Long-range quantum transfer mediated by topological edge states

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The recent fabrication and control of semiconductor quantum dot arrays open the possibility of using these systems as quantum links for transferring quantum information between distant sites, an indispensable part of large-scale quantum information processing[1]. Recently, it has been shown how to imprint nontrivial topology in a quantum dot array using Floquet engineering[2]. In this talk, I will first review the different protocols to directly transfer particles and quantum states in quantum dot arrays between distant sites. Then I will discuss an alternative way to transfer information with high fidelity using protected topological edge states in systems with non-trivial topology [3,4] and the role of topological domain walls in speeding up the particle transfer. We will consider the simplest topological insulator, the SSH chain, and also the Creutz-Ladder model, where the domain walls can hold two topological states[5]. It allows the use of one as a quantum memory while the other transfers information through the wall, allowing for complex transfer operations between topological states. It opens efficient avenues for quantum state transfer protocols in low-dimensional topological lattices.

References

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[3] N. Lang et al., npj, QI., 3 (2017) 47; F. Mei et al., Phys Rev A, 98, (2018) 012331
[4] J. Zurita et al.,, Quantum, 5 (2021) 591
[5] J. Zurita et al., Quantum, 7 (2023) 1043; J. Zurita et al., Quantum, in press

Figures

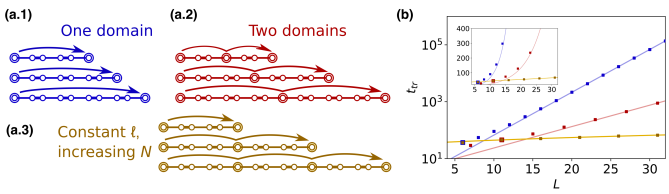

Figure 1: Transfer time between left and right states in an SSH chain as a function of distance, (a.1) a single domain of increasing length, (a.2) two domains of increasing length and (a.3) an increasing number of domains of length $\ell = 4$. (b) Transfer time t_{tr} in the three cases as a function of the total length

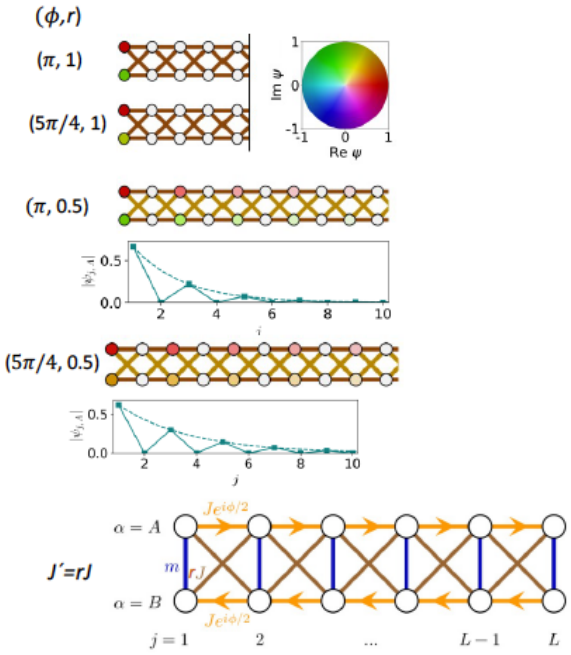

Figure 2: Chiral left end modes in the Creutz Ladder for different values of the flux and r