

# Abstract

The discovery of the quantum Hall effect revealed that phases of matter can be classified not only by symmetry breaking, as prescribed by the Landau-Ginzburg-Wilson paradigm, but also by global topological invariants. Such topological phases, often protected by symmetries and characterized by robust edge states, have since become a central theme in condensed matter physics. While the classification of non-interacting topological phases is now well established through band theory, the role of interactions and disorder introduces fundamental challenges and opportunities, particularly in low-dimensional systems where correlations and competing orders play a dominant role.

This thesis investigates the stability and emergence of many-body topological phases in 1D and quasi-1D systems, motivated both by theoretical questions and experimental progress in ultracold atoms, photonic platforms, and superconducting circuits. The key questions addressed are whether non-interacting topological phases remain stable in the presence of interactions, and whether interactions can themselves generate new topological phases with no single-particle counterpart.

In the first work, we investigate an asymmetric two-leg fermionic ladder consisting of an SSH-type dimerized chain coupled to a uniform tight-binding chain. In the non-interacting limit, the system exhibits robust topology independent of the dimerization pattern and undergoes a topological phase transition driven by interchain tunneling. Interestingly, when interchain interactions are included, the topological phase persists up to a finite strength, beyond which increasing interaction induces a further transition to the trivial phase, which we call interaction-induced topological phase transition.

The second work explores a 1D system of hardcore bosons or spinless fermions with alternating nearest-neighbor interactions. Here we show that dimerized interactions act as the hidden architects of topology, inducing edge states and enabling Thouless charge pumping even in a system that would

otherwise be gapless.

In the third work, we extend this idea to two-leg ladders. Here, the interplay of hopping, dimerization, and rung interactions generates a rich set of topological and trivial phases, including rung-Mott insulators, bond-order phases, and charge-density-wave phases. Their transitions are established through ground-state properties.

Finally, in the fourth work, we highlight the crucial role of particle statistics by comparing bosonic and fermionic ladders. For hardcore bosons, we discover an interaction-induced reentrant topological phase transition, where the system passes from topological to trivial and back to topological as interaction strengths are tuned. This phenomenon is absent in fermionic ladders, underscoring the distinct influence of quantum statistics.

In summary, this thesis paints a cumulative picture of how interactions, geometry, and statistics intertwine to create and reshape the landscape of topological phases in low-dimensional systems. The results reveal not only the destabilization of known topological phases but also the emergence of entirely new ones, offering theoretical insights that are directly relevant for ongoing experiments in quantum simulators.