Specular Andreev Reflection in the Interface of a Two-Dimensional Semiconductor with Rashba Spin-Orbit Coupling and a d-Wave Superconductor

Bo Lv, C. Zhang, and Zhongshui Ma

PRL **108**, 077002 (2012)

We reveal that the recently discovered specular Andreev reflection (SAR) [C. W. J. Beenakker, Phys. Rev. Lett. 97 067007 (2006)] can occur in semiconductors where the spin-orbit coupling is finite. We demonstrate this finding in the hybrid of a two-dimensional electron gas with Rashba spin-orbit coupling and a superconductor. In the limit of low density or a strong spin-orbit coupling, specular Andreev reflection is finite. We also show that unit electron-hole conversion is possible in a specular Andreev reflection due to the different topological structures of the equal-energy surface between electrons and holes. The SAR in the semiconductor is determined by the relative orientation of wave vector to group velocity, which can be analyzed by ray equations.

Emergent electrodynamics of skyrmions in a chiral magnet

T. Schulz, R. Ritz, A. Bauer, M. Halder, M. Wagner, C. Franz, C. Pfleiderer, K. Everschor, M. Garst, and A. Rosch

Nature Phys. AOP, doi:10.1038/nphys2231, (2012)

When an electron moves in a smoothly varying non-collinear magnetic structure, its spin orientation adapts constantly, thereby inducing forces that act both on the magnetic structure and on the electron. These forces may be described by electric and magnetic fields of an emergent electrodynamics. The topologically quantized winding number of so-called skyrmions—a type of magnetic whirl discovered recently in chiral magnets—has been predicted to induce exactly one quantum of emergent magnetic flux per skyrmion. A moving skyrmion is therefore expected to induce an emergent electric field following Faraday's law of induction, which inherits this topological quantization. Here we report Hall-effect measurements that establish quantitatively the predicted emergent electrodynamics. We obtain quantitative evidence for the depinning of skyrmions from impurities (at current densities of only $10^6\,\mathrm{A\,m^{-2}}$) and their subsequent motion. The combination of exceptionally small current densities and simple transport measurements offers fundamental insights into the connection between the emergent and real electrodynamics of skyrmions in chiral magnets, and might, in the long term, be important for applications.

Mass of a vortex in a superconducting film measured via magneto-optical imaging plus ultrafast heating and cooling

Daniel Golubchik, Emil Polturak, and Gad Koren

PRB **85**, 060504(R) (2012)

We have combined high-resolution magneto-optical imaging with an ultrafast heating and cooling technique to measure the movement of individual vortices in a superconducting film. The motion took place while the film was heated close to T_c, where pinning and viscous forces are relatively small. Under these conditions, vortices move due to the magnetic repulsion between them. We found that a finite vortex mass has to be included in the analysis in order to account for the experimental results. The extent of the motion is consistent with a vortex mass being three orders of magnitude smaller than the mass of all the electrons in the core.

Quantum Hyperdiffusion in One-Dimensional Tight-Binding Lattices

Zhenjun Zhang, Peiqing Tong, Jiangbin Gong, and Baowen Li

PRL **108**, 070603 (2012)

Transient quantum hyperdiffusion, namely, faster-than-ballistic wave packet spreading for a certain time scale, is found to be a typical feature in tight-binding lattices if a sublattice with on-site potential is embedded in a uniform lattice without on-site potential. The strength of the sublattice on-site potential, which can be periodic, disordered, or quasiperiodic, must be below certain threshold values for quantum hyperdiffusion to occur. This is explained by an energy band mismatch between the sublattice and the rest uniform lattice and by the structure of the underlying eigenstates. Cases with a quasiperiodic sublattice can yield remarkable hyperdiffusion exponents that are beyond three. A phenomenological explanation of hyperdiffusion exponents is also discussed.

Fermi surface reconstruction in hole-doped t-J models without long-range antiferromagnetic order

Matthias Punk, Subir Sachdev

arXiv:1202.4023v1

We calculate the Fermi surface of electrons in hole-doped, extended t-J models on a square lattice in a regime where no long-range antiferromagnetic order is present, and no symmetries are broken. Using the "spinon-dopon" formalism of Ribeiro and Wen, we show that short-range antiferromagnetic correlations lead to a reconstruction of the Fermi surface into hole pockets which are not necessarily centered at the antiferromagnetic Brillouin zone boundary. The Brillouin zone area enclosed by the Fermi surface is proportional to the density of dopants away from half-filling, in contrast to the conventional Luttinger theorem which counts the total electron density. This state realizes a "fractionalized Fermi liquid" (FL*), which has been proposed as a possible ground-state of the underdoped cuprates; we note connections to recent experiments. We also discuss the quantum phase transition from the FL* state to the Fermi liquid state with long-range antiferromagnetic order.

Theory of thermal spin-charge coupling in electronic systems
Benedikt Scharf, Alex Matos-Abiague, Igor Žutić, and Jaroslav Fabian
PRB **85**, 085208 (2012

The interplay between spin transport and thermoelectricity offers several novel ways of generating, manipulating, and detecting nonequilibrium spin in a wide range of materials. Here, we formulate a phenomenological model in the spirit of the standard model of electrical spin injection to describe the electronic mechanism coupling charge, spin, and heat transport and employ the model to analyze several different geometries containing ferromagnetic (F) and nonmagnetic (N) regions: F, F/N, and F/N/F junctions, which are subject to thermal gradients. We present analytical formulas for the spin-accumulation and spin-current profiles in those junctions that are valid for both tunnel and transparent (as well as intermediate) contacts. For F/N junctions, we calculate the thermal spin-injection efficiency and the spin-accumulation-induced nonequilibrium thermopower. We find conditions for countering thermal spin effects in the N region with electrical spin injection. This compensating effect should be particularly useful for distinguishing electronic from other mechanisms of spin injection by thermal gradients. For F/N/F junctions, we analyze the differences in the nonequilibrium thermopower (and chemical potentials) for parallel and antiparallel orientations of the F magnetizations, as evidence and a quantitative measure of the spin accumulation in N. Furthermore, we study the Peltier and spin Peltier effects in F/N and F/N/F junctions and present analytical formulas for the heat evolution at the interfaces of isothermal junctions.

Resonantly Tunable Majorana Polariton in a Microwave Cavity
Mircea Trif, Yaroslav Tserkovnyak
arXiv:1202.2649v1

We study the spectrum of a one-dimensional Kitaev chain placed in a microwave cavity. In the off-resonant regime, the frequency shift of the cavity can be used to identify the topological phase transition of the coupled system. In the resonant regime, the topology of the system can be controlled via the microwave cavity occupation and, moreover, for a large number of photons (classical limit), the physics becomes similar to that of periodically-driven systems (Floquet insulators). We also analyze numerically a finite chain and show the existence of a degenerate subspace in the presence of the cavity that can be interpreted as a *Majorana polariton*.

Singlet-triplet splitting in double quantum dots due to spin-orbit and hyperfine interactions
Dimitrije Stepanenko, Mark Rudner, Bertrand I. Halperin, and Daniel Loss
PRB **85**, 075416 (2012)

Frequency-dependent transport through a spin chain
Kevin A. van Hoogdalem and Daniel Loss
PRB **85**, 054413 (2012)

Incoherent dynamics in the toric code subject to disorder
Beat Röthlisberger, James R. Wootton, Robert M. Heath, Jiannis K. Pachos, and Daniel Loss
PRA **85**, 022313 (2012)

Incoherent dynamics in the toric code subject to disorderQuantum-control approach to realizing a Toffoli gate in circuit QED
Vladimir M. Stojanović, A. Fedorov, A. Wallraff, and C. Bruder
PRB **85**, 054504 (2012)