arXiv:1111.0776: **Light-cone-like spreading of correlations in a quantum many-body system**
Marc Cheneau, Peter Barmettler, Dario Poletti, Manuel Endres, Peter Schauß, Takeshi Fukuhara, Christian Gross, Immanuel Bloch, Corinna Kollath, Stefan Kuhr

How fast can correlations spread in a quantum many-body system? Based on the seminal work by Lieb and Robinson, it has recently been shown that several interacting many-body systems exhibit an effective light cone that bounds the propagation speed of correlations. The existence of such a "speed of light" has profound implications for condensed matter physics and quantum information, but has never been observed experimentally. Here we report on the time-resolved detection of propagating correlations in an interacting quantum many-body system. By quenching a one-dimensional quantum gas in an optical lattice, we reveal how quasiparticle pairs trans-port correlations with a finite velocity across the system, resulting in an effective light cone for the quantum dynamics. Our results open important perspectives for understanding relaxation of closed quantum systems far from equilibrium as well as for engineering efficient quantum channels necessary for fast quantum computations.

Nature 479, 376: **Observation of the dynamical Casimir effect in a superconducting circuit**
C. M. Wilson, G. Johansson, A. Pourkabirian, M. Simoen, J. R. Johansson, T. Duty, F. Nori & Delsing

… Forty years ago, it was suggested that a mirror undergoing relativistic motion could convert virtual photons into directly observable real photons. The phenomenon, later termed the dynamical Casimir effect, has not been demonstrated previously. Here we observe the dynamical Casimir effect in a superconducting circuit consisting of a coplanar transmission line with a tunable electrical length. The rate of change of the electrical length can be made very fast (a substantial fraction of the speed of light) by modulating the inductance of a superconducting quantum interference device at high frequencies (>10 gigahertz). In addition to observing the creation of real photons, we detect two-mode squeezing in the emitted radiation, which is a signature of the quantum character of the generation process.

Phys. Rev. Lett. 107, 213604 (2011): **Dissipative Optomechanics in a Michelson-Sagnac Interferometer**
André Xuereb, Roman Schnabel, and Klemens Hammerer

Dissipative optomechanics studies the coupling of the motion of an optical element to the decay rate of a cavity. We propose and theoretically explore a realization of this system in the optical domain, using a combined Michelson-Sagnac interferometer, which enables a strong and tunable dissipative coupling. Quantum interference in such a setup results in the suppression of the lower motional sideband, leading to strongly enhanced cooling in the non-sideband-resolved regime. With state-of-the-art parameters, ground-state cooling and low-power quantum-limited position transduction are both possible. The possibility of a strong, tunable dissipative coupling opens up a new route towards observation of such fundamental optomechanical effects as nonlinear dynamics. Beyond optomechanics, the suggested method can be readily transferred to other setups involving nonlinear media, atomic ensembles, or single atoms.

Phys. Rev. Lett. 107, 210404 (2011): **Practical Characterization of Quantum Devices without Tomography**
Marcus P. da Silva, Olivier Landon-Cardinal, and David Poulin

Quantum tomography is the main method used to assess the quality of quantum information processing devices. However, the amount of resources needed for quantum tomography is exponential in the device size. Part of the problem is that tomography generates much more information than is usually sought. Taking a more targeted approach, we develop schemes that enable (i) estimating the fidelity of an experiment to a theoretical ideal description, (ii) learning which description within a reduced subset best matches the experimental data. Both these approaches yield a significant reduction in resources compared to tomography…

Phys. Rev. Lett. 107, 210501 (2011): **Topological Order at Nonzero Temperature**
Matthew B. Hastings

We propose a definition for topological order at nonzero temperature in analogy to the usual zero temperature definition that a state is topologically ordered, or nontrivial, if it cannot be transformed into a product state (or a state close to a product state) using a local (or approximately local) quantum circuit. We prove that any two-dimensional Hamiltonian which is a sum of commuting local terms is not topologically ordered at T>0. We show that such trivial states cannot be used to store quantum information using certain stringlike operators. This definition is not too restrictive, however, as the four dimensional toric code does have a nontrivial phase at nonzero temperature.

arXiv:1111.3834: **Fundamental limitations for quantum- and nano-thermodynamics**
Michał Horodecki, Jonathan Oppenheim

The relationship between thermodynamics and statistical physics is valid in the thermodynamic limit -- when the number of particles involved becomes very large. Here we study thermodynamics in the opposite regime -- at both the nano scale, and when quantum effects become important. Applying results from quantum information theory we construct a theory of thermodynamics in these extreme limits. In the quantum regime, we find that the standard free energy no longer determines the amount of work which can be extracted from a resource, nor which state transitions can occur spontaneously. We derive a criteria for thermodynamical state transitions, and find two free energies: one which determines the amount of work which can be extracted from a small system in contact with a heat bath, and the other which quantifies the reverse process. … This implies that thermodynamical transitions are generically irreversible at this scale, and we quantify the degree to which this is so, and the condition for reversibility to hold. There are particular equilibrium processes which approach the ideal efficiency, provided that certain special conditions are met.

Phys. Rev. Lett. 107, 217401 (2011): **Microwave Photon Counter Based on Josephson Junctions**
Y.-F. Chen, D. Hover, S. Sendelbach, L. Maurer, S. T. Merkel, E. J. Pritchett, F. K. Wilhelm, and R. McDermott

We describe a microwave photon counter based on the current-biased Josephson junction. The junction is tuned to absorb single microwave photons from the incident field, after which it tunnels into a classically observable voltage state. Using two such detectors, we have performed a microwave version of the Hanbury Brown–Twiss experiment at 4 GHz and demonstrated a clear signature of photon bunching for a thermal source. The design is readily scalable to tens of parallelized junctions, a configuration that would allow number-resolved counting of microwave photons.

Phys. Rev. B 84, 184515 (2011) [Editors' Suggestion]: **Coherent control of a superconducting qubit with dynamically tunable qubit-cavity coupling** by A. J. Hoffman, S. J. Srinivasan, J. M. Gambetta, and A. A. Houck

We demonstrate coherent control and measurement of a superconducting qubit coupled to a superconducting coplanar waveguide resonator with a dynamically tunable qubit-cavity coupling strength. Rabi oscillations are measured for several coupling strengths showing that the qubit transition can be turned off by a factor of more than 1500. We show how the qubit can still be accessed in the off state via fast flux pulses. We perform pulse delay measurements with synchronized fast flux pulses on the device and observe T1 and T2 times of 1.6 and 1.9 μs, respectively. This work demonstrates how this qubit can be incorporated into quantum architectures.

Phys. Rev. B 84, 180509(R): **Majorana fermions in spin-orbit-coupled ferromagnetic Josephson junctions**
Annica M. Black-Schaffer and Jacob Linder

We study all possible Majorana modes in two-dimensional spin-orbit-coupled ferromagnetic superconductor–normal state–superconductor (SNS) Josephson junctions and propose experiments to detect them. With the S region in a nontrivial topological phase and a superconducting phase difference $\phi = \pi$ across the junction, two delocalized Majorana fermions with no excitation gap appear in the N region. In addition, if S and N belong to different topological phases and have well separated the Fermi surfaces, localized Majorana fermions with a finite excitation gap also emerge at both SN interfaces for all ϕ.

arXiv:1111.3965: **Quantum measurement occurrence is undecidable**
J. Eisert, M. P. Mueller, C. Gogolin

A famous result by Alan Turing dating back to 1936 is that a general algorithm solving the halting problem on a Turing machine for all possible inputs and programs cannot exist - the halting problem is undecidable. Formally, an undecidable problem is a decision problem for which one cannot construct a single algorithm that will always provide a correct answer in finite time. In this work, we show that surprisingly, very natural, apparently simple problems in quantum measurement theory can be undecidable even if their classical analogues are decidable. Undecidability appears as a genuine quantum property. The problem we consider is to determine whether sequentially used identical Stern-Gerlach-type measurement devices, giving rise to a tree of possible outcomes, have outcomes that never occur. Finally, we point out implications for measurement-based quantum computing and studies of quantum many-body models and suggest that a plethora of problems may indeed be undecidable.