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Realizing Topological Quantum Walks on NISQ Digital Quantum Computer

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We study the quantum walk on the off-diagonal Aubry-André-Harper (AAH) lattice with periodic modulation using a digital quantum computer. We investigate various initial states at the single-particle level, considering different hopping modulation strengths and phase factors. Initiating the quantum walk with a particle at the lattice edge reveals the robustness of the edge state, attributed to the topological nature of the AAH model, and displays the influence of the phase factor on this edge state. On the other hand, when the quantum walk begins with a particle in the lattice bulk, we observe a repulsion of the bulk walker from the edge, especially under strong hopping modulation. Furthermore, we extend our investigation to the quantum walk of two particles with nearest-neighbour (NN) interaction. We show the repulsion effect in the quantum walk when two walkers originate from the edge and bulk of the lattice due to the interaction. Additionally, when two particles are positioned at NN sites and subjected to strong hopping modulation strength, they exhibit localization in the presence of interaction. We analyze these phenomena by examining physical quantities such as density evolution, two-particle correlation, and participation entropy, and discuss their potential applications in quantum technologies.

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