Adrian Hutter **Journal Club** 6 November 2012

Surface code with decoherence: An analysis of three superconducting architectures
Joydip Ghosh, Austin G. Fowler, and Michael R. Geller
arXiv:1210.5799

We consider a realistic, multi-parameter error model and investigate the performance of the surface code for three possible fault-tolerant superconducting architectures. We map amplitude and phase damping to a diagonal Pauli "depolarization" channel via the Pauli twirl approximation, and obtain the logical error rate as a function of the qubit T1, T2 and intrinsic state preparation, gate, and readout errors. A numerical Monte Carlo simulation is performed to obtain the logical error rates and a leading order analytic model is constructed to estimate their scaling behavior below threshold. Our results suggest that large-scale fault-tolerant quantum computation should be possible with existing superconducting devices.

Ultrafast magnon-transistor at room temperature
Kevin A. van Hoogdalem and Daniel Loss
arXiv:1209.5594

We study sequential tunneling of magnetic excitations in nonitinerant systems (either magnons or spinons) through triangular molecular magnets. It is known that the quantum state of such molecular magnets can be controlled by application of an electric- or a magnetic field. Here, we use this fact to control the flow of a spin current through the molecular magnet by electric- or magnetic means. This allows us to design a system that behaves as a magnon-transistor. We show how to combine three magnon-transistors to form a NAND-gate, and give several possible realizations of the latter, one of which could function at room temperature using transistors with a 11 ns switching time.

A Majorana smoking gun for the superconductor-semiconductor hybrid topological system
S. Das Sarma, Jay D. Sau, and Tudor D. Stanescu
arXiv:1211.0539

Recent observations of a zero bias conductance peak in tunneling transport measurements in superconductor–semiconductor nanowire devices provide evidence for the predicted zero–energy Majorana modes, but not the conclusive proof for their existence. We establish that direct observation of a splitting of the zero bias conductance peak can serve as the smoking gun evidence for the existence of the Majorana mode. We show that the splitting has an oscillatory dependence on the Zeeman field (chemical potential) at fixed chemical potential (Zeeman field). By contrast, when the density is constant rather than the chemical potential – the likely situation in the current experimental set-ups – the splitting oscillations are generically suppressed. Our theory predicts the conditions under which the splitting oscillations can serve as the smoking gun for the experimental confirmation of the elusive Majorana mode.

Noise Analysis of Qubits Implemented in Triple Quantum Dot Systems in a Davies Master Equation Approach
Sebastian Mehl and David P. DiVincenzo
arXiv:1211.0417

We analyze the influence of noise for qubits implemented using triple quantum dot spin system. We give a detailed description of the physical realization and develop error models for the dominant external noise sources. We use a Davies master equation approach to describe their influence on the qubit. The triple dot system contains two meaningful realizations of a qubit: we consider a subspace and a subsystem of the full Hilbert space to implement the qubit. We test the robustness of these two implementations with respect to the qubit stability. When performing the noise analysis, we extract the initial time evolution of the qubit using a Nakajima-Zwanzig approach. We find that the initial time evolution, which is essential for qubit applications, decouples from the long time dynamics of the system. We extract probabilities for the qubit errors of dephasing, relaxation and leakage. Using the Davies model to describe the environment simplifies the noise analysis. It allows us to construct simple toy models, which closely describe the error probabilities.

Demonstrating a Driven Reset Protocol of a Superconducting Qubit
K. Geerlings, Z. Leghtas, I. M. Pop, S. Shankar, L. Frunzio, R. J. Schoelkopf, M. Mirrahimi, and M. H. Devoret
arXiv:1211.0491

Qubit reset is crucial at the start of and during quantum information algorithms. We present the experimental demonstration of a practical method to force qubits into their ground state, based on driving certain qubit and cavity transitions. Our protocol, nicknamed DDROP (Double Drive Reset of Population) is tested on a superconducting transmon qubit in a 3D cavity. Using a new method for measuring population, we show that we can prepare the ground state with a fidelity of at least 99.5% in less than 3 microseconds; faster times and higher fidelity are predicted upon parameter optimization.

Unconditional generation of bright coherent non-Gaussian light from exciton-polariton condensates
Tim Byrnes, Yoshihisa Yamamoto, and Peter van Loock
arXiv:1211.0588

Exciton-polariton condensates are considered as a deterministic source of bright, coherent non-Gaussian light. Exciton-polariton condensates emit coherent light via the photoluminescence through the microcavity mirrors due to the spontaneous formation of coherence. Unlike conventional lasers which emit coherent Gaussian light, polaritons possess a natural nonlinearity due to the interaction of the excitonic component. This produces light with a negative component to the Wigner function at steady-state operation when the phase is stabilized via a suitable method such as injection locking. In contrast to many other proposals for sources of non-Gaussian light, in our case, the light typically has an average photon number exceeding one and emerges as a continuous wave. Such a source may have uses in continuous-variable quantum information and communication.

Weak value amplified quantum sensors cannot overcome decoherence
George C. Knee, G. Andrew D. Briggs, Simon C. Benjamin, and Erik M. Gauger
arXiv:1211.0261

Sensors that harness exclusively quantum phenomena (such as entanglement) can achieve superior performance compared to those employing only classical principles. Recently, a technique based on postselected, weakly-performed measurements has emerged as a method of overcoming technical noise in the detection and estimation of small interaction parameters, particularly in optical systems. The question of which other types of noise may be combatted remains open. We here analyze whether the effect can overcome decoherence in a typical field sensing scenario. Benchmarking a weak, postselected measurement strategy against a strong, direct strategy we conclude that no advantage is achievable, and that even a small amount of decoherence proves catastrophic to the weak value amplification technique.

Bright Solitons in Spin-Orbit Coupled Bose-Einstein Condensates
Yong Xu, Yongping Zhang, and Biao Wu
arXiv:1211.0771

We study bright solitons in a Bose-Einstein condensate with a spin-orbit coupling that has been realized experimentally. Both stationary bright solitons and moving bright solitons are found. The stationary bright solitons are the ground states and possess well-defined spin parity, a symmetry involving both spatial and spin degrees of freedom; these solitons are real-valued but not positivede finite and the number of their nodes depends on the strength of spin-orbit coupling. For the moving bright solitons, their shapes are found to change with velocity due to the lack of Galilean invariance in the system. Collisions between two identical moving solitons are elastic.

Class of variational ansaetze for the "spin-incoherent" ground-state of a Luttinger liquid coupled to a spin bath
Mohammad Soltanieh-ha and Adrian E. Feiguin
arXiv:1211.0982

Interacting one-dimensional electron systems are generally referred to as "Luttinger liquids", after the effective low-energy theory in which spin and charge behave as separate degrees of freedom with independent energy scales. The "spin-incoherent Luttinger liquid" describes a finite-temperature regime that is realized when the temperature is very small relative to the Fermi energy, but larger than the characteristic spin energy scale. Similar physics can take place in the ground-state, when a Luttinger Liquid is coupled to a spin bath, which effectively introduces a "spin temperature" through its entanglement with the spin degree of freedom. We show that the spin-incoherent state can be written as a factorized wave-function, with a spin wave-function that can be described within a valence bond formalism. This enables us to calculate exact expressions for the momentum distribution function and the entanglement entropy. This picture holds not only for two antiferromagnetically coupled t-J chains, but also for the t-J-Kondo chain with strongly interacting conduction electrons. We argue that this theory is quite universal and may describe a family of problems that could be dubbed "spin-incoherent".