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Percolating states in the topological Anderson insulator
Adrian Girschik, Florian Libisch, and Stefan Rotter
Phys. Rev. B 91, 214204
We investigate the presence of percolating states in disordered two-dimensional topological insulators. In particular, we uncover a close connection between these states and the so-called topological Anderson insulator, which is a topologically nontrivial phase induced by the presence of disorder. The decay of this phase could previously be connected to a delocalization of bulk states with increasing disorder strength. We identify this delocalization to be the result of a percolation transition of states that circumnavigate the hills of the bulk disorder potential.

Enhancement of bulk photovoltaic effect in topological insulators
Liang Z. Tan, Andrew M. Rappe
arXiv:1508.03564
We investigate the shift current bulk photovoltaic response of materials close to a band inversion topological phase transition. We find that the bulk photocurrent reverses direction across the band inversion transition, and that its magnitude is enhanced in the vicinity of the phase transition. These results are demonstrated with first principles DFT calculations of BiTeI and $CsPbI_3$ under hydrostatic pressure, and explained with an analytical model, suggesting that this phenomenon remains robust across disparate material systems.

Closing the proximity gap in a three-terminal superconducting junction
C. Padurariu, T. Jonckheere, J. Rech, R. Mélin, D. Feinberg, T. Martin, Yu. V. Nazarov
arXiv:1508.03289
We describe the proximity effect in a short disordered metallic junction between three superconducting leads. Andreev bound states in the multi-terminal junction may cross the Fermi level. We reveal that for a quasi-continuous metallic density of states, crossings at the Fermi level manifest as closing of the proximity-induced gap. We calculate the local density of states for a wide range of transport parameters using quantum circuit theory. The gap closes inside an area of the space spanned by the superconducting phase differences. We derive an approximate analytic expression for the boundary of the area and compare it to the full numerical solution. The size of the area increases with the transparency of the junction and is sensitive to asymmetry. The finite density of states at zero energy is unaffected by electron-hole decoherence present in the junction, although decoherence is important at higher energies. Our predictions can be tested using tunneling transport spectroscopy. To encourage experiments, we calculate the current-voltage characteristic in a typical measurement setup. We show how the structure of the local density of states can be mapped out from the measurement.

Floquet Majorana Fermions in superconducting quantum dots
Mónica Benito, Gloria Platero
arXiv:1508.03233
We consider different configurations of ac driven quantum dots coupled to superconductor leads where Majorana fermions can exist as collective quasiparticles. The main goal is to tune the existence, localization and properties of these zero energy quasiparticles by means of periodically driven external gates. In particular, we analyze the relevance of the system and driving symmetry. We predict the existence of different sweet spots with Floquet Majorana fermions in configurations where they are not present in the undriven system.

Revealing puddles of electrons and holes in compensated topological insulators
N. Borgwardt, J. Lux, I. Vergara, Zhiwei Wang, A.A. Taskin, Kouji Segawa, P.H.M. van Loosdrecht, Yoichi Ando, A. Rosch, M. Grüninger
arXiv:1508.03212
Three-dimensional topological insulators harbour metallic surface states with exotic properties. In transport or optics, these properties are typically masked by defect-induced bulk carriers. Compensation of donors and acceptors reduces the carrier density, but the bulk resistivity remains disappointingly small. We show that measurements of the optical conductivity in BiSbTeSe2 pinpoint the presence of electron-hole puddles in the bulk at low temperatures, which is essential for understanding DC bulk transport. The puddles arise from large fluctuations of the Coulomb potential of donors and acceptors, even in the case of full compensation. Surprisingly, the number of carriers appearing within puddles drops rapidly with increasing temperature and almost vanishes around 40 K. Monte Carlo simulations show that a highly non-linear screening effect arising from thermally activated carriers destroys the puddles at a temperature scale set by the Coulomb interaction between neighbouring dopants, explaining the experimental observation semi-quantitatively. This mechanism remains valid if donors and acceptors do not compensate perfectly.

Tunable Fermi surface topology and Lifshitz transition in bilayer graphene

Anastasia Varlet, Marcin Mucha-Kruczyński, Dominik Bischoff, Pauline Simonet, Takashi Taniguchi, Kenji Watanabe, Vladimir Fal'ko, Thomas Ihn, Klaus Ensslin
arXiv:1508.02922
Bilayer graphene is a highly tunable material: not only can one tune the Fermi energy using standard gates, as in single-layer graphene, but the band structure can also be modified by external perturbations such as transverse electric fields or strain. We review the theoretical basics of the band structure of bilayer graphene and study the evolution of the band structure under the influence of these two external parameters. We highlight their key role concerning the ease to experimentally probe the presence of a Lifshitz transition, which consists in a change of Fermi contour topology as a function of energy close to the edges of the conduction and valence bands. Using a device geometry that allows the application of exceptionally high displacement fields, we then illustrate in detail the way to probe the topology changes experimentally using quantum Hall effect measurements in a gapped bilayer graphene system.

Strong interface-induced spin-orbit coupling in graphene on WS2
Zhe Wang, Dong-Keun Ki, Hua Chen, Helmuth Berger, Allan H. MacDonald, Alberto F. Morpurgo
arXiv:1508.02912
Interfacial interactions allow the electronic properties of graphene to be modified, as recently demonstrated by the appearance of satellite Dirac cones in the band structure of graphene on hexagonal boron nitride (hBN) substrates. Ongoing research strives to explore interfacial interactions in a broader class of materials in order to engineer targeted electronic properties. Here we show that at an interface with a tungsten disulfide (WS2) substrate, the strength of the spin-orbit interaction (SOI) in graphene is very strongly enhanced. The induced SOI leads to a pronounced low-temperature weak anti-localization (WAL) effect, from which we determine the spin-relaxation time. We find that spin-relaxation time in graphene is two-to-three orders of magnitude smaller on WS2 than on SiO2 or hBN, and that it is comparable to the intervalley scattering time. To interpret our findings we have performed first-principle electronic structure calculations, which both confirm that carriers in graphene-on-WS2 experience a strong SOI and allow us to extract a spin-dependent low-energy effective Hamiltonian. Our analysis further shows that the use of WS2 substrates opens a possible new route to access topological states of matter in graphene-based systems.

Mechanically induced two-qubit gates and maximally entangled states for single electron spins in a carbon nanotube
Heng Wang, Guido Burkard
arXiv:1508.02107
We theoretically analyze a system where two electrons are trapped separately in two quantum dots on a suspended carbon nanotube (CNT), subject to external ac electric driving. An indirect mechanically-induced coupling of two distant single electron spins is induced by the interaction between the spins and the mechanical motion of the CNT. We show that a two-qubit iSWAP gate and arbitrary single-qubit gates can be obtained from the intrinsic spin-orbit coupling. Combining the iSWAP gate and single-qubit gates, maximally entangled states of two spins can be generated in a single step by varying the frequency and the strength of the external electric driving field. The spin-phonon coupling can be turned off by electrostatically shifting the electron wave function on the nanotube.