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Number Fluctuations of Sparse Quasiparticles in a Superconductor,
PRL 106, 167004 (2001) (*Editor's Suggestion*)
We have directly measured quasiparticle number fluctuations in a thin film superconducting Al resonator in thermal equilibrium. The spectrum of these fluctuations provides a measure of both the density and the lifetime of the quasiparticles. We observe that the quasiparticle density decreases exponentially with decreasing temperature, as theoretically predicted, but saturates below 160 mK to 25–55/μm^3. We show that this saturation is consistent with the measured saturation in the quasiparticle lifetime, which also explains similar observations in qubit decoherence times.

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Integrability of the Rabi Model, PRL 107, 100401 (2011) (*Viewpoint*)
The Rabi model is a paradigm for interacting quantum systems. It couples a bosonic mode to the smallest possible quantum model, a two-level system. I present the analytical solution which allows us to consider the question of integrability for quantum systems that do not possess a classical limit. A criterion for quantum integrability is proposed which shows that the Rabi model is integrable due to the presence of a discrete symmetry. Moreover, I introduce a generalization with no symmetries; the generalized Rabi model is the first example of a nonintegrable but exactly solvable system.

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Observing Majorana bound states of Josephson vortices in topological superconductors, PNAS 108, 11810 (2011)
In recent years there has been an intensive search for Majorana fermion states in condensed matter systems. Predicted to be loca- lized on cores of vortices in certain nonconventional superconduc- tors, their presence is known to render the exchange statistics of bulk vortices non-Abelian. Here we study the equations governing the dynamics of phase solitons (fluxons) in a Josephson junction in a topological superconductor. We show that the fluxon will bind a localized zero energy Majorana mode and will consequently behave as a non-Abelian anyon. The low mass of the fluxon, as well as its experimentally observed quantum mechanical wave-like nature, will make it a suitable candidate for vortex interferometry experiments demonstrating non-Abelian statistics. We suggest two experiments that may reveal the presence of the zero mode carried by the fluxon. Specific experimental realizations will be discussed as well.

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Majorana Modes at the Ends of Superconductor Vortices in Doped Topological Insulators, PRL 107, 097001 (2011) (*Viewpoint*)
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.

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Coulomb blockade of Majorana fermion induced transport, arXiv:1108.4308v1
We study Coulomb charging effects for transport through a topological superconducting grain, where Majorana bound states are present at the interface to normal-conducting leads. We construct the general Keldysh functional integral representation, and provide detailed results for the nonlinear current-voltage relation under weak Coulomb blockade conditions.

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Near-Zero-Field Nuclear Magnetic Resonance, PRL 107, 107601 (*Editor's Suggestion*)
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.