Journal Club

Adiabatic State Preparation of Interacting Two-Level Systems
R. T. Brierley, C. Creatore, P. B. Littlewood, and P. R. Eastham, Phys. Rev. Lett. **109**, 043002
We consider performing adiabatic rapid passage (ARP) using frequency-swept driving pulses to excite a collection of interacting two-level systems. Such a model arises in a wide range of many-body quantum systems, such as cavity QED or quantum dots, where a nonlinear component couples to light. We analyze the one-dimensional case using the Jordan-Wigner transformation, as well as the mean-field limit where the system is described by a Lipkin-Meshkov-Glick Hamiltonian. These limits provide complementary insights into the behavior of many-body systems under ARP, suggesting our results are generally applicable. We demonstrate that ARP can be used for state preparation in the presence of interactions, and identify the dependence of the required pulse shapes on the interaction strength.

Response function and elementary excitations of a Bose-Einstein condensed gas with equal Rashba and Dresselhaus spin-orbit coupling
G. I. Martone, Y. Li, L. P. Pitaevskii, and S. Stringari, arXiv:1207.6804
By calculating the dynamic density response function we identify the excitation spectrum of a Bose-Einstein condensate with equal Rashba and Dresselhaus spin-orbit coupling at zero temperature. The propagation of phonons is strongly affected by the coupling and the velocity of sound vanishes when one approaches the second-order phase transition between the spin polarized and the zero-momentum quantum phases. We also point out the emergence of a roton minimum in the excitation spectrum for small values of the Raman coupling...

Half-metallic magnetization plateaux, Z. Hao and O. A. Starykh, arXiv:1207.7124
We propose a novel interaction-based route to half-metal state for interacting electrons on two-dimensional lattices. Magnetic field applied parallel to the lattice is used to tune one of the spin densities to a particular commensurate with the lattice value in which the system spontaneously 'locks in' via van Hove enhanced density wave state. Electrons of opposite spin polarization retain their metallic character and provide for the half-metal state which, in addition, supports magnetization plateau in a finite interval of external magnetic field...

Decoherence of superconducting qubits caused by quasiparticle tunneling
G. Catelani, S. E. Nigg, S. M. Girvin, R. J. Schoelkopf, and L. I. Glazman, arXiv:1207.7084
In superconducting qubits, the interaction of the qubit degree of freedom with quasiparticles defines a fundamental limitation for the qubit coherence. We develop a theory of the pure dephasing rate Γ_ϕ *caused by quasiparticles tunneling through a Josephson junction and of the inhomogeneous broadening due to changes in the occupations of Andreev states in the junction. To estimate* Γ_ϕ*, we derive a master equation for the qubit dynamics. The tunneling rate of free quasiparticles is enhanced by their large density of states at energies close to the superconducting gap. Nevertheless, we find that* Γ_ϕ *is small compared to the rates determined by extrinsic factors in most of the current qubit designs (phase and flux qubits, transmon, fluxonium). The split transmon, in which a single junction is replaced by a SQUID loop, represents an exception that could make possible the measurement of* Γ_ϕ*...*

Transition from fractional to Majorana fermions in Rashba nanowires

J. Klinovaja, P. Stano, and D. Loss, arXiv:1207.7322

We study hybrid superconducting-semiconducting nanowires in the presence of Rashba spin-orbit interaction as well as helical magnetic fields. We show that the interplay between them leads to a competition of phases with two topological gaps closing and reopening, resulting in unexpected reentrance behavior. Besides the topological phase with localized Majorana fermions (MFs) we find new phases characterized by fractionally charged fermion (FF) bound states of Jackiw-Rebbi type. The system can be fully gapped by the magnetic fields alone, giving rise to FFs that transmute into MFs upon turning on superconductivity. We find explicit analytical solutions for MF and FF bound states and determine the phase diagram numerically by determining the corresponding Wronskian null space...

Large Magnetoresistance Oscillations in Mesoscopic Superconductors due to Current-Excited Moving Vortices

G. R. Berdiyorov, M. V. Milošević, M. L. Latimer, Z. L. Xiao, W. K. Kwok, and F. M. Peeters, Phys. Rev. Lett. **109**, 057004 (2012)

We show in the case of a superconducting Nb ladder that a mesoscopic superconductor typically exhibits magnetoresistance oscillations whose amplitude and temperature dependence are different from those stemming from the Little-Parks effect. We demonstrate that these large resistance oscillations (as well as the monotonic background on which they are superimposed) are due to current-excited moving vortices, where the applied current in competition with the oscillating Meissner currents imposes or removes the barriers for vortex motion in an increasing magnetic field. Because of the ever present current in transport measurements, this effect should be considered in parallel with the Little-Parks effect in low-critical temperature (Tc) samples...

Spectral and power properties of inline long Josephson junctions

L. S. Revin and A. L. Pankratov, Phys. Rev. B **86**, 054501 (2012)

Spectral and power properties of inline long Josephson junctions operating in a flux flow regime are investigated using direct computer simulation of the sine-Gordon equation with a noise source. Good agreement of simulation results with the formula for the linewidth [Pankratov Phys. Rev. B ***65****, 054504 (2002)] is achieved. The comparison with long Josephson junction of overlap geometry is performed. It is demonstrated that the inline junction has the linewidth which is by a factor of 2 larger than the overlap junction, while the maximal oscillation power is roughly the same in spite of the fact that the velocity-matching step height of the inline junction is much smaller than that of the overlap one.*

Manipulation of qubits in nonorthogonal collective storage modes

J. Refsgaard and K. Mølmer, Phys. Rev. A **86**, 022302 (2012)

We present an analysis of transfer of quantum information between the collective spin degrees of freedom of a large ensemble of two-level systems and a single central qubit. The coupling between the central qubit and the individual ensemble members may be varied and thus provides access to more than a single storage mode. Means to store and manipulate several independent qubits are derived for the case where the variation in coupling strengths does not allow addressing orthogonal modes of the ensemble. While our procedures and analysis may apply to a number of different physical systems, for concreteness, we study the transfer of quantum states between a single electron spin and an ensemble of nuclear spins in a quantum dot.