CMT Journal club, 10.02.2015, Marcel Serina

1. **Universal spin-triplet superconducting correlations of Majorana fermions**

   Xin Liu, Jay D. Sau, S. Das Sarma

2. **Edge states and integer quantum Hall effect in topological insulator thin films**

   Song-Bo Zhang, Hai-Zhou Lu, Shun-Qing Shen; *arXiv:1502.01792*

   The integer quantum Hall effect is a topological state of quantum matter in two dimensions, and has recently been observed in three-dimensional topological insulator thin films. Here we study the Landau levels and edge states of surface Dirac fermions in topological insulators under strong magnetic field. We examine the formation of the quantum plateaux of the Hall conductance and find two different patterns, in one pattern the filling number covers all integers while only odd integers in the other. We focus on the quantum plateau closest to zero energy and demonstrate the breakdown of the quantum spin Hall effect resulting from structure inversion asymmetry. The phase diagrams of the quantum Hall states are presented as functions of magnetic field, gate voltage and chemical potential. This work establishes an intuitive picture of the edge states to understand the integer quantum Hall effect for Dirac electrons in topological insulator thin films.

3. **Detecting Goldstone Modes with Entanglement Entropy**

   B. Kulchytskyy, C. M. Herdman, Stephen Inglis, Roger G. Melko; *arXiv:1502.01722*

   In the face of mounting numerical evidence, Metlitski and Grover [arXiv:1112.5166] have given compelling analytical arguments that systems with spontaneous broken continuous symmetry contain a sub-leading contribution to the entanglement entropy that diverges logarithmically with system size. They predict that the coefficient of this log is a universal quantity that depends on the number of Goldstone modes. In this paper, we confirm the presence of this log term through quantum Monte Carlo calculations of the second Rényi entropy on the spin 1/2 XY model. Devising an algorithm to facilitate convergence of entropy data at extremely low temperatures, we demonstrate that the single Goldstone mode in the ground state can be identified through the coefficient of the log term. Furthermore, our simulation accuracy allows us to obtain an additional geometric constant additive to the Rényi entropy, that matches a predicted fully-universal form obtained from a free bosonic field theory with no adjustable parameters.

4. **Symmetry-protected Topological Phases at Finite Temperature**

   O. Viyuela, A. Rivas, M.A. Martin-Delgado; *arXiv:1502.01355*

   We have applied the recently developed theory of topological Uhlmann numbers to an emblematic model of topological insulator in 2D such as the Qi-Wu-Zhang model. We have found a stable symmetry-protected topological phase under external thermal fluctuations in two-dimensions. A complete phase diagram for this model is computed as a function of temperature and coupling constants in the original Hamiltonian. It shows the appearance of large stable phases of matter with topological properties compatible with thermal fluctuations or external noise and the existence of critical lines separating abruptly trivial phases from topological phases. These novel critical temperatures represent thermal topological phase transitions. The initial part of the paper comprises a self-contained explanation of the Uhlmann geometric phase needed to understand the topological properties that it may acquire when applied to topological insulators and superconductors.

5. **A discretized Chern-Simons gauge theory on arbitrary graphs**

   Kai Sun, Krishna Kumar, Eduardo Fradkin; *arXiv:1502.00641*

   In this paper, we show how to discretize the Chern-Simons gauge theory on generic planar lattices/graphs (with or without translational symmetries) embedded in arbitrary 2D closed orientable manifolds. We find that, as long as a one-to-one correspondence between vertices and faces can be defined on the graph such that each face is paired up with a neighboring vertex (and vice versa), a discretized Chern-Simons theory can be constructed consistently. We further verify that all the essential properties of the Chern-Simons gauge theory are preserved in the discretized setup. In addition, we find that the existence of such a one-to-one correspondence is not only a sufficient condition for discretizing a Chern-Simons gauge theory but, for the discretized theory to be nonsingular and to preserve some key properties of the topological field theory, this correspondence is also a necessary one. A specific example will then be provided, in which we discretize the Chern-Simons gauge theory on a tetrahedron.

6. **Andreev spectroscopy of Majorana states in topological superconductors with multipocket Fermi surfaces**

   Ana C. Silva, Miguel A. N. Araújo, Pedro D. Sacramento; *arXiv:1502.00895*

   The topological properties of a multiband topological superconductor in two dimensions are studied, when the latter is obtained by introducing electron pairing in an otherwise topological insulator. The type of pairing, doping and Fermi surface topology play an essential role. Considering the Andreev reflection problem, we use a previously developed quantum waveguide theory for multiorbital systems and find that, when the Fermi surface has several pockets, this theory retrieves the correct number of Majorana fermion states as predicted by the topological index. By varying band structure parameters, the Fermi surface topology of the normal phase can be made to change, whereby the number of Majorana modes also varies. We calculate the effect of such transitions on the Andreev differential conductance.

7. **Electrical control and interaction effects of the RKKY interaction in helical liquids**

   Yu-Wen Lee, Yu-Li Lee; *arXiv:1502.01201*

   We study the RKKY interaction mediated by the helical edge states of a quantum spin Hall insulator in the presence of the Rashba spin-orbital coupling induced by an external electric field and the electron-electron interaction. We show that in the presence of the Rashba coupling, the RKKY interaction induced by the helical edge states contains not only the Heisenberg-like and the Dzyaloshinskii-Moria terms but also the nematic-type term that is not present originally, with the range functions depending on the strength of the Rashba coupling. We also show that the electron-electron interaction changes the strength of the RKKY interaction by modifying the power of the $1/|x|$ dependence of the range functions. In particular, by varying the strength of the interaction or the Rashba coupling, there is an (impurity) quantum phase transition involving the sign change of the RKKY interaction at the value of the Luttinger liquid parameter K=1/2. Since both the strength of the Rashba coupling and the chemical potential of the helical edge states are electrically controllable by external gate voltages, our results not only shed light on the nature of magnetic impurity correlations in the edge of a two-dimensional topological insulator, but also pave a way to manipulate the qubits in quantum computing.

8. **Anderson transition for Google matrix eigenstates**

   O.V.Zhirov, D.L.Shepelyansky; *arXiv:1502.00584*

   We introduce a number of random matrix models describing the Google matrix G of directed networks. The properties of their spectra and eigenstates are analyzed by numerical matrix diagonalization. We show that for certain models it is possible to have an algebraic decay of PageRank vector with the exponent similar to real directed networks. At the same time the spectrum has no spectral gap and a broad distribution of eigenvalues in the complex plain. The eigenstates of G are characterized by the Anderson transition from localized to delocalized states and a mobility edge curve in the complex plane of eigenvalues.

9. **Surface plasmons for doped graphene**

   M. Bordag, I.G. Pirozhenko; *arXiv:1502.00421*

   Within the Dirac model for the electronic excitations of graphene, we calculate the full polarization tensor with finite mass and chemical potential. It has, besides the (00)-component, a second form factor, which must be accounted for. We obtain explicit formulas for both form factors and for the reflection coefficients. Using these, we discuss the regions in the momentum-frequency plane where plasmons may exist and give numeric solutions for the plasmon dispersion relations. It turns out that plasmons exist for both, TE and TM polarizations over the whole range of the ratio of mass to chemical potential, except for zero chemical potential, where only a TE plasmon exists.

10. **Nonlocal Damping of Helimagnets in One-Dimensional Interacting Electron Systems**

    Kjetil M. D. Hals, Karsten Flensberg, Mark S. Rudner; *arXiv:1502.00268*

    We investigate magnetization relaxation in interacting one-dimensional helimagnetic systems. Relaxation results from the emission of plasmonic excitations into the itinerant electron system due to slow changes of the magnetization profile. This dissipation mechanism leads to a highly nonlocal form of magnetization damping that is strongly dependent on the electron-electron interaction. Forward scattering processes lead to a spatially constant damping, whereas backscattering processes produce a spatially oscillating damping. Due to the nonlocal damping, the thermal fluctuations become spatially correlated over the entire system. We calculate the characteristic magnetization relaxation times for chains of magnetic Fe atoms, magnetic quantum wires, and nuclear helimagnets.