Journal club 23/05/2014 on
"Synthetic Gauge Fields in Synthetic Dimensions" PRL **112**, 043001
by A. Celi, P. Massignan, J. Ruseckas, N. Goldman, I.B. Spielman, G. Juzeliunas, and M. Lewenstein

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Topological Phases in Triangular Lattices of Ru Adsorbed on Graphene: ab-initio calculations,
Phys. Rev. B **89**, 155438 (2014),
C. Mera Acosta, Matheus P. Lima, R. H. Miwa, Antonio J. R. da Silva, and A. Fazzio
ABSTRACT: We have performed an ab initio investigation of the electronic properties of the graphene sheet adsorbed by Ru adatoms (Ru/graphene). For a particular set of triangular arrays of Ru adatoms, we find the formation of four (spin-polarized) Dirac cones attributed to a suitable overlap between two hexagonal lattices: one composed by the C sites of the graphene sheet, and the other formed by the surface potential induced by the Ru adatoms. Upon the presence of spin-orbit coupling (SOC) nontrivial band gaps take place at the Dirac cones promoting several topological phases. Depending on the Ru concentration, the system can be topologically characterized among the phases i) Quantum Spin Hall (QSH), ii) Quantum Anomalous Hall (QAH), iii) metal iv) or trivial insulator. For each concentration, the topological phase is characterized by the ab-initio calculation of the Chern number.

Non-Abelian Majorana Doublets in Time-Reversal Invariant Topological Superconductor,
Phys. Rev. X **4**, 021018 (2014) Xiong-Jun Liu, Chris L. M. Wong, and K. T. Law
ABSTRACT: The study of non-Abelian Majorana zero modes advances our understanding of the fundamental physics in quantum matter, and pushes the potential applications of such exotic states to topological quantum computation. It has been shown that in two-dimensional (2D) and 1D chiral superconductors, the isolated Majorana fermions obey non-Abelian statistics. However, Majorana modes in a Z_2 time-reversal invariant (TRI) topological superconductor come in pairs due to Kramers' theorem. Therefore, braiding operations in TRI superconductors always exchange two pairs of Majoranas. In this work, we show interestingly that, due to the protection of time-reversal symmetry, non-Abelian statistics can be obtained in 1D TRI topological superconductors and may have advantages in applying to topological quantum computation. Furthermore, we unveil an intriguing phenomenon in the Josephson effect, that the periodicity of Josephson currents depends on the fermion parity of the superconducting state. This effect provides direct measurements of the topological qubit states in such 1D TRI superconductors.

Majorana zero modes on a 1D chain for quantum computation,
arXiv:1405.1180 [quant-ph]
Lei Chen, W. LiMing, and Jia-Hui Huang,
ABSTRACT: Numerical calculations for Majorana zero modes on a one-dimensional chain are performed using the technique of block diagonalization for general parameter settings. It is found that Majorana zero modes occur near the ends of the chain and decay exponentially away from the ends. The phase diagrams show that Majorana zero modes of a long-enough chain indeed have a parameter domain of $2t > |\mu|$ as predicted from the bulk property of the chain, but a short chain has a much smaller parameter domain than the prediction. Through a numerical simulation Majorana zero modes are found to be robust under the disturbance of noise. Finally the reversion of the parity of the ground states is studied by applying a bias voltage on the quantum dot at an end of the chain. It is found that for a weak coupling between

a chain and a quantum dot the parity of the ground states can be reversed through adiabatically tuning the bias voltage.

Chiral symmetry and bulk–boundary correspondence in periodically driven one-dimensional systems,

arXiv:1405.1709 [cond-mat.mes-hall],
J. K. Asboth, B. Tarasinski, and P. Delplace,
ABSTRACT: Over the past few years, topological insulators have taken center stage in solid state physics. The desire to tune the topological invariants of the bulk and thus control the number of edge states has steered theorists and experimentalists towards periodically driving parameters of these systems. In such periodically driven setups, by varying the drive sequence the effective (Floquet) Hamiltonian can be engineered to be topological: then, the principle of bulk–boundary correspondence guarantees the existence of robust edge states. It has also been realized, however, that periodically driven systems can host edge states not predicted by the Floquet Hamiltonian. The exploration of such edge states, and the corresponding topological phases unique to periodically driven systems, has only recently begun. We contribute to this goal by identifying the bulk topological invariants of periodically driven one-dimensional lattice Hamiltonians with chiral symmetry. We find simple closed expressions for these invariants, as winding numbers of blocks of the unitary operator corresponding to a part of the time evolution, and ways to tune these invariants using sublattice shifts. We illustrate our ideas on the periodically driven Su-Schrieffer-Heeger model, which we map to a discrete time quantum walk, allowing theoretical results about either of these systems to be applied to the other. Our work helps interpret the results of recent simulations where a large number of Floquet Majorana fermions in periodically driven superconductors have been found, and of recent experiments on discrete time quantum walks.

Ising anyons with a string tension,

Phys. Rev. B **89**, 201103(R) (2014),
M. D. Schulz, S. Dusuel, G. Misguich, K. P. Schmidt, and J. Vidal,
ABSTRACT: We consider the string-net model on the honeycomb lattice for Ising anyons in the presence of a string tension. This competing term induces a nontrivial dynamics of the non-Abelian anyonic quasiparticles and may lead to a breakdown of the topological phase. Using high-order series expansions and exact diagonalizations, we determine the robustness of this doubled Ising phase which is found to be separated from two gapped phases. An effective quantum dimer model emerges in the large tension limit giving rise to two different translation symmetry-broken phases. Consequently, we obtain four transition points, two of which are associated with first-order transitions whereas the two others are found to be continuous and provide examples of recently proposed Bose condensation for anyons.

Anomalous Hall effect with ultracold gases,

arXiv:1405.2565 [cond-mat.quant-gas],
O. Dutta, A. Przysiezna, and J. Zakrzewski,
ABSTRACT: We study ultracold fermions trapped in a shaken two dimensional triangular lattice. We find that, a combination of interaction induced tunneling and shaking can result in an emergent dice lattice along with controllable staggered magnetic flux and synthetic non-Abelian fields. Moreover, by tuning the staggered flux, we show that one can enter the regime of Quantum Anomalous Hall effect. Our results are reminiscent of Anomalous Hall conductivity in spin-orbit coupled Ferromagnets.