Geometry, topology and symmetry in strongly correlated materials

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**Research Overview**

Topological phenomena in strongly correlated systems are poorly understood due to the fact that they lie outside the conventional paradigm of symmetry breaking; nevertheless, they hold great potential in engineering new devices and quantum computation by virtue of their novel electronic properties. To advance our understanding of these systems, I focus on the following areas of research:

1. Developing a unified theory of the fractional quantum Hall effect and fractional Chern insulators. By incorporating aspects of the quantum geometry of the single particle Hilbert space in these systems, I have developed new analytic and numerical tools which aid the search for more experimentally accessible realizations of quantum Hall phenomena.

2. The role of crystal symmetries in topological phenomena. Using topological arguments, I’ve improved constraints on symmetry enforced degeneracies and complete the classification of short-range entangled topological states with crystal symmetries.

3. The exploration of topological phenomena in periodically driven systems. I plan to characterize these topologically robust phenomena, study the effects of interactions, the physical consequences of the classification, and connect these with experiments such as those on the fractional Josephson effect.

**Band geometry of fractional Chern insulators**

Haldane model

Kagome lattice model

Ruby lattice model

with a Chern insulator (an insulator with filled bands with a non-zero Chern number). In [7] we show that this is multiply degenerate. At the X point, these degeneracies are exact and protected by topological order. In [7] we show that this is the case even at certain integer fillings of systems with nonsymmetric space group symmetries.

**Recent publications**


