Intertwining Non-Abelian Evolution and Quantum Control *via* non-Abelian Thouless pumping

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Abstract: Non-Abelian Thouless pumping merges adiabatic quantum control with topological quantum transport. In this talk, we demonstrate how it can be utilized to simulate topological phases of matter, investigate complex Hamiltonians, and control quantum evolution.

Non-Abelian evolution is a landmark concept in modern theoretical physics. However, the extent to which non-commutative dynamics influences entanglement and transport in quantum systems remains an open question. In this talk, we introduce the concept of non-Abelian Thouless pumping [1] as a means to simulate topological phases of matter, explore complex Hamiltonians, and control quantum evolution.

The first part of the talk offers a brief introduction to geometric phases and non-Abelian holonomies in the context of quantum transport. We present different lattice models where the adiabatic manipulation of lattice parameters induces non-Abelian Thouless pumping. This process results in both the displacement of an initially localized state and a geometric unitary transformation within the degenerate subspace. Additionally, we establish a connection between the non-Abelian adiabatic evolution of a Rice-Mele ladder model and a Yang monopole model.

The second part of the talk proposes the application of non-Abelian Thouless pumping in one-dimensional discrete-time quantum walks on lattices with flat degenerate Bloch bands. Our results reveal how the interplay between non-commutativity and topology enables geometrically protected quantum coin and shift operators.

By composing different non-Abelian pumping cycles, we uncover various classes of tunable, protected quantum walks. These walks break parity symmetry and are governed by a dynamic process described by a Weyl-like equation. The degree of entanglement can be controlled accurately, while closed-form analytical expressions, confirmed numerically, determine the asymptotic statistical distribution.

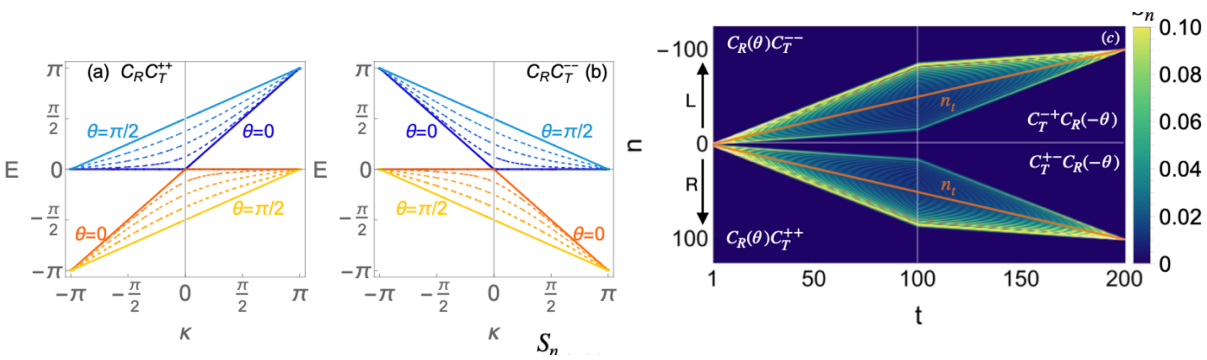

Fig. 1 Floquet quasi-energy (a-b) and evolution pattern (c) of parity-brosken quantum walks.

References

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