Journal Club

M. Vanevic and Yu. V. Nazarov
Quantum phase slips in superconducting wires with weak links, arXiv:1108.3553
Quantum phase slips are traditionally considered in homogeneous diffusive wires. We argue that even in realistic, apparently homogeneous wires, the phase slips can occur at weak links where the local resistivity is slightly higher. We model the weak link as a general coherent conductor and obtain accurate estimate of the quantum phase-slip amplitude.

William F. Koehl, Bob B. Buckley, F. Joseph Heremans, Greg Calusine & David D. Awschalom
Room temperature coherent control of defect spin qubits in silicon carbide,
Nature **479**, 84–87 (2011)
Electronic spins in semiconductors have been used extensively to explore the limits of external control over quantum mechanical phenomena. A long-standing goal of this research has been to identify or develop robust quantum systems that can be easily manipulated, for future use in advanced information and communication technologies. Recently, a point defect in diamond known as the nitrogen–vacancy centre has attracted a great deal of interest because it possesses an atomic-scale electronic spin state that can be used as an individually addressable, solid-state quantum bit (qubit), even at room temperature. These exceptional quantum properties have motivated efforts to identify similar defects in other semiconductors, as they may offer an expanded range of functionality not available to the diamond nitrogen–vacancy centre. Notably, several defects in silicon carbide (SiC) have been suggested as good candidates for exploration, owing to a combination of computational predictions and magnetic resonance data. Here we demonstrate that several defect spin states in the 4H polytype of SiC (4H-SiC) can be optically addressed and coherently controlled in the time domain at temperatures ranging from 20 to 300 kelvin. Using optical and microwave techniques similar to those used with diamond nitrogen–vacancy qubits, we study the spin-1 ground state of each of four inequivalent forms of the neutral carbon–silicon divacancy, as well as a pair of defect spin states of unidentified origin. These defects are optically active near telecommunication wavelengths, and are found in a host material for which there already exist industrial-scale crystal growth and advanced microfabrication techniques. In addition, they possess desirable spin coherence properties that are comparable to those of the diamond nitrogen–vacancy centre. This makes them promising candidates for various photonic, spintronic and quantum information applications that merge quantum degrees of freedom with classical electronic and optical technologies.

Yang-Le Wu, B. Andrei Bernevig, N. Regnault
Zoology of Fractional Chern Insulators, arXiv:1111.1172
We study four different models of Chern insulators in the presence of strong electronic repulsion at partial fillings. We observe that all cases exhibit a Laughlin-like phase at filling fraction 1/3. We provide evidence of such a strongly correlated topological phase by studying both the energy and the entanglement spectra. In order to identify the key ingredients of the emergence of Laughlin physics in these systems, we show how they are affected when tuning the band structure. We

also address the question of the relevance of the Berry curvature flatness in this problem. Using three-body interactions, we show that some models can also host a topological phase reminiscent of the nu=1/2 Pfaffian Moore-Read state. Additionally, we identify the structures indicating cluster correlations in the entanglement spectra.

Kazuhiro Tsutsui, Akihito Takeuchi, Gen Tatara, Shuichi Murakami
Spin Currents Induced by Nonuniform Rashba-Type Spin-Orbit Field, arXiv:1111.1197
We study the spin relaxation torque in nonmagnetic or ferromagnetic metals with nonuniform spin-orbit coupling within the Keldysh Green's function formalism. In non-magnet, the relaxation torque is shown to arise when the spin-orbit coupling is not uniform. In the absence of an external field, the spin current induced by the relaxation torque is proportional to the vector chirality of Rashba-type spin-orbit field (RSOF). In the presence of an external field, on the other hand, spin relaxation torque arises from the coupling of the external field and vector chirality of RSOF. Our result indicates that spin-sink or source effects are controlled by designing RSOF in junctions.

Noriaki Ogawa, Tadashi Takayanagi, Tomonori Ugajin
Holographic Fermi Surfaces and Entanglement Entropy, arXiv:1111.1023
We argue that Landau-Fermi liquids do not have any gravity duals in the purely classical limit. We employ the logarithmic behavior of entanglement entropy to characterize the existence of Fermi surfaces. By imposing the null energy condition, we show that the specific heat always behaves anomalously. We also present a classical gravity dual which has the expected behavior of the entanglement entropy and specific heat for non-Fermi liquids.

Neill Lambert, Robert Johansson, Franco Nori
A macro-realism inequality for opto-electro-mechanical systems, arXiv:1106.3138
We show how to apply the Leggett-Garg inequality to opto-electro-mechanical systems near their quantum ground state. We find that by using a dichotomic quantum non-demolition measurement (via, e.g., an additional circuit-QED measurement device) either on the cavity or on the nanomechanical system itself, the Leggett-Garg inequality is violated. We argue that only measurements on the mechanical system itself give a truly unambigous violation of the Leggett-Garg inequality for the mechanical system. In this case, a violation of the Leggett-Garg inequality indicates physics beyond that of "macroscopic realism" is occurring in the mechanical system. Finally, we discuss the difficulties in using unbound non-dichotomic observables with the Leggett-Garg inequality.

Maissam Barkeshli and Xiao-Liang Qi
Topological Response Theory of Doped Topological Insulators,
Phys. Rev. Lett. **107**, 206602 (2011)
We generalize the topological response theory of three-dimensional topological insulators (TI) to metallic systems—specifically, doped TI with finite bulk carrier density and a time-reversal symmetry breaking field near the surface. We show that there is an inhomogeneity-induced Berry phase contribution to the surface Hall conductivity that is completely determined by the occupied states and is independent of other details such as band dispersion and impurities. In the limit of zero bulk carrier density, this intrinsic surface Hall conductivity reduces to the half-integer quantized surface Hall conductivity of TI. Based on our theory we predict the behavior of the surface Hall conductivity for a doped topological insulator with a top gate, which can be directly compared with experiments.