PRL 112, 013601: **Single-Polariton Optomechanics**
Juan Restrepo, Cristiano Ciuti, and Ivan Favero
This Letter investigates a hybrid quantum system combining cavity quantum electrodynamics and optomechanics. The Hamiltonian problem of a photon mode coupled to a two-level atom via a Jaynes- Cummings coupling and to a mechanical mode via radiation pressure coupling is solved analytically. The atom-cavity polariton number operator commutes with the total Hamiltonian leading to an exact description in terms of tripartite atom-cavity-mechanics polarons. We demonstrate the possibility to obtain cooling of mechanical motion at the single-polariton level and describe the peculiar quantum statistics of phonons in such an unconventional regime.

PRL 112, 023603: **Generalized Dicke Nonequilibrium Dynamics in Trapped Ions**
Sam Genway, Weibin Li, Cenap Ates, Benjamin P. Lanyon, and Igor Lesanovsky
We explore trapped ions as a setting to investigate non-equilibrium phases in a generalized Dicke model of dissipative spins coupled to phonon modes. We find a rich dynamical phase diagram including superradiant-like regimes, dynamical phase coexistence, and phonon-lasing behavior. A particular advantage of trapped ions is that these phases and transitions among them can be probed in situ through fluorescence. We demonstrate that the main physical insights are captured by a minimal model and consider an experimental realization with Ca+ ions trapped in a linear Paul trap with a dressing scheme to create effective two-level systems with a tunable rate.

Science Express: **Discovery of a Three-Dimensional Topological Dirac Semimetal Na3Bi** by Z. K. Liu, B. Zhou, Y. Zhang, H. M. Weng, D. Prabhakaran, S.-K. Mo, Z. X. Shen, Z. Fang, X. Dai, Z. Hussain, and Y. L. Chen
Three-dimensional (3D) topological Dirac semimetals (TDSs) represent a novel state of quantum matter that can be viewed as 3D graphene. In contrast to two-dimensional (2D) Dirac fermions in graphene on the surface of 3D topological insulators, TDSs possess 3D Dirac fermions in the bulk. By investigating the electronic structure of Na3Bi with angle resolved photoemission spectroscopy, we discovered 3D Dirac fermions with linear dispersions along all momentum directions. Furthermore, we demonstrated the robustness of 3D Dirac fermions in Na3Bi against in situ surface doping. Our results establish Na3Bi as a model system of 3D TDSs, which can serve as an ideal platform for the systematic study of quantum phase transitions between rich topological states.

Nat Phys: **Real-space tailoring of the electron–phonon coupling in nanotube mechanical resonators**
A. Benyamini, A. Hamo, S. Viola Kusminskiy, F. von Oppen and S. Ilani
A mechanism for coupling the electrons and vibrational motion of a suspended carbon nanotube is demonstrated. Tailoring the coupling between specific electronic and phononic modes by controlling the position of quantum dots along the resonating tube enables spatial imaging of the mode shape.

PRL 112, 026801: **Coherent Operations and Screening in Multielectron Spin Qubits**
A. P. Higginbotham, F. Kuemmeth, M. P. Hanson, A. C. Gossard, and C. M. Marcus
Multielectron spin qubits are demonstrated, and performance examined by comparing coherent exchange oscillations in coupled single-electron and multielectron quantum dots, measured in the same device. Fast (>1 GHz) exchange oscillations with a quality factor Q~15 are found for the multielectron case, compared to Q~2 for the single-electron case, the latter consistent with experiments in the literature. A model of dephasing that includes voltage and hyperfine noise is developed that is in good agreement with both single- and multielectron data, though in both cases additional exchange-independent dephasing is needed to obtain quantitative agreement.

Nat Phys: **Universal dynamics of a degenerate unitary Bose gas**
P. Makotyn, C. E. Klauss, D. L. Goldberger, E. A. Cornell and D. S. Jin
Here we present time-resolved measurements of the momentum distribution of a Bose-condensed gas that is suddenly jumped to unitarity. Contrary to expectation, we observe that the gas lives long enough to permit the momentum to evolve to a steady-state distribution, consistent with universality, while remaining degenerate.

arXiv:1401.2671: **Topological Superconducting Phases of Weakly Coupled Quantum Wires**
Inbar Seroussi, Erez Berg, and Yuval Oreg
An array of quantum wires is a natural starting point in realizing two-dimensional topological phases. We study a system of weakly coupled quantum wires with Rashba spin-orbit coupling, proximity coupled to a conventional s-wave superconductor. A variety of topological phases are found in this model. These phases are characterized by "Strong" and "Weak" topological invariants, that capture the appearance of mid-gap Majorana modes (either chiral or non-chiral) on edges along and perpendicular to the wires. In particular, a phase with a single chiral Majorana edge mode (analogous to a p+ip superconductor) can be realized. At special values of the magnetic field and chemical potential, this edge mode is almost completely localized at the outmost wires. In addition, a phase with two co-propagating chiral edge modes is observed. We also consider ways to distinguish experimentally between the different phases in tunneling experiments.

PRX 4, 011002: **Transition-Metal Pentatelluride ZrTe5 and HfTe5: A Paradigm for Large-Gap Quantum Spin Hall Insulators** by Hongming Weng, Xi Dai, and Zhong Fang
Quantum spin Hall (QSH) insulators, a new class of quantum matter, can support topologically protected helical edge modes inside a bulk insulating gap, which can lead to dissipationless transport. A major obstacle to reaching a wide application of QSH is the lack of suitable QSH compounds, which should be easily fabricated and have a large bulk gap. Here, we predict that single-layer ZrTe5 and HfTe5 are the most promising candidates for large-gap insulators, with a bulk direct (indirect) band gap as large as 0.4 eV (0.1 eV) and which are robust against external strains. The three-dimensional crystals of these two materials are good layered compounds with very weak interlayer bonding, and they are located near the phase boundary between weak and strong topological insulators, paving a new way for future experimental studies on both the QSH effect and topological phases.

arXiv:1401.3539: **Thermal conductance as a probe of the non-local order parameter for a topological superconductor with gauge fluctuations** by B. van Heck, E. Cobanera, J. Ulrich, and F. Hassler
The order parameter of a low-dimensional superconductor is subject to phase slips driven by quantum fluctuations. We investigate the effect of these phase slips on a helical quantum wire coupled to a superconductor by proximity. The effective low-energy description of the wire is that of a Majorana chain minimally coupled to a dynamical Z2 gauge field. Hence the wire emulates a matter-coupled gauge theory, with fermion parity playing the role of the gauged global symmetry. Quantum phase slips lift the ground state degeneracy associated with unpaired Majorana edge modes at the ends of the chain, a change that can be understood as a transition between the confined and the Higgs-mechanism regimes of the gauge theory. We identify the quantization of thermal conductance at the transition as a robust experimental feature separating the phases of the system. We explain this result by establishing a relation between thermal conductance and the Fredenhagen-Marcu string order-parameter for confinement in gauge theories. Our work indicates that thermal transport could serve as a measure of non-local order parameters for emergent or simulated topological quantum order.

arXiv:1401.3323: **The fate and heir of Majorana zero modes in a quantum wire array**
Da Wang, Zhoushen Huang, and Congjun Wu
Experimental signatures of Majorana zero modes in single quantum wires with spin-orbit coupling have been reported as zero bias peaks in the tunneling spectroscopy. We study whether these zero modes can persist in an array of coupled s-wave superconducting wires, and if not, what their remnant could be. The bulk exhibits topologically distinct gapped phases and an intervening gapless phase. Even though the bulk pairing structure is topological, the interaction between Majorana zero modes and superfluid phases leads to spontaneous time-reversal symmetry breaking. Consequently, edge supercurrent loops emerge and edge Majorana fermions are in general gapped out except when the number of chains is odd, in which case one Majorana fermion will survive.

arXiv:1401.3010: **Disorder-induced subgap states and Majorana zero-energy edge modes in 2D topological insulator-superconductor hybrid structures** by Hoi-Yin Hui, Jay D. Sau, and S. Das Sarma
Contrary to the widespread belief that Majorana zero-energy modes, existing as bound edge states in 2D topological insulator (TI)-superconductor (SC) hybrid structures, are unaffected by non-magnetic static disorder by virtue of Anderson's theorem, we show that such a protection against disorder does not exist in realistic multi-channel TI/SC/ferromagnetic insulator (FI) sandwich structures of experimental relevance since the time-reversal symmetry is explicitly broken locally at the SC/FI interface where the end Majorana mode (MM) resides. We find that although the MM itself and the bulk topological superconducting phase inside the TI are indeed universally protected against disorder, disorder-induced subgap states are generically introduced at the TI edge due to the presence of the FI/SC interface as long as multiple edge channels are occupied. We discuss the implications for the detection and manipulation of the edge MM in realistic TI/SC/FI experimental systems.

PRL 112, 026602: **Observation of Edge Transport in the Disordered Regime of Topologically Insulating InAs/GaSb Quantum Wells** by Ivan Knez, Charles T. Rettner, See-Hun Yang, and Stuart S. P. Parkin, Lingjie Du and Rui-Rui Du, and Gerard Sullivan
We observe edge transport in the topologically insulating InAs/GaSb system in the disordered regime. Using asymmetric current paths we show that conduction occurs exclusively along the device edge, exhibiting a large Hall signal at zero magnetic fields, while for symmetric current paths, the conductance between the two mesoscopicly separated probes is quantized to 2e2/h. Both quantized and self-averaged transport show resilience to magnetic fields, and are temperature independent for temperatures between 20 mK and 1 K.

arXiv:1401.4416: **Quantum control and process tomography of a semiconductor quantum dot hybrid qubit**
Dohun Kim, Zhan Shi, C. B. Simmons, D. R. Ward, J. R. Prance, Teck Seng Koh, John King Gamble, D. E. Savage, M. G. Lagally, Mark Friesen, S. N. Coppersmith, M. A. Eriksson
Here we demonstrate a new qubit that offers both simplicity - it requires no special preparation and lives in a double quantum dot with no added complexity - and is very fast: we demonstrate full control on the Bloch sphere with π-rotation times less than 100 ps in two orthogonal directions. We report full process tomography, extracting high fidelities equal to or greater than 85% for X-rotations and 94% for Z-rotations.