Journal Club, 28^{th} August, 2012 (Rakesh Tiwari)

Odd-frequency superconducting pairing in topological insulators
Annica M. Black-Schaffer and Alexander V. Balatsky
arXiv:1208.4315
We discuss the appearance of odd-frequency spin-triplet s-wave superconductivity, first proposed by Berezinskii [*JETP* **20**, 287 (1974)], on the surface of a topological insulator proximity coupled to a conventional spin-singlet s-wave superconductor. Using both analytical and numerical methods we show that this disorder robust odd-frequency state is present whenever there is an in-surface gradient in the proximity induced gap, including superconductor-normal state (SN) junctions. The time-independent order parameter for the odd-frequency superconductor is proportional to the in-surface gap gradient. The induced odd-frequency component does not produce any low-energy states.

Synthetic Topological Degeneracy by Anyon Condensation
Yi-Zhuang You, Chao-Ming Jian, Xiao-Gang Wen
arXiv:1208.4109
Topological degeneracy is the degeneracy of the ground states in a many-body system in the large-system-size limit. Topological degeneracy cannot be lifted by any local perturbation of the Hamiltonian. The topological degeneracies on closed manifolds have been used to discover/define topological order in many-body systems, which contain excitations with fractional statistics. In this paper, we study a new type of topological degeneracy induced by condensing anyons along a line in 2D topological ordered states. Such topological degeneracy can be viewed as carried by each end of the line-defect, which is a generalization of Majorana zero-modes. The topological degeneracy can be used as a quantum memory. The ends of line-defects carry projective non-Abelian statistics, and braiding them allow us to perform fault tolerant quantum computations.

Magnetic field tuned dimensional crossover in spin-orbit coupled semiconductor nanowires with induced superconducting pairing
Tudor D. Stanescu, Roman M. Lutchyn, S. Das Sarma
arXiv:1208.4136
We show that the topological Majorana quasiparticles hosted by semiconductor nanowires much longer than the superconducting coherence length are adiabatically connected with discrete zero-energy states generically occurring in short nanowires. We demonstrate that these zero-energy crossings can be tuned by an external magnetic field and are protected by the particle-hole symmetry. We study the evolution of the low-energy spectrum as a function of the magnetic field, wire length, and chemical potential, manifestly establishing that the low-energy physics of short wires is directly related to that occurring in long nanowires. In the presence of finite energy resolution, invariably operational under experimental conditions, the near-zero-energy states of a short wire give rise to a zero bias conductance peak over a finite magnetic field range.

Rotational Quantum Friction
Rongkuo Zhao and J. B. Pendry
arXiv:1208.4232
We investigate the frictional forces due to quantum fluctuations, acting on a small sphere rotating near a surface. At zero temperature, we find the frictional force near a surface to be several orders of magnitude larger than that for the sphere rotating in vacuum. For metallic materials with typical conductivity, quantum friction is maximized by matching the frequency of rotation with the conductivity. Materials with poor conductivity are favored to obtain large quantum frictions. For semiconductor materials that are able to support surface plasmon polaritons, quantum friction can be further enhanced by several orders of magnitude due to the excitation of surface plasmon polaritons.

Catalyst-Free Growth of Millimeter-Long Topological Insulator Bi2Se3 Nanoribbons and the Observation of pi Berry Phase
L. Fang, Y. Jia, D. J. Miller, M. L. Latimer, Z. L. Xiao, U. Welp, G. W. Crabtree, W. -K. Kwok
arXiv:1208.4532
We report the growth of single-crystalline Bi2Se3 nanoribbons with lengths up to several millimeters via a catalyst-free physical vapor deposition method. Scanning transmission electron microscopy analysis reveals that the nanoribbons grow along the (1120) direction. We obtain a detailed characterization of the electronic structure of the Bi2Se3 nanoribbons from measurements of Shubnikov-de Haas (SdH) quantum oscillations. Angular dependent magneto-transport measurements reveal a dominant two-dimensional contribution originating from surface states and weak contribution from the bulk states. The catalyst-free synthesis yields high-purity nanocrystals enabling the observation of a large number of SdH oscillation periods and allowing for an accurate determination of the pi-Berry phase, one of the key features of Dirac fermions in topological insulators. The long-length nanoribbons can empower the potential for fabricating multiple nanoelectronic devices on a single nanoribbon.

Designing Topological Bands in Reciprocal Space
N. R. Cooper and R. Moessner
arXiv:1208.4579
Motivated by new capabilities to realise artificial gauge fields in ultracold atomic systems, and by their potential to access correlated topological phases in lattice systems, we present a new strategy for designing topologically non-trivial band structures. Our approach is simple and direct: it amounts to considering tight-binding models directly in reciprocal space. These models naturally cause atoms to experience highly uniform magnetic flux density and lead to topological bands with very narrow dispersion, without fine-tuning of parameters. Further, our construction immediately yields instances of optical Chern lattices, as well as band structures of higher Chern number, $\mid C \mid > 1$.

Why is the bulk resistivity of topological insulators so small?
Brian Skinner, Tianran Chen, and B. I. Shklovskii
arXiv:1208.4601
As-grown topological insulators (TIs) are typically heavily-doped n-type crystals. Compensation by acceptors is used to move the Fermi level to the middle of the band gap, but even then TIs have a frustratingly small bulk resistivity. We show that this small resistivity is the result of band bending by poorly screened fluctuations in the random Coulomb potential. Using numerical simulations of a completely compensated TI, we find that the bulk resistivity has an activation energy of just 0.15 times the band gap, in good agreement with experimental data. At lower temperatures activated transport crosses over to variable range hopping with a relatively large localization length.

Andreev current and subgap conductance of spin-valve SFF structures
A. S. Vasenko, A. Ozaeta, S. Kawabata, F. W. J. Hekking and F. S. Bergeret
arXiv:1208.4741
The Andreev current and the subgap conductance in a superconductor/ insulator/ ferromagnet (SIF) structure in the presence of a small spin-splitting field show novel interesting features (A. Ozaeta et al., Phys. Rev. B 86, 060509(R), 2012). For example, the Andreev current at zero temperature can be enhanced by a spin-splitting field h, smaller than the superconducting gap, as has been recently reported by the authors. Also at finite temperatures the Andreev current has a peak for values of the spin-splitting field close to the superconducting gap. Finally, the differential subgap conductance at low temperatures shows a peak at the bias voltage eV = h. In this paper we investigate the Andreev current and the subgap conductance in SFF structures with arbitrary direction of magnetization of the F layers. We show that all aforementioned features occur now at the value of the "effective field", which is the field acting on the Cooper pairs in the multi-domain ferromagnetic region, averaged over the decay length of the superconducting condensate into a ferromagnet. We also briefly discuss the heat transport and electron cooling in the considered structures.

Bose-Hubbard Models with Synthetic Spin-Orbit Coupling: Mott Insulators, Spin Textures, and Superfluidity
William S. Cole, Shizhong Zhang, Arun Paramekanti, and Nandini Trivedi
Phys. Rev. Lett. **109**, 085302 (2012)
Motivated by the experimental realization of synthetic spin-orbit coupling for ultracold atoms, we investigate the phase diagram of the Bose-Hubbard model in a non-Abelian gauge field in two dimensions. Using a strong coupling expansion in the combined presence of spin-orbit coupling and tunable interactions, we find a variety of interesting magnetic Hamiltonians in the Mott insulator (MI), which support magnetic textures such as spin spirals and vortex and Skyrmion crystals. An inhomogeneous mean-field treatment shows that the superfluid (SF) phases inherit these exotic magnetic orders from the MI and display, in addition, unusual modulated current patterns. We present a slave-boson theory which gives insight into such intertwined spin-charge orders in the SF, and discuss signatures of these orders in Bragg scattering, in situ microscopy, and dynamic quench experiments.

Mean-field analysis of spinor bosons in optical superlattices
Andreas Wagner, Andreas Nunnenkamp, and Christoph Bruder
Phys. Rev. A 86, 023624 (2012)