Spin-Orbit Echo

N. Sugimoto and N. Nagaosa, Science 336, 1413 (2012)

Preserving and controlling the quantum information content of spins is a central challenge of spintronics. In solids, the relativistic spin-orbit interaction (SOI) leads to a finite spin lifetime. Here, we show that spin information is preserved by the hidden conserved "twisted spin" and survives elastic disorder scatterings. This twisted spin is an adiabatic invariant with respect to a slow change in the SOI. We predict an echo phenomenon, spin-orbit echo, which indicates the recovery of the spin moment when the SOI is tuned off adiabatically, even after spin relaxation has occurred; this is confirmed by numerical simulations. A concrete experiment in two-dimensional semiconductor quantum wells with Rashba-Dresselhaus SOI is proposed to verify our prediction.

How close can one approach the Dirac point in graphene experimentally?

A.S. Mayorov, D.C. Elias, I.S. Mukhin, S.V. Morozov, L.A. Ponomarenko, K.S. Novoselov, A.K. Geim, R.V. Gorbachev, arxiv:1206.3848

The above question is frequently asked by theorists who are interested in graphene as a model system, especially in context of relativistic quantum physics. We offer an experimental answer by describing electron transport in suspended devices with carrier mobilities of several 106 cm2V-1s-1 and with the onset of Landau quantization occurring in fields below 5 mT. The observed charge inhomogeneity is as low as ≈108 cm-2, allowing a neutral state with a few charge carriers per entire micron-scale device. Above liquid helium temperatures, the electronic properties of such devices are intrinsic, being governed by thermal excitations only. This yields that the Dirac point can be approached within 1 meV, a limit currently set by the remaining charge inhomogeneity. No sign of an insulating state is observed down to 1 K, which establishes the upper limit on a possible bandgap.

Field-induced Coulomb Blockade and Quantum Confinement in Graphene

Satoshi Moriyama, Yoshifumi Morita, Eiichiro Watanabe, and Daiju Tsuya, arxiv:1206.4797

We report an approach to confine the carriers in single-layer graphene, which leads to quantum devices with field-induced quantum confinement. We demonstrated that the novel Coulomb-blockade eect evolves under a uniform magnetic field perpendicular to the graphene device. Our experimental results show that field induced quantum dots are realized in graphene, and a quantum confinement-deconfinement transition is switched by the magnetic field.

ac Josephson Effect in Finite-Length Nanowire Junctions with Majorana Modes

Pablo San-Jose, Elsa Prada, and Ramo´n Aguado, PRL 108, 257001 (2012)

It has been predicted that superconducting junctions made with topological nanowires hosting Majorana bound states (MBS) exhibit an anomalous 4-periodic Josephson effect. Finding an experimental setup with these unconventional properties poses, however, a serious challenge: for finite-length wires, the equilibrium supercurrents are always 2 periodic as anticrossings of states with the same fermionic parity are possible. We show, however, that the anomaly survives in the transient regime of the ac Josephson effect. Transients are, moreover, protected against decay by quasiparticle poisoning as a consequence of the quantum Zeno effect, which fixes the parity of Majorana qubits. The resulting longlived ac Josephson transients may be effectively used to detect MBS.

On the possibility of the fractional ac Josephson effect in non-topological conventional superconductor-normal-superconductor junctions

Jay D. Sau, Erez Berg, and Bertrand I. Halperin, arxiv:1206.4596

Topological superconductors supporting Majorana Fermions with non-abelian statistics are presently a subject of intense theoretical and experimental effort. It has been proposed that the observation of a half-frequency or a fractional Josephson effect is a more reliable test for topological superconductivity than the search for end zero modes. Low-energy end modes can occur accidentally due to impurities. In fact, the fractional Josephson effect has been observed for the semiconductor nanowire system. Here we consider the ac Josephson effect in a conventional s-wave superconductor-normal metal-superconductor junction at a finite voltage. Using a Floquet-Keldysh treatment of the finite voltage junction, we show that the power dissipated from the junction, which measures the ac Josephson effect, can show a peak at half (or even incommensurate fractions) of the Josephson frequency. The ac fractional Josephson peak can also be understood simply in terms of Landau-Zener processes associated with the Andreev bound state spectrum of the junction.

Role of Nuclear Quadrupole Coupling on Decoherence and Relaxation of Central Spins in Quantum Dots
N. A. Sinitsyn, Yan Li, S. A. Crooker, A. Saxena, and D. L. Smith, arxiv:1206.3681
Strain-induced gradients of local electric fields in semiconductor quantum dots can couple to the quadrupole moments of nuclear spins. We develop a theory describing the influence of this quadrupolar coupling (QC) on the spin correlators of electron and hole "central" spins localized in such dots. We show that when the QC strength is comparable to or larger than the hyperfine coupling strength between nuclei and the central spin, the relaxation rate of the central spin is strongly enhanced and can be exponential. We demonstrate a good agreement with recent experiments on spin relaxation in hole-doped (In,Ga)As self-assembled quantum dots.

Optical measurements of spin noise as a high resolution spectroscopic tool
V.S. Zapasskii, A. Greilich, S.A. Crooker, Y. Li, G.G. Kozlov, D.R. Yakovlev, D. Reuter, A.D. Wieck, M. Bayer, arxiv:1206.4168
The intrinsic fluctuations of electron spins in semiconductors and atomic vapors generate a small, randomly-varying "spin noise" that can be detected by sensitive optical methods such as Faraday rotation. Recent studies have demonstrated that the frequency, linewidth, and lineshape of this spin noise directly reveals dynamical spin properties such as dephasing times, relaxation mechanisms and g-factors without perturbing the spins away from equilibrium. Here we demonstrate that spin noise measurements using wavelength-tunable probe light forms the basis of a powerful and novel spectroscopic tool to provide unique information that is fundamentally inaccessible via conventional linear optics. In particular, the wavelength dependence of the detected spin noise power can reveal homogeneous linewidths buried within inhomogeneously-broadened optical spectra, and can resolve overlapping optical transitions belonging to different spin systems. These new possibilities are explored both theoretically and via experiments on spin systems in opposite limits of inhomogeneous broadening (alkali atom vapors and semiconductor quantum dots).

Ancilla-Assisted Calibration of a Measuring Apparatus
G. Brida, L. Ciavarella, I. P. Degiovanni, M. Genovese, A. Migdall, M. G. Mingolla, M. G. A. Paris, F. Piacentini, and S.V. Polyakov, PRL 108, 253601 (2012)
A quantum measurement can be described by a set of matrices, one for each possible outcome, which represents the positive operator-valued measure (POVM) of the sensor. Efficient protocols of POVM extraction for arbitrary sensors are required. We present the first experimental POVM reconstruction that takes explicit advantage of a quantum resource, i.e., nonclassical correlations with an ancillary state. A POVM of a photon-number-resolving detector is reconstructed by using strong quantum correlations of twin beams generated by parametric down-conversion. Our reconstruction method is more statistically robust than POVM reconstruction methods that use classical input states.

Generation of Bulk Quasi-Stationary States in Floquet Topological Insulators
Yaniv Tenenbaum Katan and Daniel Podolsky, arxiv:1206.3315
Floquet topological insulators are topological phases of matter generated by the application of time-periodic perturbations on otherwise conventional insulators. We demonstrate that spatial variations in the time-periodic potential lead to localized quasi-stationary states in two-dimensional systems. These states include one-dimensional interface modes at the nodes of the external potential, and fractionalized excitations at vortices of the external potential. We also propose a setup by which light can induce currents in these systems. We explain these results by showing a close analogy to px + ipy superconductors.

Crossed Andreev reflection in quantum wires with strong spin-orbit interaction
Koji Sato, Daniel Loss, and Yaroslav Tserkovnyak, Phys. Rev. B 85, 235433 (2012)
We theoretically study tunneling of Cooper pairs from an s-wave superconductor into two semiconductor quantum wires with strong spin-orbit interaction under magnetic field, which approximate helical Luttinger liquids. The entanglement of electrons within a Cooper pair can be detected at low temperatures by the electric current cross correlations in the wires. By controlling the relative orientation of the wires, either lithographically or mechanically, on the substrate, these current correlations can be tuned, as dictated by the initial spin entanglement. This proposal of a spin-to-charge readout of quantum correlations is alternative to a recently proposed utilization of the quantum spin Hall insulator.

Ig prize of the week: **Molecular adsorption study of nicotine and caffeine on the single-walled carbon nanotube from first principles**; *Hyung-Jun Lee, Gunn Kim, and Young-Kyun Kwon*; arxiv:1206.3474