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Unpaired Majorana modes on dislocations and string defects in Kitaev's honeycomb model

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We study the gapped phase of Kitaev's honeycomb model (a Z2 spin liquid) on a lattice with topological defects. We find that some dislocations and string defects carry unpaired Majorana fermions. Physical excitations associated with these defects are (complex) fermion modes made out of two (real) Majorana fermions connected by a Z2 gauge string. The quantum state of these modes is robust against local noise and can be changed by winding a Z2 vortex around one of the dislocations. The exact solution respects gauge invariance and reveals a crucial role of the gauge field in the physics of Majorana modes. To facilitate these theoretical developments, we recast the degenerate perturbation theory for spins in the language of Majorana fermions.

Absence of Quantum Time Crystals in Ground States

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arXiv:1410.2143v1

In analogy with crystalline solids around us, Wilczek recently proposed the idea of "time crystals" as phases that spontaneously break the continuous time translation into a discrete subgroup. The proposal stimulated further studies and vigorous debates whether it can be realized in a physical system. However, a precise definition of the time crystal is needed to resolve the issue. Here we first present a definition of time crystals based on the time-dependent correlation functions of the order parameter. We then prove a no-go theorem that rules out the possibility of time crystals defined as such, in the ground state of a general Hamiltonian which consists of only short-range interactions.

Clock Quantum Monte Carlo: an imaginary-time method for real-time quantum dynamics

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arXiv:1410.1877v1

In quantum information theory, there is an explicit mapping between general unitary dynamics and Hermitian ground state eigenvalue problems known as the Feynman-Kitaev Clock. A prominent family of methods for the study of quantum ground states are quantum Monte Carlo methods, and recently the full configuration interaction quantum Monte Carlo (FCIQMC) method has demonstrated great promise for practical systems. We combine the Feynman-Kitaev Clock with FCIQMC to formulate a new technique for the study of quantum dynamics problems. Numerical examples using quantum circuits are provided as well as a technique to further mitigate the sign problem through time-dependent basis rotations. Moreover, this method allows one to combine the parallelism of Monte Carlo techniques with the locality of time to yield an effective parallel-in-time simulation technique.

The fate of many-body localization under periodic driving

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arXiv:1410.3455v1

We study many-body localised quantum systems subject to periodic driving. We find that the presence of a mobility edge anywhere in the spectrum is enough to lead to delocalisation for any driving strength and frequency. By contrast, for a fully localised many-body system, a delocalisation transition occurs at a finite driving frequency. We present numerical studies on a system of interacting one-dimensional bosons and the quantum random energy model, as well as simple physical pictures accounting for those results.

Detector-Device-Independent Quantum Key Distribution

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arXiv:1410.1850v1

Recently, a quantum key distribution (QKD) scheme based on entanglement swapping, called measurement-device-independent QKD (mdiQKD), was proposed to bypass all detector side-channel attacks. While mdiQKD is conceptually elegant and offers a supreme level of security, the experimental complexity is challenging for practical systems. For instance, it requires interference between two widely separated independent single-photon sources, and the rates are dependent on detecting two photons - one from each source. We present a QKD scheme that removes the need for a two-photon system and instead uses the idea of a two-qubit single-photon (TQSP) to significantly simplify the implementation and improve the efficiency of mdiQKD in several aspects.

Topological Superconductivity in Ferromagnetic Metal Chains

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arXiv:1410.3453v1

Recent experiments have provided evidence that a possible platform for one-dimensional (1D) topological superconductivity, transition metal atom chains formed on a superconducting substrate, can be realized experimentally. We address the properties of this type of system by using a Slater-Koster tight-binding model to account for important features of transition metal electronic structure. We predict that topological superconductivity is nearly universal when ferromagnetic transition metal chains form straight lines on superconducting substrates and that it is possible for more complex chain structures. The proximity induced gap is ??Eso/J where ? is the s-wave pair-potential on the chain, Eso is the spin-orbit splitting energy induced in the normal chain state bands by hybridization with the superconducting substrate, and J is the exchange-splitting of the ferromagnetic chain d-bands. Because of the topological character of the 1D superconducting state, Majorana end modes appear within the gaps of finite length chains. Pb is a particularly favorable substrate material for ferromagnetic chain topological superconductivity because it provides both strong s-wave pairing and strong Rashba spin-orbit coupling, but there seems to be considerable freedom to optimize the 1D topological superconductivity by varying the atomic composition and structure of the chain. We note that in the absence of disorder a new chain magnetic symmetry, one that is also present in the crystalline topological insulators, can stabilize multiple Majorana modes at the end of a single chain.

Kitaev Chains with Long-Range Pairing

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We propose and analyze a generalization of the Kitaev chain for fermions with long-range p-wave pairing, which decays with distance as a power law with exponent ?. Using the integrability of the model, we demonstrate the existence of two types of gapped regimes, where correlation functions decay exponentially at short range and algebraically at long range (?¿1) or purely algebraically (?¡1). Most interestingly, along the critical lines, long-range pairing is found to break conformal symmetry for sufficiently small ?. This is accompanied by a violation of the area law for the entanglement entropy in large parts of the phase diagram in the presence of a gap and can be detected via the dynamics of entanglement following a quench. Some of these features may be relevant for current experiments with cold atomic ions.

Chiral spin liquid and emergent anyons in a Kagome lattice Mott insulator

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Topological phases in frustrated quantum spin systems have fascinated researchers for decades. One of the earliest proposals for such a phase was the chiral spin liquid, a bosonic analogue of the fractional quantum Hall effect, put forward by Kalmeyer and Laughlin in 1987. Elusive for many years, recent times have finally seen this phase realized in various models, which, however, remain somewhat artificial. Here we take an important step towards the goal of finding a chiral spin liquid in nature by examining a physically motivated model for a Mott insulator on the Kagome lattice with broken time-reversal symmetry. We discuss the emergent phase from a network model perspective and present an unambiguous numerical identification and characterization of its universal topological properties, including ground-state degeneracy, edge physics and anyonic bulk excitations, by using a variety of powerful numerical probes, including the entanglement spectrum and modular transformations.