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Electron correlations in low-dimensional topological systems [1]

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We study the correlation effects in topological insulators/superconductors and the resulting topological edge states in low dimensions.

We first give an example of topological Mott insulator in one dimension [1], where bulk is a correlated topological insulator while the edge state exhibits a typical Mott behavior [2]. We elucidate these properties by examining the bulk topological invariant and the entanglement spectrum of a correlated electron model. We clarify how gapless edge states in a non-interacting topological band insulator evolve into spinon edge states in a topological Mott insulator. Furthermore, we propose a topological Mott transition, which occurs in spin liquid phases in the Mott insulator and is accompanied by a gap closing in the spin excitation spectrum.

Then we deal with a two-dimensional system by employing a double-layer Kane-Mele model [3, 4], and show a concrete example of topological Mott insulator in two dimensions. It is clarified how the topological Mott state evolves from the ordinary spin Hall insulating state with increasing the Hubbard interaction at a given temperature and then undergoes a phase transition to a trivial Mott insulating state. With a bosonization approach at zero temperature, we address which collective excitations host gapless edge modes in the topological Mott insulating state [3, 5]. We further demonstrate an intriguing crossover behavior induced by the interplay between topology and correlation; the edge state change its character from fermionic to bosonic with decreasing temperature.

We also discuss the reduction of topological classification due to correlation effects. Two examples are addressed. One is a two-dimensional weak topological insulator[6], which shows the reduction of classification from Z to Z4. To this end, we explore a double-layer honeycomb lattice model with correlation. The other is a topological superconductor [7], which exemplifies the reduction from Z2 to ZxZ8. It is shown that a heavy-fermion superlattice CeCoIn5/YbCoIn5 can provide a possible platform to experimentally confirm this reduction.

If time allows, we address a laser-induced topological superconductivity in cuprate thin films[8], which will provide a versatile platform for creating correlated topological superconductors in nonequilibrium conditions.

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