Direct measurement of the Zak phase in topological Bloch bands
Marcos Atala, Monika Aidelsburger, Julio T. Barreiro, Dmitry Abanin, Takuya Kitagawa, Eugene Demler and Immanuel Bloch
Nature Phys. 9, 795 (2013)
Geometric phases that characterize the topological properties of Bloch bands play a fundamental role in the band theory of solids. Here we report on the measurement of the geometric phase acquired by cold atoms moving in one-dimensional optical lattices. Using a combination of Bloch oscillations and Ramsey interferometry, we extract the Zak phase—the Berry phase gained during the adiabatic motion of a particle across the Brillouin zone—which can be viewed as an invariant characterizing the topological properties of the band. For a dimerized lattice, which models polyacetylene, we measure a difference of the Zak phase $\delta\varphi_{\text{Zak}} = 0.97(2)\pi$ for the two possible polyacetylene phases with different dimerization. The two dimerized phases therefore belong to different topological classes, such that for a filled band, domain walls have fractional quantum numbers. Our work establishes a new general approach for probing the topological structure of Bloch bands in optical lattices.

Nondestructive Detection of an Optical Photon
Andreas Reiserer, Stephan Ritter, Gerhard Rempe
Science, Vol. 342, pp. 1349
All optical detectors to date annihilate photons upon detection, thus excluding repeated measurements. Here, we demonstrate a robust photon detection scheme that does not rely on absorption. Instead, an incoming photon is reflected from an optical resonator containing a single atom prepared in a superposition of two states. The reflection toggles the superposition phase, which is then measured to trace the photon. Characterizing the device with faint laser pulses, a single-photon detection efficiency of 74% and a survival probability of 66% are achieved. The efficiency can be further increased by observing the photon repeatedly. The large single-photon nonlinearity of the experiment should enable the development of photonic quantum gates and the preparation of exotic quantum states of light.

Edge Physics of the Quantum Spin Hall Insulator from Quantum Dot Optical Absorption
Romain Vasseur, Joel E. Moore
arXiv:1312.3568
The gapless edge modes of the Quantum Spin Hall insulator form a helical liquid in which the direction of motion along the edge is determined by the spin orientation of the electrons. In order to probe the Luttinger liquid physics of these edge states and their interaction with a magnetic (Kondo) impurity, we consider a setup where the helical liquid is tunnel-coupled to a semiconductor quantum dot which is excited by optical absorption, thereby inducing an effective quantum quench of the tunneling. At low energy, the absorption spectrum is dominated by a power-law singularity. The corresponding exponent is directly related to the interaction strength (Luttinger parameter) and can be computed exactly using boundary conformal field theory thanks to the unique nature of the Quantum Spin Hall edge.

Inducing Spin Correlations and Entanglement in a Double Quantum Dot through Nonequilibrium Transport
C. A. Büsser and F. Heidrich-Meisner
Phys. Rev. Lett. 111, 246807 (2013)
For a double quantum dot system in a parallel geometry, we demonstrate that by combining the effects of a flux and driving an electrical current through the structure, the spin correlations between electrons localized in the dots can be controlled at will. In particular, a current can induce spin correlations even if the spins are uncorrelated in the initial equilibrium state. Therefore, we are able to engineer an entangled state in this double-dot structure. We take many-body correlations fully into account by simulating the real-time dynamics using the time-dependent density matrix renormalization group method. Using a canonical transformation, we provide an intuitive explanation for our results, related to Ruderman-Kittel-Kasuya-Yoshida physics driven by the bias.

Localized electron states near the armchair edge of graphene
P. A. Maksimov, A. V. Rozhkov, and A. O. Sboychakov
Phys. Rev. B 88, 245421 (2013)

It is known that zigzag graphene edge is able to support edge states: There is a nondispersive single-electron band localized near the zigzag edge. However, it is generally believed that no edge states exist near the unmodified armchair edge, while they do appear if the edge is subjected to suitable modifications (e.g., chemical functionalization). We explicitly present two types of edge modification which support the localized states. Unlike zigzag edge states, which have zero energy and show no dispersion, properties of the armchair localized states depend sensitively on the type of edge modification. Under suitable conditions they demonstrate pronounced dispersion. While the zigzag edge state wave function decays monotonously when we move away from the edge, the armchair edge state wave function shows nonmonotonous decay. Such states may be observed in scanning tunneling spectroscopy experimentally.

Coulomb interaction effects on the Majorana states in quantum wires
Andrei Manolescu, D. C. Marinescu, Tudor D. Stanescu
arXiv:1312.3888
The stability of the Majorana modes in the presence of a repulsive interaction is studied in the standard semiconductor wire - metallic superconductor configuration. The effects of short-range Coulomb interaction, which is incorporated using a purely repulsive δ-function to model the strong screening effect due to the presence of the superconductor, are determined within a Hartree-Fock approximation of the effective Bogoliubov-De Gennes Hamiltonian that describes the low-energy physics of the wire. Through a numerical diagonalization procedure we obtain interaction corrections to the single particle eigenstates and calculate the extended topological phase diagram in terms of the chemical potential and the Zeeman energy. We find that, for a fixed Zeeman energy, the interaction shifts the phase boundaries to a higher chemical potential, whereas for a fixed chemical potential this shift can occur either to lower or to higher Zeeman energies. This effects can be interpreted as a renormalization of the g-factor due to the interaction. The minimum Zeeman energy needed to realize Majorana fermions decreases with increasing the strength of the Coulomb repulsion. Furthermore, we find that in wires with multi-band occupancy this effect can be enhanced by increasing the chemical potential, i. e. by occupying higher energy bands.

Extreme Harmonic Generation in an Electrically Driven Spin Qubit
J. Stehlik, M. D. Schroer, M. Z. Maialle, M. H. Degani, J. R. Petta
arXiv:1312.3875
We report the observation of multiple harmonic generation in electric dipole spin resonance in an InAs nanowire double quantum dot. The harmonics display a remarkable detuning dependence: near the interdot charge transition as many as 8 harmonics are observed, while at large detunings we only observe the fundamental spin resonance condition. The detuning dependence indicates that the observed harmonics may be due to Landau-Zener dynamics at anti-crossings in the energy level spectrum. Numerical simulations support this observation.

Microwave manipulation of electrically injected spin polarized electrons in silicon
C. C. Lo, J. Li, I. Appelbaum, J. J. L. Morton
arXiv:1312.3663
We demonstrate microwave manipulation of the spin states of electrically injected spin-polarized electrons in silicon. Although the silicon channel is bounded by ferromagnetic metal films, we show that moderate microwave power can be applied to the devices without altering the device operation significantly. Resonant microwave irradiation is used to induce spin rotation of spin-polarized electrons as they travel across a silicon channel, and the resultant spin polarization is subsequently detected by a ferromagnetic Schottky barrier spin detector. These results demonstrate the potential for combining advanced electron spin resonance techniques to complement the study of semiconductor spintronic devices beyond standard magnetotransport measurements.

Time-Reversal Invariant Parafermions in Interacting Rashba Nanowires
Jelena Klinovaja, Daniel Loss
arXiv:1312.1998

Circuit QED with hole-spin qubits in Ge/Si nanowire quantum dots
Christoph Kloeffel, Mircea Trif, Peter Stano, and Daniel Loss
Phys. Rev. B 88, 241405(R) (2013)