Parametric four-wave mixing toolbox for superconducting resonators
A. V. Sharypov, Xiuhao Deng, Lin Tian, arXiv:1204.5450v1 [quant-ph]
We study a superconducting circuit that can act as a toolbox to generate various Bogoliubov-linear and nonlinear quantum operations on the microwave photon modes of superconducting resonators within one single circuit. The quantum operations are generated by exploring dispersive four-wave mixing (FWM) processes involving the resonator modes. Different FWM geometries can be realized by adjusting the circuit parameters and by applying appropriate microwave drivings. We illustrate this scheme using a circuit made of two superconducting qubits that couple with each other. Each qubit couples with one superconducting resonator. We also discuss main quantum errors in this scheme and study the fidelity of the quantum operations by numerical simulation. Our scheme provides a practical approach to realize quantum information protocols on superconducting resonators.

Renormalization group approach for the scattering off a single Rashba impurity in a helical liquid
François Crépin, Jan Carl Budich, Fabrizio Dolcini, Patrik Recher, Björn Trauzettel
arXiv:1205.0374v1 [cond-mat.mes-hall]
The occurrence of two-particle inelastic backscattering has been conjectured in helical edge states of topological insulators and is expected to alter transport. In this Letter, by using a renormalization group approach, we provide a microscopic derivation of this process, in the presence of a time-reversal invariant Rashba impurity potential. Unlike previous approaches to the problem, we are able to prove that such an effect only occurs in the presence of electron-electron interactions. Furthermore, we find that the linear conductance as a function of temperature exhibits a crossover between two scaling behaviors: T^{4K} *for* $K > 1/2$ *and* T^{8K-2} *for* $K < 1/2$*, with* K *the Luttinger parameter.*

Probing the existence and dynamics of Majorana fermion via transport through a quantum dot
arXiv:1205.0322v1 [cond-mat.mes-hall], Yunshan Cao, Peiyue Wang, Gang Xiong, Xin-Qi Li
We consider an experimentally feasible setup to demonstrate the existence and coherent dynamics of Majorana fermion. The transport setup consists of a quantum dot and a tunnel-coupled semiconductor nanowire which is anticipated to generate Majorana excitations under some conditions. For transport under finite bias voltage, we find that a subtraction of the source and drain currents can expose the essential feature of the Majorana fermion, including the zero-energy nature by gate-voltage modulating the dot level. Moreover, coherent oscillating dynamics of the Majorana fermion between the nanowire and the quantum dot is reflected in the shot noise via a spectral dip together with a pronounced zero-frequency noise enhancement effect. Important parameters, e.g. for the Majorana's mutual interaction and its coupling to the quantum dot, can be extracted out in experiment using the derived analytic results.

Precisely timing dissipative quantum information processing
M. J. Kastoryano, M. M. Wolf, J. Eisert, arXiv:1205.0985v1 [quant-ph]
Dissipative engineering constitutes a framework within which quantum information processing protocols are powered by weak (Markovian) system-environment interaction rather than by unitary dynamics alone. This framework embraces noise as a resource, and consequently, offers a number of advantages compared to one based on unitary dynamics alone, e.g., that large classes of initial states are rapidly driven to desirable steady states. One apparent drawback of this scheme is that it does not seem to allow for precisely timed sequential operations, conditional measurements or error correction. In this work, we provide a solution to these challenges, by introducing some basic dissipative gadgets which allow us to precisely initiate, trigger and time dissipative operations, while keeping the system Liouvillian time independent. These gadgets open up novel perspectives for thinking of timed, protected dissipative quantum information processing. As an example, we sketch how universal computation can be performed with geometrically local interactions. We also suggest that instances of dissipative error correction are possible, sketching models of topological error correction without any explicit time dependent control or measurement feedback, in fewer than 4 dimensions.

Strain-Induced Quantum Hall States in Graphene
Yichen Chang, Tameem Albash, Stephan Haas, arXiv:1205.1169v1 [cond-mat.mes-hall]
We examine strain-induced quantized Landau levels in graphene. Specifically, arc-bend strains are found to cause non-uniform pseudo-magnetic fields. Using an effective Dirac model which describes the low-energy physics around the nodal points, we show that several of the key qualitative properties of graphene in a strain-induced pseudo-magnetic field are different compared to the case of an externally applied physical magnetic field. We discuss how using different strain strengths allows us to spatially separate the two components of the pseudo-spinor on the different sublattices of graphene. These field theory results are checked against a tight-binding calculation on the graphene honeycomb lattice, which is found to exhibit all the features described. Furthermore, we find that introducing a Hubbard repulsion on the mean-field level induces a measurable polarization difference between the A and B sublattices, which provides an independent experimental test of the theory presented here.

Thermal metal-insulator transition in a helical topological superconductor

I. C. Fulga, A. R. Akhmerov, J. Tworzydło, B. Béri, C. W. J. Beenakker, arXiv:1205.1441v1 [cond-mat.mes-hall]
Two-dimensional superconductors with time-reversal symmetry have a Z_2 topological invariant, that distinguishes phases with and without helical Majorana edge states. We study the topological phase transition in a class-DIII network model, and show that it is associated with a metal-insulator transition for the thermal conductance of the helical superconductor. The localization length diverges at the transition with critical exponent nu approx 2.0, about twice the known value in a chiral superconductor.

Classification and analysis of two dimensional abelian fractional topological insulators
Michael Levin, Ady Stern, arXiv:1205.1244v1 [cond-mat.str-el]
We present a general framework for analyzing fractionalized, time reversal invariant electronic insulators in two dimensions. The framework applies to all insulators whose quasiparticles have abelian braiding statistics. First, we construct the most general Chern-Simons theories that can describe these states. We then derive a criterion for when these systems have protected gapless edge modes – that is, edge modes that cannot be gapped out without breaking time reversal or charge conservation symmetry. The systems with protected edge modes can be regarded as fractionalized analogues of topological insulators. We show that previous examples of 2D fractional topological insulators are special cases of this general construction. As part of our derivation, we define the concept of "local Kramers degeneracy" and prove a local version of Kramers theorem.

Continuous Quantum Hypothesis Testing
Mankei Tsang, Phys. Rev. Lett. 108, 170502 (2012), doi:10.1103/PhysRevLett.108.170502
I propose a general quantum hypothesis testing theory that enables one to test hypotheses about any aspect of a physical system, including its dynamics, based on a series of observations. For example, the hypotheses can be about the presence of a weak classical signal continuously coupled to a quantum sensor, or about competing quantum or classical models of the dynamics of a system. This generalization makes the theory useful for quantum detection and experimental tests of quantum mechanics in general. In the case of continuous measurements, the theory is significantly simplified to produce compact formulas for the likelihood ratio, the central quantity in statistical hypothesis testing. The likelihood ratio can then be computed efficiently in many cases of interest. Two potential applications of the theory, namely, quantum detection of a classical stochastic waveform and test of harmonic-oscillator energy quantization, are discussed.

Exact Solution for a Non-Markovian Dissipative Quantum Dynamics
Luca Ferialdi and Angelo Bassi, Phys. Rev. Lett. 108, 170404 (2012), doi:10.1103/PhysRevLett.108.170404
We provide the exact analytic solution of the stochastic Schrödinger equation describing a harmonic oscillator interacting with a non-Markovian and dissipative environment. This result represents an arrival point in the study of non-Markovian dynamics via stochastic differential equations. It is also one of the few exactly solvable models for infinite-dimensional systems. We compute the Green's function; in the case of a free particle and with an exponentially correlated noise, we discuss the evolution of Gaussian wave functions.

Magnetic-field induced inequivalent vortex zero modes in strained graphene
Bitan Roy, Phys. Rev. B 85, 165453 (2012), doi:10.1103/PhysRevB.85.165453
Zero energy states in the Dirac spectrum with U(1) symmetric massive vortices of various underlying insulating orders in strained graphene are constructed in the presence of the magnetic field. An easy-plane vortex of antiferromagnet and quantum spin Hall orders host two zero energy states, however, with two different length scales. Such inequivalent zero modes can lead to oscillatory charge and magnetization, and their usual quantizations get restored only far from the vortex core. Otherwise, these zero modes can be delocalized from each other by tuning the mutual strength of two fields. One can, therefore, effectively bind a single zero mode in the vortex core. A possible experimental setup to capture signature of this theory in real graphene as well as in optical honeycomb lattices is mentioned. Generalization of this scenario with underlying topological defects of Kekulé superconductors can localize a single Majorana mode in the vicinity of the defect core.

Thin-Film Magnetization Dynamics on the Surface of a Topological Insulator
Yaroslav Tserkovnyak and Daniel Loss, Phys. Rev. Lett. 108, 187201 (2012), doi:10.1103/PhysRevLett.108.187201

Finite frequency noise properties of the non-equilibrium Anderson impurity model
Christoph P. Orth, Daniel F. Urban, Andreas Komnik, arXiv:1205.0876v1 [cond-mat.mes-hall]

Trouble with the Lorentz law of force: Incompatibility with special relativity and momentum conservation, Masud Mansuripur, arXiv:1205.0096v1 [physics.gen-ph], pointed out in Science doi:10.1126/science.336.6080.404