

Lattice-Induced Criticality in Chiral Edge Reconstruction

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The nontrivial bulk topology of a 2D Chern phase manifests itself through chiral edge modes at its boundary. In quantum Hall systems, their low-energy physics is described by chiral Luttinger liquid theory [1]. Electron-electron interactions and a smooth confining potential at the edge, however, can induce edge reconstruction, generating additional low-energy modes without closing the bulk gap and thereby modifying transport and spectral properties [2–4].

Conventional theories of edge reconstruction have been developed primarily for continuum quantum Hall systems, whereas chiral boundary modes also arise in lattice Chern insulators without Landau levels [5,6]. We investigate how this intrinsic lattice structure can modify the universal critical theory of chiral-edge reconstruction by focusing on a neutral reconstruction mode that is staggered with respect to the underlying lattice. Translation by one lattice spacing reverses the sign of its order parameter, giving rise to a Z_2 symmetry. Consequently, when the reconstruction occurs continuously, this sector exhibits Ising criticality, in contrast to generic finite-momentum reconstruction in the continuum.

The reconstructed neutral mode is furthermore coupled to the pre-existing chiral charge mode. In the infrared, this coupling renormalizes the dispersions of both sectors and can invalidate a low-energy description based solely on linear dispersion. Nonlinear dispersion then becomes essential, producing a nontrivial reorganization of the infrared theory. We determine the possible infrared scenarios generated by this coupled system.

Our results show that lattice structure can affect not only microscopic properties of a topological edge but also the structure of its universal critical theory. They provide an effective-field-theory framework for staggered edge reconstruction in Chern insulators and related lattice topological systems.

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