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Electric quantum walks without electric field: an optical implementation scheme

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Quantum walks are known to provide a universal platform for quantum algorithms and hence, are useful for quantum computation and information processing. Unlike other methods of simulating quantum protocols, quantum walks can be realized in classical systems. One of the interesting class of quantum walks is the electric quantum walk where the dynamics of the (charged) quantum walker is influenced by an external electric field. In this work we present a scheme to implement this dynamics without the electric field. This is done by using the classical light and a linear optical setup. The walk is performed over the quantized orbital angular momentum of the light beam whereas the optical polarization constitutes the coin space for the walker. The effect of the electric field is also simulated by the linear optical devices. We explore different phases of the dynamics such as the localization and the Bloch oscillations by choosing proper settings of the optical setup. We also study the (non-quantum) entanglement arising between the orbital angular momentum and the optical polarization.

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