
A silicon-based surface code quantum computer
Joe OGorman, Naomi H. Nickerson, Philipp Ross, John J. L. Morton, and Simon C. Benjamin
arXiv:1406.5149

Individual impurity atoms in silicon can make superb individual qubits, but it remains an immense challenge to build a multi-qubit processor: There is a basic conflict between nanometre separation desired for qubit-qubit interactions, and the much larger scales that would enable control and addressing in a manufacturable and fault tolerant architecture. Here we resolve this conflict by establishing the feasibility of surface code quantum computing using solid state spins, or data qubits, that are widely separated from one another. We employ a second set of probe spins which are mechanically separate from the data qubits and move in-and-out of their proximity. The spin dipole-dipole interactions give rise to phase shifts; measuring a probes total phase reveals the collective parity of the data qubits along the probes path. We introduce a protocol to balance the systematic errors due to the spins being imperfectly located during device fabrication. Detailed simulations show that the surface codes threshold then corresponds to misalignments that are substantial on the scale of the array, indicating that it is very robust. We conclude that this simple orbital probe architecture overcomes many of the difficulties facing solid state quantum computing, while minimising the complexity and offering qubit densities that are several orders of magnitude greater than other systems. The code written for our numerical simulations is openly available online [1].

Non-Abelian topological insulators from an array of quantum wires
Eran Sagi and Yuval Oreg
Phys. Rev. B **90**, 201102(R)

We suggest a construction of a large class of topological states using an array of quantum wires. First, we show how to construct a Chern insulator using an array of alternating wires that contain electrons and holes, correlated with an alternating magnetic field. This is supported by semiclassical arguments and a full quantum-mechanical treatment of an analogous tight-binding model. We then show how electron-electron interactions can stabilize fractional Chern insulators (Abelian and non-Abelian). In particular, we construct a non-Abelian Z_3 parafermion state. Our construction is generalized to wires with alternating spin-orbit couplings, which give rise to integer and fractional (Abelian and non-Abelian) topological insulators. The states we construct are effectively two dimensional, and are therefore less sensitive to disorder than one-dimensional systems. The possibility of experimental realization of our construction is addressed.

Ground state entanglement constrains low-energy excitations
Isaac H. Kim and Benjamin J. Brown
arXiv:1410.7411

For a general quantum many-body system, we show that its ground state entanglement imposes a fundamental constraint on the low-energy excitations. For two-dimensional systems, our result implies that any system that supports anyons must have a nonvanishing topological entanglement entropy. We demonstrate the generality of this argument by applying it to three-dimensional quantum many-body systems, and showing that there is a pair of ground state topological invariants that are associated to their physical boundaries. From the pair, one can determine whether the given boundary can or cannot absorb point-like or line-like excitations.

Magnetic Resonance Detection of Individual Proton Spins Using Quantum Reporters
A.O. Sushkov, I. Lovchinsky, N. Chisholm, R.L. Walsworth, H. Park, and M.D. Lukin
Phys. Rev. Lett. **113**, 197601

We demonstrate a method of magnetic resonance imaging with single nuclear-spin sensitivity under ambient conditions. Our method employs isolated electronic-spin quantum bits (qubits) as magnetic resonance reporters on the surface of high purity diamond. These spin qubits are localized with nanometer-scale uncertainty, and their quantum state is coherently manipulated and measured optically via a proximal nitrogen-vacancy color center located a few nanometers below the diamond surface. This system is then used for sensing, coherent coupling, and imaging of

individual proton spins on the diamond surface with angstrom resolution. Our approach may enable direct structural imaging of complex molecules that cannot be accessed from bulk studies. It realizes a new platform for probing novel materials, monitoring chemical reactions, and manipulation of complex systems on surfaces at a quantum level.

Thermally activated local collapse of a flattened dipolar condensate
E. B. Linscott and P. B. Blakie
Phys. Rev. A **90**, 053605

We consider the metastable dynamics of a flattened dipolar condensate. We develop an analytic model that quantifies the energy barrier to the system undergoing local collapse to form a density spike. We also develop a stochastic Gross-Pitaevskii equation theory for a flattened dipolar condensate, which we use to perform finite-temperature simulations verifying the local collapse scenario. We predict that local collapses play a significant role in the regime where rotons are predicted to exist and will be an important consideration for experiments looking to detect these excitations.

Quantum phase transition of nonlocal Ising chain with transverse field in a resonator
Yu-Na Zhang, Xi-Wang Luo, Guang-Can Guo, Zheng-Wei Zhou, and Xingxiang Zhou
Phys. Rev. B **90**, 094510

We study the quantum phase transition in a spin chain with variable Ising interactions and position-dependent coupling to a resonator field. Such a complicated model, usually not present in natural physical systems, can be simulated by an array of qubits based on man-made devices and exhibits interesting behavior. We show that, when the coupling between the qubit and field is strong enough, a superradiant phase transition occurs, and it is possible to pick a particular field mode to undergo this phase transition by properly modulating the strength of the Ising interaction. We also study the impact of the resonator field on the magnetic properties of the spin chain and find a rich set of phases characterized by distinctive qubit correlation functions.

Landscape-Inversion Phase Transition in Dipolar Colloids: Tuning the Structure and Dynamics of 2D Crystals
Ricard Alert, Jaume Casademunt, and Pietro Tierno
Phys. Rev. Lett. **113**, 198301

We study the 2D crystalline phases of paramagnetic colloidal particles with dipolar interactions and constrained on a periodic substrate. Combining theory, simulation, and experiments, we demonstrate a new scenario of first-order phase transitions that occurs via a complete inversion of the energy landscape, featuring nonconventional properties that allow for (i) tuning of crystal symmetry, (ii) control of dynamical properties of different crystalline orders via tuning of their relative stability with an external magnetic field, (iii) an equivalent but independent control of the same dynamic properties via temporal modulations of that field, and (iv) nonstandard phase-ordering kinetics involving spontaneous formation of transient metastable domains.

High-Precision Test of Landauers Principle in a Feedback Trap
Yonggun Jun, Momcilo Gavrilov, and John Bechhoefer
Phys. Rev. Lett. **113**, 190601

We confirm Landauers 1961 hypothesis that reducing the number of possible macroscopic states in a system by a factor of 2 requires work of at least $kT \ln 2$. Our experiment uses a colloidal particle in a time-dependent, virtual potential created by a feedback trap to implement Landauers erasure operation. In a control experiment, similar manipulations that do not reduce the number of system states can be done reversibly. Erasing information thus requires work. In individual cycles, the work to erase can be below the Landauer limit, consistent with the Jarzynski equality.

Theory of melting at high pressures: Amending density functional theory with quantum Monte Carlo
L. Shulenburger, M. P. Desjarlais, and T. R. Mattsson
Phys. Rev. B **90**, 140104(R)

We present an improved first-principles description of melting under pressure based on thermodynamic integration comparing density functional theory (DFT) and quantum Monte Carlo (QMC) treatments. The method is applied to address the longstanding discrepancy between DFT calculations and diamond anvil cell (DAC) experiments on the

melting curve of xenon, a noble gas solid where van der Waals binding is challenging for traditional DFT methods. The calculations show agreement with data below 20 GPa and that the high-pressure melt curve is well described by a Lindemann behavior up to at least 80 GPa, in contrast to DAC data.