Surface code quantum computing by lattice surgery Clare Horsman, Austin G. Fowler, Simon Devitt, Rodney Van Meter, arXiv:1111.4022

In recent years, surface codes have become the preferred method for quantum error correction in large scale computational and communications architectures. Their comparatively high fault-tolerant thresholds and their natural 2-dimensional nearest neighbour (2DNN) structure make them an obvious choice for large scale designs in experimentally realistic systems. While fundamentally based on the toric code of Kitaev, there are many variants, two of which are the planar- and defect-based codes. Planar codes require fewer qubits to implement (for the same strength of error correction), but are restricted to encoding a single qubit of information. Interactions between encoded qubits are achieved via transversal operations, thus destroying the inherent 2DNN nature of the code. In this paper we introduce a new technique enabling the coupling of two planar codes without transversal operations, maintaining the 2DNN of the encoded computer. Our lattice surgery technique comprises splitting and merging planar code surfaces, and enables us to perform universal quantum computation (including magic state injection) while removing the need for braided logic in a strictly 2DNN design, and hence reduces the overall qubit resources for logic operations. We show how lattice surgery allows us to distribute encoded GHZ states in a more direct (and overhead friendly) manner, and how a demonstration of an encoded CNOT between two distance 3 logical states is possible with 53 physical qubits, half of that required in any other known construction in 2D.

Unconventional Josephson Signatures of Majorana Bound States Liang Jiang, David Pekker, Jason Alicea, Gil Refael, Yuval Oreg, and Felix von Oppen, Phys. Rev. Lett. 107, 236401 (2011)

A junction between two topological superconductors containing a pair of Majorana fermions exhibits a fractional Josephson effect, 4 periodic in the superconductors phase difference. An additional fractional Josephson effect, however, arises when the Majorana fermions are spatially separated by a superconducting barrier. This new term gives rise to a set of Shapiro steps which are essentially absent without Majorana modes and therefore provides a unique signature for these exotic states.

Seeing Topological Order in Time-of-Flight Measurements E. Alba, X. Fernandez-Gonzalvo, J. Mur-Petit, J. K. Pachos, and J. J. Garcia-Ripoll, Phys. Rev. Lett. 107, 235301 (2011)

In this Letter, we provide a general methodology to directly measure topological order in cold atom systems. As an application, we propose the realization of a characteristic topological model, introduced by Haldane, using optical lattices loaded with fermionic atoms in two internal states. We demonstrate that time-of-flight measurements directly reveal the topological order of the system in the form of momentum-space Skyrmions.

Exactly solvable topological chiral spin liquid with random exchange Victor Chua and Gregory A. Fiete, Phys. Rev. B 84, 195129 (2011)

We extend the Yao-Kivelson decorated honeycomb lattice Kitaev model [H. Yao and S. A. Kivelson Phys. Rev. Lett. 99 247203 (2007)] of an exactly solvable chiral spin liquid by including disordered exchange couplings. We have determined the phase diagram of this system and found that disorder enlarges the region of the topological non-Abelian phase with finite Chern number. We study the energy level statistics as a function of disorder and other parameters in the Hamiltonian, and show that the phase transition between the non-Abelian and Abelian phases of the model at large disorder can be associated with pair annihilation of extended states at zero energy. Analogies to integer quantum Hall systems, topological Anderson insulators, and disordered topological Chern insulators are discussed.

Topological phases and delocalization of quantum walks in random environments Hideaki Obuse and Norio Kawakami, Phys. Rev. B 84, 195139 (2011)

We investigate one-dimensional (1D) discrete-time quantum walks (QWs) with spatially or temporally random defects as a consequence of interactions with random environments. We focus on the QWs with chiral symmetry in a topological phase, and reveal that chiral symmetry together with the bipartite nature of the QWs brings about intriguing behaviors such as coexistence of topologically protected edge states at zero energy and Anderson transitions in the 1D chiral class at nonzero energy in their dynamics. In contrast to results of previous studies, therefore, the spatially disordered QWs can avoid complete localization due to the Anderson transition. It is further confirmed that the edge states are robust to spatial disorder but not to temporal disorder.

Entanglement entropy of gapped phases and topological order in three dimensions Tarun Grover, Ari M. Turner, and Ashvin Vishwanath, Phys. Rev. B 84, 195120 (2011)

We discuss entanglement entropy of gapped ground states in different dimensions, obtained on partitioning space into two regions. For trivial phases without topological order, we argue that the entanglement entropy may be obtained by integrating an entropy density over the partition boundary that admits a gradient expansion in the curvature of the boundary. This constrains the expansion of entanglement entropy as a function of system size and points to an even-odd dependence on dimensionality. For example, in contrast to the familiar result in two dimensions, a size-independent constant contribution to the entanglement entropy can appear for trivial phases in any odd spatial dimension. We then discuss phases with topological entanglement entropy (TEE) that cannot be obtained by adding local contributions. We find that in three dimensions there is just one type of TEE, as in two dimensions, that depends linearly on the number of connected components of the boundary (the zeroth Betti number). In D¿3 dimensions, new types of TEE appear which depend on the higher Betti numbers of the boundary manifold. We construct generalized toric code models that exhibit these TEEs and discuss ways to extract TEE in D3.

Room temperature current suppression on multilayer edge molecular spintronics device Pawan Tyagi, arXiv:1111.6352

Molecular conduction channels between two ferromagnetic electrodes can produce strong exchange coupling and dramatic effect on the spin transport, thus enabling the realization of novel logic and memory devices. However, fabrication of molecular spintronics devices is extremely challenging and inhibits the insightful experimental studies. Recently, we produced Multilayer Edge Molecular Spintronics Devices (MEMSDs) by bridging the organometallic molecular clusters (OMCs) across a 2 nm thick insulator of a magnetic tunnel junction (MTJ), along its exposed side edges. These MEMSDs exhibited unprecedented increase in exchange coupling between ferromagnetic films and dramatic changes in the spin transport. This paper focuses on the dramatic current suppression phenomenon exhibited by MEMSDs at room temperature. In the event of current suppression, the effective MEMESDs' current reduced by as much as six orders in magnitude as compared to the leakage current level of a MTJ test bed. In the suppressed current state, MEMSD's transport could be affected by the temperature, light radiation, and magnetic field. In the suppressed current state MEMSD also showed photovoltaic effect. This study motivates the investigation of MEMSDs involving other combinations of MTJs and promising magnetic molecules like single molecular magnets and porphyrin. Observation of current suppression on similar systems will unequivocally establish the utility of MEMSD approach.

Spin texture readout of a Moore-Read topological quantum register J.C. Romers, K. Schoutens, arXiv:1111.6032

We study the composite Charged Spin Texture (CST) over the Moore-Read quantum Hall state that arises when a collection of elementary CSTs are moved to the same location. Following an algebraic approach based on the characteristic pair correlations of the Moore-Read state, we find that the resulting CST is set by the fusion sector of the underlying non-Abelian quasiparticles. This phenomenon provides a novel way to read out the quantum register of a non-Abelian topologically ordered phase.

Localized end states in density modulated quantum wires and rings Suhas Gangadharaiah, Luka Trifunovic, Daniel Loss, arXiv:1111.5273

We study finite quantum wires and rings in the presence of a charge density wave gap induced by a periodic modulation of the chemical potential. We show that the Tamm-Shockley bound states emerging at the ends of the wire are stable against weak disorder and interactions, for discrete open chains and for continuum systems. The low-energy physics can be mapped onto the Jackiw-Rebbi equations describing massive Dirac fermions and bound end states. We treat interactions via the continuum model and show that they increase the charge gap and further localize the end states. In an Aharonov-Bohm ring with weak link, the bound states give rise to an unusual 4π-peridodicity in the spectrum and persistent current as function of an external flux. The electrons placed in the two localized states on the opposite ends of the wire can interact via exchange interactions and this setup can be used as a double quantum dot hosting spin-qubits.

Topologically protected Landau levels in bilayer graphene in finite electric fields Tohru Kawarabayashi, Yasuhiro Hatsugai, Hideo Aoki, arXiv:1111.5894

The zero-energy Landau level of bilayer graphene is shown to be anomalously sharp (delta-function like) against bond disorder as long as the disorder is correlated over a few lattice constants.The robustness of the zero-mode anomaly can be attributed to the preserved chiral symmetry. Unexpectedly, even when we apply a finite potential difference (i.e., an electric field) between the top and the bottom layers, the valley-split $n = 0$ Landau levels remain anomalously sharp although they are now shifted away from the zero energy, while the $n = 1$ Landau levels exhibit the usual behavior.