Topological state transfer and maximal entanglement between distant qubits using a minimal quasicrystal pump

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Coherent quantum state transfer over macroscopic distances between non-neighboring elements in quantum circuits is a crucial component to increase connectivity and simplify quantum information processing. To facilitate such transfers, an efficient and easily controllable quantum pump would be highly beneficial. In this work, we demonstrate such a quantum pump based on a one-dimensional quasicrystal Fibonacci chain (FC). In particular, we utilize the unique properties of quasicrystals to pump the edge-localized winding states between the two distant ends of the chain by only minimal manipulation of the FC at its endpoints. We establish the necessary conditions for successful state transfer within a fully time-dependent picture and also demonstrate rthe obustness of the transfer protocol against disorder. We then couple external qubits to each end of the FC and establish highly adaptable functionality as a quantum bus with both on-demand switching of the qubit states and generation of maximally entangled Bell states between the qubits. Thanks to the minimal control parameters, the setup is well-suited for implementation across diverse experimental platforms, thus establishing quasicrystals as an efficient platform for versatile quantum information processing.

Figures

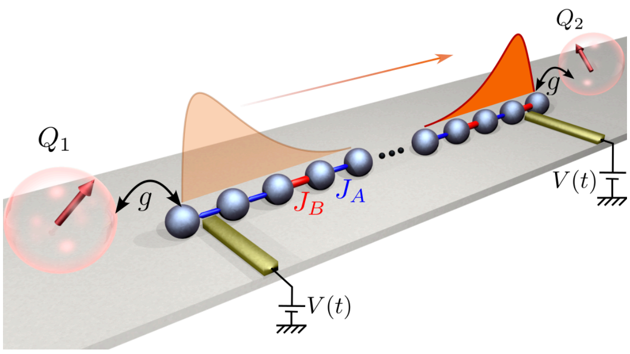

Figure 1: The Fibonacci quantum pump consists of an FC with weak bonds J_A (blue) and strong bonds J_B (red). The transfer protocol *V(t)* dynamically modifies the outermost bonds of the Fibonacci chain and induces a transfer of a winding state from the left end (light orange) to the right (dark orange). External qubits Q_1 and Q_2 are coupled to the FQP with coupling constant *g*. The FQP can transfer a state between the two qubits or generate maximally entangled states between them.

References

[1] A. K. Ghosh, R. S. Souto, V. Azimi-Mousolou, A. M. Black-Schaffer, and P. Holmvall. Phys. Rev. B **112** (2025) 205427.