Staggered quantum walks with superconducting microwave resonators

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Quantum walks form the building blocks in designing quantum search algorithms [1]. In one-dimensional (1D) discrete-time quantum walks (DTQWs) [2], a two-level quantum system plays the role of a quantum coin, which is able to exist in a superposition of states, leading to a ballistic spreading of the walker encoded in a set of discrete states. In continuous-time quantum walks (CTQWs) [3], the excitation exchange between the neighboring sites, in a lattice, directly works as a walker with no need of a coin. Recently we have proposed the staggered quantum walk (SQW with Hamiltonians) [4], which employs graph tessellations to define local Hamiltonians. This model has two general advantages - Firstly, it is quite general and includes several quantum quantum walk model as particular cases. Secondly, the SQW with Hamiltonians is highly fitted for implementation through bosonic nearest neighbor interactions, similarly to the CTQW [5], with the advantage of being able to outperform classical search algorithms at lower dimensional lattice structures [6]. The intrinsic difficulty is the required ability to have a high control over interactions required. Here we present a discussion on the SQW with Hamiltonians model and on the requirements for it to be implemented. We specifically propose an implementation employing microwave resonators coupled through SQUIDs [7]. The implementation is a prototype to describe any general dynamics on triangle-free graphs. In that class of graphs, which includes N-dimensional square lattices and trees, the resonators interact in a pairwise way in each element of the tessellation. In the proposal the lattice dynamics is coherently controlled through external electromagnetic pulses.

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