Observation of Radiation Pressure Shot Noise
T. P. Purdy, R. W. Peterson, and C. A. Regal, arXiv:1209.6334v1 [quant-ph]
The quantum mechanics of position measurement of a macroscopic object is typically inaccessible due to strong environmental coupling and classical noise. Here we show that a micromechanical mem- brane resonator subject to an increasingly strong continuous position measurement exhibits a quantum mechanical back action force that rises in accordance with the Heisenberg uncertainty relation. For our optically-based position measurements, the specific form of the back action is that of a fluctuating radia- tion pressure from the Poisson-distributed photons in the coherent measurement field, termed radiation pressure shot noise. We demonstrate a radiation pressure shot noise drive that is comparable in magni- tude to the thermal forces in our system. Additionally, we observe a temporal correlation between the fluctuations in radiation force and position of the resonator that may also be interpreted as a quantum non-demolition measurement of the photon field.

Achieving steady-state entanglement of remote micromechanical oscillators by cascaded cavity coupling
Huatang Tan, L. F. Buchmann, H. Seok, Gaoxiang Li, arXiv:1210.2345v1 [quant-ph]
In this paper, we propose a scheme for generating steady-state entanglement of remote micromechanical oscillators in unidirectionally-coupled cavities. For the system of two mechanical oscillators, we show that when two cavity modes in each cavity are driven at red- and blue-detuned sidebands, respectively, a stationary two-mode squeezed vacuum state of the two mechanical oscillators can be generated with the help of the cavity dissipation. The degree of squeezing is controllable by adjusting the relative strength of the pump lasers. Our calculations also show that the achieved mechanical entanglement is robust against thermal fluctuations of phononic environments. For the case of multiple mechanical oscillators, we find that the steady-state genuine multipartite entanglement can also be built up among the remote mechanical oscillators by the cavity dissipation. The present scheme does not require nonclassical light input or conditional quantum measurements, and it can be realized with current experimental technology.

Nanoscale Torsional Optomechanics
P.H. Kim, C. Doolin, B.D. Hauer, A.J.R. MacDonald, M.R. Freeman, P.E. Barclay, J.P. Davis
arXiv:1210.1852 [cond-mat.mes-hall]
*Optomechanical transduction is demonstrated for nanoscale torsional resonators evanescently coupled to optical microdisk whispering gallery mode resonators. The on-chip, integrated devices are measured using a fully fiber-based system, including a tapered and dimpled optical fiber probe. With a thermomechanically calibrated optomechanical noise floor down to 7 $fm/\sqrt{Hz}$, these devices open the door for a wide range of physical measurements involving extremely small torques, as little as 4×10^{-20} N*m.*

Photon-phonon entanglement in coupled optomechanical arrays
Uzma Akram, William Munro, Kae Nemoto, and G. J. Milburn, Phys. Rev. A 86, 042306 (2012)
We consider an array of three optomechanical cavities coupled either reversibly or irreversibly to each other and calculate the amount of entanglement between the different optical and mechanical modes. We show that the composite system exhibits intercavity photon-phonon entanglement.

Circuit QED with fluxonium qubits: theory of the dispersive regime
Guanyu Zhu, David G. Ferguson, Vladmir E. Manucharyan, Jens Koch, arXiv:1210.1605 [cond-mat.mes-hall]
In circuit QED, protocols for quantum gates and readout of superconducting qubits often rely on the dispersive regime, reached when the qubit-photon detuning Δ is large compared to their mutual coupling strength. For qubits including the Cooper-pair box and transmon, selection rules dramatically restrict the contributions to dispersive level shifts χ. By contrast, without selection rules many virtual transitions contribute to χ and can produce sizable dispersive shifts even at large detuning. We present theory for a generic multi-level qudit capacitively coupled to one or multiple harmonic modes, and give general expressions for the effective Hamiltonian in second and fourth order perturbation theory. Applying our results to the fluxonium system, we show that the absence of strong selection rules explains the surprisingly large dispersive shifts observed in experiments and also leads to the prediction of a two-photon vacuum Rabi splitting. Quantitative predictions from our theory are in good agreement with experimental data over a wide range of magnetic flux and reveal that fourth-order resonances are important for the phase modulation observed in fluxonium spectroscopy.

Thermal emission in the ultrastrong coupling regime
A. Ridolfo, M. Leib, S. Savasta, M. J. Hartmann, arXiv:1210.2318 [quant-ph]
We study thermal emission of a cavity quantum electrodynamic system in the ultrastrong-coupling regime where the atom-cavity coupling rate becomes comparable the cavity resonance frequency. In this regime, the standard descriptions of photodetection and dissipation fail. Following an approach that was recently put forward by Ridolfo et al.[arXiv:1206.0944], we are able to calculate the emission of systems with arbitrary strength of light matter interaction, by expressing the electric field operator in the cavity-emitter dressed basis. Here we present thermal photoluminescence spectra, calculated for given temperatures and for different couplings in particular for available circuit QED parameters.

Robust Quantum Gates for a Singlet-Triplet Spin Qubit
Hugo Ribeiro, J. R. Petta, Guido Burkard, arXiv:1210.1957 [cond-mat.mes-hall]
We show that universal quantum control of a two-electron singlet-triplet spin qubit can be achieved using Landau-Zener-Stückelberg interferometry. Going beyond normal Landau-Zener dynamics with infinitely long constant velocity sweeps across an energy level anti-crossing, we focus on a physical system consisting of a two-electron double quantum dot, where the spin states can be admixtures of charge states and the level velocity can be tuned in a time-dependent fashion. Our results indicate that charge coherence must be treated on an equal footing with spin coherence. In particular, we predict the presence of finite-time effects, which result in population transfer even in cases of an incomplete sweep through the anti-crossing. The competing requirements of adiabaticity and coherence are reconciled using specially designed pulses with a tunable level velocity. As a relevant example, we demonstrate that a Hadamard gate can be implemented for a realistic set of conditions in a GaAs double quantum dot device.

Renormalization effects in interacting quantum dots coupled to superconducting leads
David Futterer, Jacek Swiebodzinski, Michele Governale, Jürgen König, arXiv:1210.2267 [cond-mat.mes-hall]
We study subgap transport through an interacting quantum dot tunnel coupled to one normal and two superconducting leads. To check the reliability of an approximation of an infinitely-large gap Δ in the superconducting leads and weak tunnel coupling to the normal lead, we perform a $1/\Delta$ expansion, and we analyze next-to-leading order corrections in the tunnel coupling to the normal lead. Furthermore, we propose a resummation approach to calculate the Andreev bound states for finite Δ. The results are substantially more accurate than those obtained by mean-field treatments and favorably compare with numerical exact results.

Inelastic magnetic scattering effect on LDOS of topological insulators
Peter Thalmeier, Alireza Akbari, arXiv:1210.2222 [cond-mat.mes-hall]
Magnetic ions such as Fe, Mn and Co with localized spins may be adsorbed on the surface of topological insulators like Bi2Se3. They form scattering centers for the helical surface states which have a Dirac cone dispersion as long as the local spins are disordered. However, the local density of states (LDOS) may be severely modified by the formation of bound states. Commonly only elastic scattering due to normal and exchange potentials of the adatom is assumed. Magnetization measurements show, however, that considerable magnetic single ion anisotropies exist which lead to a splitting of the local impurity spin states resulting in a singlet ground state. Therefore inelastic scattering processes of helical Dirac electrons become possible as described by a dynamical local self energy of second order in the exchange interaction. It influences bound state formation and leads to significant new anomalies in the LDOS at low energies and low temperatures which we calculate within T-matrix approach. We propose that they may be used for spectroscopy of local impurity spin states by appropriate tuning of chemical potential and magnetic field.

The fractional a.c. Josephson effect in a semiconductor–superconductor nanowire as a signature of Majorana particles
Leonid P. Rokhinson, Xinyu Liu, Jacek K. Furdyna, Nature Physics, doi:10.1038/nphys2429
Topological superconductors that support Majorana fermions have been predicted when one-dimensional semiconducting wires are coupled to a superconductor. Such excitations are expected to exhibit non-Abelian statistics and can be used to realize quantum gates that are topologically protected from local sources of decoherence. Here we report the observation of the fractional a.c. Josephson effect in a hybrid semiconductor–superconductor InSb/Nb nanowire junction, a hallmark of topological matter. When the junction is irradiated with a radiofrequency f_0 in the absence of an external magnetic field, quantized voltage steps (Shapiro steps) with a height $\Delta V = hf_0/2e$ are observed, as is expected for conventional superconductor junctions, where the supercurrent is carried by charge- 2e Cooper pairs. At high magnetic fields the height of the first Shapiro step is doubled to hf_0/e, suggesting that the supercurrent is carried by charge- e quasiparticles. This is a unique signature of the Majorana fermions, predicted almost 80 years ago.

Valley-based field-effect transistors in graphene
M.-K. Lee, N.-Y. Lue, C.-K. Wen, and G. Y. Wu, Phys. Rev. B 86, 165411 (2012)

Probing graphene grain boundaries with optical microscopy
Dinh Loc Duong *et al.*, Nature, doi:10.1038/nature11562

Experimental realization of a topological crystalline insulator in SnTe
Y. Tanaka, Zhi Ren, T. Sato, K. Nakayama, S. Souma, T. Takahashi, Kouji Segawa , Yoichi Ando, Nature Physics, doi:10.1038/nphys2442

Testing Planck-Scale Gravity with Accelerators
Vahagn Gharibyan, Phys. Rev. Lett. 109, 141103 (2012)