Correlated Chern insulators in two-dimensional Raman lattices: a cold-atom regularization of strongly-coupled four-Fermi field theories

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Abstract

We show that ultra-cold atoms with synthetic spin-orbit coupling in Raman lattices can be used as versatile
quantum simulators to explore the connections between correlated Chern insulators and strongly-coupled
four-Fermi field theories that are related to the Gross-Neveu model in (2+1) dimensions. Exploiting this multidisciplinary
perspective, we identify a large-N quantum anomalous Hall (QAH) effect in absence of any external
magnetic field, and use it to delimit regions in parameter space where these correlated topological phases appear,
the boundaries of which are controlled by strongly-coupled fixed points of the four-Fermi relativistic field
theory. We further show how, for strong interactions, the QAH effect gives way to magnetic phases described by
a two-dimensional quantum compass model in a transverse field. We present a detailed description of the phase
diagram using the large-N effective potential, and variational techniques such as projected entangled pairs.

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