Stony Brook University
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Abstract

Exactly Solvable Models for Topological Phases of Matter

By

Nicolas Alessandro Tarantino

Topological systems are characterized by some collection of features which remain unchanged under deformations of the Hamiltonian which leave the band gap open. While the earliest examples studied free fermion systems and found that some band structures support topological edge modes, we can also ask the reversed question, i.e. Given a band gap, what topological features can be engineered?

This classification problem proved to have numerous answers depending on which extra assumptions we allow, producing many candidate phases. While free fermion topological features could be classified by their band structures (culminating in the 10-fold way classification), strongly interacting systems defied this approach, and so classification outstripped the construction of even the most elementary Hamiltonians, leaving us with a number of phases which could exist, but do not have a single strongly interacting representative.

The purpose of this thesis is to resolve this by construct commuting projector models (CPM), a class of exactly solvable model, for two types of topological phases, known as symmetry enriched topological (SET) order and fermionic symmetry protected topological (SPT) phases respectively. After introducing the background and history of commuting projector models, we will move on to the details of how these Hamiltonians are built in our two cases. In the first, we will construct a CPM for a SET, showing how to encode the necessary group cohomology data into a lattice model. In the second, we construct a CPM for a fermionic SPT, and find that we must include a combinatorial representation of a spin structure to make the model consistent. While these two projects were independent, they are linked thematically by a technique known as decoration, where extra data is encoded onto simple models to generate exotic phases.

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