An all electron topological insulator in InAs double wells
Sigurdur I. Erlingsson, J. Carlos Egues

We show that electrons in ordinary III-V semiconductor double wells with an in-plane modulating periodic potential and inter well spin-orbit interaction are tunable Topological Insulators (TIs). Here the essential TI ingredients, namely, band inversion and the opening of an overall bulk gap in the spectrum arise, respectively, from (i) the combined effect of the double well even-odd state splitting Δ_{SAS} together with the superlattice potential and (ii) the interband Rashba spin-orbit coupling η. We corroborate our exact diagonalization results by an analytical nearly-free electron description that allows us to derive an effective Bernevig-Hughes-Zhang (BHZ) model. Interestingly, the gate-tunable Δ_{SAS} drives a topological phase transition featuring a discontinuous Chern number at $\Delta_{SAS}\sim 5.4$ meV. Finally, we explicitly verify the bulk-edge correspondence by considering a strip configuration and determining not only the bulk bands in the non-topological and topological phases but also the edge states and their Dirac-like spectrum in the topological phase. The edge electronic densities exhibit peculiar spatial oscillations as they decay away into the bulk. For concreteness, we present our results for InAs-based wells with realistic parameters.

Hyperferroelectrics: proper ferroelectrics with persistent polarization
Kevin F. Garrity, Karin M. Rabe, David Vanderbilt

All known proper ferroelectrics are unable to polarize normal to a surface or interface if the resulting depolarization field is unscreened, but there is no fundamental principle that enforces this behavior. In this work, we introduce hyperferroelectrics, a new class of proper ferroelectrics which polarize even when the depolarization field is unscreened, this condition being equivalent to instability of a longitudinal optic mode in addition to the transverse-optic-mode instability characteristic of proper ferroelectrics. We use first principles calculations to show that several recently discovered hexagonal ferroelectric semiconductors have this property, and we examine its consequences both in the bulk and in a superlattice geometry.

Scaling of Anomalous Hall Effect in Chemically Disordered L10-Mn1.5Ga

L. J. Zhu, D. Pan, J. H. Zhao

The anomalous Hall effect (AHE) in perpendicularly magnetized L10-Mn1.5Ga single-crystalline films is investigated as a function of degree of long-range chemical ordering and temperature. Our results provide firm evidence that weak localization, phonons and magnons have negligibly smaller effect on skew scattering contributions to AHE resistivity than defects, the overlook of which in conventional scaling laws results in significant discrepancies and exponent n beyond 2 when fitting the data. We find that the broken of long-range chemical ordering strongly affects both intrinsic and extrinsic contributions of AHE conductivity, e.g., it greatly suppresses intrinsic contributions by influencing the topology of the band structures. Our results are of great importance for both physical understanding and technological engineering of the AHE.

Memory function approach to in-plane anisotropic resistivity in the antiferromagnetic phase of iron-based superconductors
Koudai Sugimoto, Peter Prelovšek, Eiji Kaneshita, Takami Tohyama

We theoretically examine anisotropy of in-plane resistivity in striped antiferromagnetic phase of iron-based superconductor by applying a memory-function approach to the ordered phase with isotropic nonmagnetic impurity. Near undoped region, where the Drude weight gives anisotropy opposite to experimental observation, the memory-function approach yields a proper anisotropic behavior: The resistivity in the antiferromagnetically ordered direction is smaller than that in the ferromagnetic direction. The anisotropy reverses when holes are introduced. The origin of the anisotropy is attributed to the interplay of impurity scattering and anisotropic electronic states.

Nanoscale nuclear magnetic resonance with a 1.9-nm-deep nitrogen-vacancy sensor
M. Loretz, S. Pezzagna, J. Meijer, C. L. Degen

We present nanoscale NMR measurements performed with nitrogen-vacancy (NV) centers located down to about 2 nm from the diamond surface. NV centers were created by shallow ion implantation followed by a slow, nanometer-by-nanometer removal of diamond material using oxidative etching in air. The close proximity of NV centers to the surface yielded large 1H NMR signals of up to 3.4 uT-rms, corresponding to ~700 statistically polarized or ~10 fully polarized proton spins in a ~(2.3 nm)^3 detection volume.

Exact time-dependent density-functional potentials for strongly correlated tunneling electrons
Matthew J. P. Hodgson, James D. Ramsden, Jacob B. J. Chapman, Piers Lillystone, Rex W Godby

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By propagating the many-body Schr\"odinger equation, we determine the exact time-dependent Kohn-Sham potential for a system of strongly correlated electrons which undergo field-induced tunneling. Numerous features are entirely absent from the approximations commonly used in time-dependent density-functional theory. The self-interaction correction is strong and time dependent, owing to electron localization, and prominent dynamic spatial potential steps arise from minima in the charge density, as modified by the Coulomb interaction experienced by the partially tunneled electron.

Gapless superconductivity and string theory
S. Khlebnikov

Coexistence of superconducting and normal components in nanowires at currents below the critical (a "mixed" state) would have important consequences for the nature and range of potential applications of these systems. From the theoretical perspective, it represents a genuine interaction effect, not seen in the mean-field theory. Here we consider properties of such a state in the gravity dual of a strongly coupled superconductor constructed from D3 and D5 branes. We find numerically uniform gapless solutions containing both components but argue that they are unstable against phase separation, as their free energies are not convex. We speculate on the possible nature of the resulting non-uniform sate ("emulsion") and draw analogies between that state and the familiar mixed state of a type II superconductor in a magnetic field.

Annihilation of colliding Bogoliubov quasiparticles reveals their Majorana nature

C.W.J. Beenakker
The single-particle excitations of a superconductor are coherent superpositions of electrons and holes near the Fermi level, called Bogoliubov quasiparticles. They are Majorana fermions, meaning that pairs of quasiparticles can annihilate. We calculate the annihilation probability at a beam splitter for chiral quantum Hall edge states, obtaining a $1\pm cos\phi$ dependence on the phase difference ϕ of the superconductors from which the excitations originated (with the $\pm$ sign distinguishing singlet and triplet pairing). This provides for a nonlocal measurement of the superconducting phase in the absence of any supercurrent.