Quantum Magnetomechanics with Levitating Superconducting Microspheres
O. Romero-Isart, L. Clemente, C. Navau, A. Sanchez, J. I. Cirac, arXiv:1112.5609v1 [quant-ph]

We show that by magnetically trapping a superconducting microsphere close to a quantum circuit, it is experimentally feasible to perform ground state cooling and to prepare quantum superpositions of the center-of-mass motion of the microsphere. Due to the absence of clamping losses and time dependent electromagnetic fields, the mechanical motion of micrometer-sized metallic spheres in the Meissner state is predicted to be extremely well isolated from the environment. Hence, we propose to combine the technology of magnetic mictrotraps and superconducting qubits to bring relatively large objects to the quantum regime.

Synthetic 3D Spin-Orbit Coupling
Brandon M. Anderson, Gediminas Juzelinas, Ian B. Spielman, Victor M. Galitski, arXiv:1112.6022v1 [cond-mat.quant-gas]

We describe a method for creating a three-dimensional analogue to Rashba spin-orbit coupling in systems of ultracold atoms. This laser induced coupling uses Raman transitions to link four internal atomic states with a tetrahedral geometry, and gives rise to a Dirac point that is robust against environmental perturbations. We present an exact result showing that such a spin-orbit coupling in a fermionic system always rise to a molecular bound state.

AC Josephson effect in finite-length nanowire junctions with Majorana modes
Pablo San-Jose, Elsa Prada, Ramon Aguado, arXiv:1112.5983v1 [cond-mat.mes-hall]

It has been predicted that superconducting junctions made with topological nanowires hosting Majorana fermions exhibit an exotic Josephson effect which, owing to fermionic parity conservation, is 4π-periodic in the superconducting phase difference. Finding an experimental setup with these unconventional properties poses, however, a serious challenge: for finite-length junctions, the equilibrium supercurrents are always 2π-periodic as anticrossings of states with the same parity are possible. Landau-Zener transitions, induced by a dc bias voltage, are a conceivable route to revealing the 4π-effect. However, inelastic processes are expected to induce parity-mixing quasiparticle poisoning and hence destroy the anomalous periodicity. We here demonstrate that this intuition may be wrong: the ac Josephson current retains its anomalous 4π-periodic components during long-lived transients in the topological phase. Remarkably, quasiparticle escape towards the contacts can induce a quantum Zeno effect which fixes the parity of the Majorana logical qubits and delays the decay of transients. Hence, transient spectral properties may be effectively used to detect Majorana states.

Implementation of a Toffoli gate with superconducting circuits
A. Fedorov, L. Steffen, M. Baur, M. P. da Silva & A. Wallraff, Nature (2011), doi:10.1038/nature10713

The Toffoli gate is a three-quantum-bit (three-qubit) operation that inverts the state of a target qubit conditioned on the state of two control qubits. It makes universal reversible classical computation possible and, together with a Hadamard gate, forms a universal set of gates in quantum computation. It is also a key element in quantum error correction schemes. The Toffoli gate has been implemented in nuclear magnetic resonance, linear optics and ion trap systems. Experiments with superconducting qubits have also shown significant progress recently: two-qubit algorithms and two-qubit process tomography have been implemented, three-qubit entangled states have been prepared, first steps towards quantum teleportation have been taken and work on quantum computing architectures has been done. Implementation of the Toffoli gate with only single- and two-qubit gates requires six controlled-NOT gates and ten single-qubit operations, and has not been realized in any system owing to current limits on coherence. Here we implement a Toffoli gate with three superconducting transmon qubits coupled to a microwave resonator. By exploiting the third energy level of the transmon qubits, we have significantly reduced the number of elementary gates needed for the implementation of the Toffoli gate, relative to that required in theoretical proposals using only two-level systems. Using full process tomography and Monte Carlo process certification, we completely characterize the Toffoli gate acting on three independent qubits, measuring a fidelity of 68.50.5 per cent. A similar approach to realizing characteristic features of a Toffoli-class gate has been demonstrated with two qubits and a resonator and achieved a limited characterization considering only the phase fidelity. Our results reinforce the potential of macroscopic superconducting qubits for the implementation of complex quantum operations with the possibility of quantum error correction.

Entanglement can Completely Defeat Quantum Noise
Jianxin Chen, Toby S. Cubitt, Aram W. Harrow, and Graeme Smith, Phys. Rev. Lett. 107, 250504 (2011)

We describe two quantum channels that individually cannot send any classical information without some chance of decoding error. But together a single use of each channel can send quantum information perfectly reliably. This proves that the zero-error classical capacity exhibits superactivation, the extreme form of the superadditivity phenomenon in which entangled inputs allow communication over zero-capacity channels. But our result is stronger still, as it even allows zero-error quantum communication when the two channels are combined. Thus our result shows a new remarkable way in which entanglement across two systems can be used to resist noise, in this case perfectly. We also show a new form of superactivation by entanglement shared between sender and receiver.

Coulomb Oscillations in Antidots in the Integer and Fractional Quantum Hall Regimes
A. Kou, C. M. Marcus, L. N. Pfeiffer, K. W. West, arXiv:1201.1600v1 [cond-mat.mes-hall]

We report measurements of resistance oscillations in micron-scale antidots in both the integer and fractional quantum Hall regimes. In the integer regime, we conclude that oscillations are of the Coulomb type from the scaling of magnetic field period with the number of edges bound to the antidot. Based on both gate-voltage and field periods, we find at filling factor $\nu = 2$ a tunneling charge of e and two charged edges. Generalizing this picture to the fractional regime, we find (again, based on field and gate-voltage periods) at $\nu = 2/3$ a tunneling charge of (2/3)e and a single charged edge.

Phenomenology and Dynamics of Majorana Josephson Junction
D. I. Pikulin, Yuli V. Nazarov,arXiv:1112.6368v1 [cond-mat.supr-con]

We derive a generic phenomenological model of a Majorana Josephson junction that accounts for avoided crossing of Andreev states, and investigate its dynamics at constant bias voltage to reveal an unexpected pattern of any-π Josephson effect in the limit of slow decoherence.

Composite fermions description of fractional topological insulators
Dario Ferraro, Giovanni Viola, arXiv:1112.5399v1 [cond-mat.str-el]

We propose an alternative formulation of the Levin-Stern criterion for the robustness of the edge states of Abelian fractional topological insulators in terms of a $\mathbb{Z}_2$ classification of composite fermions. We consider the standard toy model where spin up and spin down electrons are subjected to opposite magnetic fields. In this model electrons of the same spin interact via a repulsive force, while electrons of different spin do not interact. By applying the composite fermions approach to this time-reversal symmetric system, we are able to obtain a hierarchy of topological insulators with spin Hall conductance $\sigma_s = \frac{e}{2\pi}\frac{p}{2mp+1}$, being $p, m \in \mathbb{N}$. They show stable edge states only for odd p, as a consequence of the Kramer's theorem.

Electric-Field Induced Majorana Fermions in Armchair Carbon Nanotubes
Jelena Klinovaja, Suhas Gangadharaiah, Daniel Loss, arXiv:1201.0159v1 [cond-mat.mes-hall]

We consider theoretically an armchair Carbon nanotube (CNT) in the presence of an electric field and in contact with an s-wave superconductor. We show that the proximity effect opens up superconducting gaps in the CNT of different strengths for the exterior and interior branches of the two Dirac points. For strong proximity induced superconductivity the interior gap can be of the p-wave type, while the exterior gap can be tuned by the electric field to be of the s-wave type. Such a setup supports a single Majorana bound state at each end of the CNT. In the case of a weak proximity induced superconductivity, the gaps in both branches are of the p-wave type. However, the temperature can be chosen in such a way that the smallest gap is effectively closed. Using renormalization group techniques we show that the Majorana bound states exist even after taking into account electron-electron interactions.

Material- and geometry-independent multishell cloaking device Pattabhiraju C. Mundru, Venkatesh Pappakrishnan, and Dentcho A. Genov, Phys. Rev. B 85, 045402 (2012)

In this paper we propose a multishell generic cloaking system. A transparency condition independent of the object's optical and geometrical properties is proposed in the quasistatic regime of operation. The suppression of dipolar scattering is demonstrated in both cylindrically and spherically symmetric systems. A realistic tunable low-loss shell design is proposed based on a composite metal-dielectric shell. The effects due to dissipation and dispersion on the overall scattering cross section are thoroughly evaluated. It is shown that a strong reduction of scattering by a factor of up to 103 can be achieved across the entire optical spectrum. Full wave numerical simulations for complex shaped particles are performed validating the analytical theory. The proposed design does not require optical magnetism and is generic in the sense that it is independent of the object's material and geometrical properties.

Demonstration of temporal cloaking Moti Fridman, Alessandro Farsi, Yoshitomo Okawachi & Alexander L. Gaeta, Nature 481, 6265 (2012), doi:10.1038/nature10695

Recent research has uncovered a remarkable ability to manipulate and control electromagnetic fields to produce effects such as perfect imaging and spatial cloaking. To achieve spatial cloaking, the index of refraction is manipulated to flow light from a probe around an object in such a way that a hole in space is created, and the object remains hidden. Alternatively, it may be desirable to cloak the occurrence of an event over a finite time period, and the idea of temporal cloaking has been proposed in which the dispersion of the material is manipulated in time, producing a time hole in the probe beam to hide the occurrence of the event from the observer. This approach is based on accelerating the front part of a probe light beam and slowing down its rear part to create a well controlled temporal gapinside which an event occurssuch that the probe beam is not modified in any way by the event. The probe beam is then restored to its original form by the reverse manipulation of the dispersion. Here we present an experimental demonstration of temporal cloaking in an optical fibre-based system by applying concepts from the spacetime duality between diffraction and dispersive broadening. We characterize the performance of our temporal cloak by detecting the spectral modification of a probe beam due to an optical interaction and show that the amplitude of the event (at the picosecond timescale) is reduced by more than an order of magnitude when the cloak is turned on. These results are a significant step towards the development of full spatio-temporal cloaking.