S. Sasaki, M. Kriener, K. Segawa, K. Yada, Y. Tanaka, M. Sato, and Y. Ando
Topological Superconductivity in $Cu_xBi_2Se_3$,
PRL **107**, 217001 (2011)
A topological superconductor (TSC) is characterized by the topologically protected gapless surface state that is essentially an Andreev bound state consisting of Majorana fermions. While a TSC has not yet been discovered, the doped topological insulator $Cu_xBi_2Se_3$, which superconducts below ~3 K, has been predicted to possess a topological superconducting state. We report that the point-contact spectra on the cleaved surface of superconducting $Cu_xBi_2Se_3$ present a zero-bias conductance peak (ZBCP) which signifies unconventional superconductivity. Theoretical considerations of all possible superconducting states help us conclude that this ZBCP is due to Majorana fermions and gives evidence for a topological superconductivity in $Cu_xBi_2Se_3$. In addition, we found an unusual pseudogap that develops below ~20 K and coexists with the topological superconducting state.

A. Yamakage, K. Yada, M. Sato, and Y. Tanaka
Topological Superconductivity in $Cu_xBi_2Se_3$,
arXiv:1112.5036v3 (2012)
We develop a theory of the tunneling spectroscopy for superconducting topological insulators (STIs), where the surface Andreev bound states (SABSs) appear as helical Majorana fermions. Based on the symmetry and topological nature of parent topological insulators, we find that the SABSs in the STIs have a profound structural transition in the energy dispersions. The transition results in a variety of Majorana fermions, by tuning the chemical potential and the effective mass of the energy band. We clarify that Majorana fermions in the vicinity of the transitions give rise to robust zero bias peaks in the tunneling conductance between normal metal/STI junctions.

X. Zhang, C.-L. Hung, S.-K. Tung, C. Chin
Observation of Quantum Criticality with Ultracold Atoms in Optical Lattices,
Science **335**, 1070 (2012)
Quantum criticality emerges when a many-body system is in the proximity of a continuous phase transition that is driven by quantum fluctuations. In the quantum critical regime, exotic, yet universal properties are anticipated; ultracold atoms provide a clean system to test these predictions. We report the observation of quantum criticality with two-dimensional Bose gases in optical lattices. On the basis of in situ density measurements, we observe scaling behavior of the equation of state at low temperatures, locate the quantum critical point, and constrain the critical exponents. We observe a finite critical entropy per particle that carries a weak dependence on the atomic interaction strength. Our experiment provides a prototypical method to study quantum criticality with ultracold atoms.

J. Erhart, S. Sponar, G. Sulyok, G. Badurek, M. Ozawa, and Y. Hasegawa
Experimental demonstration of a universally valid error–disturbance uncertainty relation in spin measurements,
Nat. Phys. **8**, 185 (2012)
The uncertainty principle generally prohibits simultaneous measurements of certain pairs of observables and forms the basis of indeterminacy in quantum mechanics. Heisenberg's original formulation, illustrated by the famous γ-ray microscope, sets a lower bound for the product of the measurement error and the disturbance. Later, the uncertainty relation was reformulated in terms of standard deviations, where the focus was exclusively on the indeterminacy of predictions, whereas the unavoidable recoil in measuring devices has been ignored. A correct formulation of the error–disturbance uncertainty relation, taking recoil into account, is essential for a deeper understanding of the uncertainty principle, as Heisenberg's original relation is valid only under specific circumstances. A new error–disturbance relation, derived using the theory of general quantum measurements, has been claimed to be universally valid. Here, we report a neutron-optical experiment that records the error of a spin-component measurement as well as the disturbance caused on another spin-component. The results confirm that both error and dis- turbance obey the new relation but violate the old one in a wide range of an experimental parameter.

J. Pollanen, J.I.A. Li, C.A. Collett, W.J. Gannon, W.P. Halperin, and J.A. Sauls
New chiral phases of superfluid ^{3}He stabilized by anisotropic silica aerogel,
Nat. Phys. ADVANCE ONLINE PUBLICATION (2012)
Recent experiments have observed bulk superconductivity in doped topological insulators. Here we ask whether vortex Majorana zero modes, previously predicted to occur when s-wave superconductivity is induced on the surface of topological insulators, survive in these doped systems with metallic normal states. Assuming inversion symmetry, we find that they do but only below a critical doping. The critical doping is tied to a topological phase transition of the vortex line, at which it supports gapless excitations along its length. The critical point depends only on the vortex orientation and a suitably defined SU(2) Berry phase of the normal state Fermi surface. By calculating this phase for available band structures we determine that superconducting p-doped Bi_2Te_3, among others, supports vortex end Majorana modes. Surprisingly, superconductors derived from topologically trivial band structures can support Majorana modes too.

J.-P. Brantut, J. Meineke, D. Stadler, S. Krinner, and T. Esslinger
Conduction of Ultracold Fermions Through a Mesoscopic Channel,
arXiv:1203.1927v1
In a mesoscopic conductor electric resistance is detected even if the device is defect-free. We engineer and study a cold-atom analog of a mesoscopic conductor. It consists of a narrow channel connecting two macroscopic reservoirs of fermions that can be switched from ballistic to diffusive. We induce a current through the channel and find ohmic conduction, even for a ballistic channel. An analysis of in-situ density distributions shows that in the ballistic case the dissipation is localized at the entrance and exit of the channel, revealing the presence of contact resistance. In contrast, a diffusive channel with disorder displays dissipation over the whole channel. Our approach opens the way towards quantum simulation of mesoscopic devices with quantum gases.

N. Brunner, J. Sharam, and T. Vértesi
Testing the Structure of Multipartite Entanglement with Bell Inequalities
PRL 108, 110501 (2011)
We show that the rich structure of multipartite entanglement can be tested following a device-independent approach. Specifically we present Bell inequalities for distinguishing between different types of multipartite entanglement, without placing any assumptions on the measurement devices used in the protocol, in contrast with usual entanglement witnesses. We first address the case of three qubits and present Bell inequalities that can be violated by W states but not by Greenberger-Horne-Zeilinger states, and vice versa. Next, we devise 'subcorrelation Bell inequalities' for any number of parties, which can provably not be violated by a broad class of multipartite entangled states (generalizations of Greenberger-Horne-Zeilinger states), but for which violations can be obtained for W states. Our results give insight into the nonlocality of W states. The simplicity and robustness of our tests make them appealing for experiments

L. Britnell, R.V. Gorbachev, R. Jalil, B.D. Belle, F. Schedin, A. Mishchenko, T. Georgiou, M.I. Katsnelson, L. Eaves, S.V. Morozov, N.M.R. Peres, J. Leist, A.K. Geim, K.S. Novoselov, L.A. Ponomarenko
Field-Effect Tunneling Transistor Based on Vertical Graphene Heterostructures,
Science **335**, 947
We investigate nuclear magnetic resonance (NMR) in near zero field, where the Zeeman interaction can be treated as a perturbation to the electron mediated scalar interaction (J coupling). This is in stark contrast to the high-field case, where heteronuclear J couplings are normally treated as a small perturbation. We show that the presence of very small magnetic fields results in splitting of the zero-field NMR lines, imparting considerable additional information to the pure zero-field spectra. Experimental results are in good agreement with first-order perturbation theory and with full numerical simulation when perturbation theory breaks down. We present simple rules for understanding the splitting patterns in near-zero-field NMR, which can be applied to molecules with nontrivial spectra.