev reflection may be efficiently controlled via an external electric field owing to the buckled structure of silicene. In particular, we demonstrate that it is possible to obtain a fully spin-valley polarized crossed Andreev reflection process without any contamination of elastic cotunneling or local Andreev reflection, in stark contrast to ordinary metals. It is also shown that the supercurrent flowing in the S/N/S junction can be fully spin-valley polarized and that it is controllable by an external electric field.

ArXiv:1308.4156 [cond-mat.mes-hall]

Interplay between Kondo and Majorana interactions in quantum dots

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We study properties of a quantum dot coupled to a one-dimensional topological superconductor and a normal lead and discuss the interplay between Kondo and Majorana-induced couplings in quantum dot. The latter appears due to the presence of Majorana zero-energy modes localized at the ends of the one-dimensional superconductor. We investigatea the phase diagram of the system as a function of Kondo and Majorana interactions and show, using both a renormalization-group analysis and numerical simulations using the density-matrix renormalization group method, that the Kondo fixed point is generically unstable in such a system. Instead, the infrared fixed point is controlled by the Majorana-induced coupling, and is characterized by the non-trivial correlations between a localized spin on the dot and a fermion parity of the topological superconductor and normal lead.

ArXiv:1308.3523 [cond-mat.str-el]

Decay of fermionic quasiparticles in one-dimensional quantum liquids

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The low energy properties of one-dimensional quantum liquids are commonly described in terms of the Tomonaga-Luttinger liquid theory, in which the elementary excitations are free bosons. To this approximation the theory can be alternatively recast in terms of free fermions. In both approaches, small perturbations give rise to finite life times of excitations. We evaluate the decay rate of fermionic excitations and show that it scales as eighth power of energy, in contrast to the much faster decay of bosonic excitations. Our results can be tested experimentally by measuring the broadening of power-law features in the density structure factor or spectral functions.

ArXiv:1308.3969 [cond-mat.mes-hall]

Topological superconducting phase in helical Shiba chains

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Recently, it has been suggested that topological superconductivity and Majorana end states can be realized in a chain of magnetic impurities on the surface of an s-wave superconductor when the magnetic moments form a spin helix as a result of the RKKY interaction mediated by the superconducting substrate. Here, we investigate this scenario theoretically by developing a tight-binding Bogoliubov-de Gennes description starting from the Shiba bound states induced by the individual magnetic impurities. While the resulting model Hamiltonian has similarities with the Kitaev model for one-dimensional spinless p-wave superconductors, there are also important differences, most notably the long-range nature of hopping and pairing as well as the complex hopping amplitudes. We use both analytical and numerical approaches to explore the consequences of these differences for the phase diagram and the localization properties of the Majorana end states when the Shiba chain is in a topological superconducting phase.

ArXiv:1308.1285 [cond-mat.mes-hall]

Transmission phase lapses through a quantum dot in a strong magnetic field

Yehuda Dinaii, Yuval Gefen, Bernd Rosenow

The phase of the transmission amplitude through a mesoscopic system contains information about the system's quantum mechanical state and excitations thereof. In the absence of an external magnetic field, abrupt phase lapses occur between transmission resonances of quantum dots and can be related to the signs of tunneling matrix elements. They are smeared at finite temperatures. By contrast, we show here that in the presence of a strong magnetic field, phase lapses represent a genuine interaction effect and may occur also on resonance. For some realistic parameter range these phase lapses are robust against finite temperature broadening.

ArXiv:1308.4591 [cond-mat.mes-hall]

Electron-Phonon Coupling in Two-Dimensional Silicene and Germanene

Jia-An Yan, Ryan Stein, David M. Schaefer, Xiao-Qian Wang, M. Y. Chou

Following the work in graphene, we report a first-principles study of electron-phonon coupling (EPC) in low-buckled (LB) monolayer silicene and germanene. Despite of the similar honeycomb atomic arrangement and linear band dispersion, the EPC matrix-element squares of the Γ-E_g and K-A_1 modes in silicene are only about 50% of those in graphene. However, the smaller Fermi velocity in silicene compensates this reduction by providing a larger joint electronic density of states near the Dirac point. We predict that Kohn anomalies associated with these two optical modes are significant in silicene. In addition, the EPC-induced frequency shift and linewidth of the Raman-active Γ-E_g mode in silicene are calculated as a function of doping. The results are comparable to those in graphene, indicating a similar non-adiabatic dynamical origin. In contrast, the EPC in germanene is found to be much reduced.

ArXiv:1308.5345 [cond-mat.mes-hall]

Universal Scaling of Quantum Anomalous Hall Plateau Transition

Jing Wang, Biao Lian, Shou-Cheng Zhang

We study the critical properties of the quantum anomalous Hall (QAH) plateau transition in magnetic topological insulators. We introduce a microscopic model for the plateau transition in QAH effect at the coercive field and then map it to the network model of quantum percolation in the integer quantum Hall effect plateau transition. Generally, an intermediate plateau with zero Hall conductance could occur at the coercive field. Universal scaling of the transport coefficients ρ_{xy} and ρ_{xx} are predicted.

ArXiv:1308.5549 [cond-mat.mes-hall]

Spin Hall effect in AA-stacked bilayer graphene

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Intrinsic spin Hall effect in the AA-stacked bilayer graphene is studied theoretically. The low-energy electronic spectrum for states in the vicinity of the Dirac points is obtained from the corresponding $\mathbf{k}\cdot\mathbf{p}$ Hamiltonian. The spin Hall conductivity in the linear response regime is determined within the Green function formalism. Conditions for the existence of spin Hall insulator phase are also analyzed, and it is shown that the spin Hall insulator phase can exist for a sufficiently large spin-orbit coupling, which opens a gap in the spectrum. The electric field perpendicular to the graphene plane leads then to reduction of the gap width and suppression of the spin Hall insulator phase. The low temperature spin Nernst effect is also calculated from the zero temperature spin Hall conductivity.

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Quantum transport signatures of chiral edge states in Sr$_2$RuO$_4$

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