Construction of Distinct Discrete Time Scattering Quantum Walk Formulations on the Honeycomb Lattice

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ABSTRACT

Here we address the scattering construction of discrete time quantum walks on the honeycomb lattice. We write the system general (unitary) one step time evolution operator in terms of: i) complete arbitrary scattering matrices $\Gamma(j,k)$, defined on the sites (j,k) of the lattice and; and ii) topological directional functions Φ, which represent the distinct ways we can keep track of the propagation directions along the three bonds attached to each (j,k). By imposing the Φs to comply with all the honeycomb translational and point group symmetries (in the case of $\Gamma(j,k)=\Gamma$), we obtain in total ten independent model versions, presenting different dynamical features. To study some of their traits, we consider the idea of characteristic paths CPs (closely related to classical random walks), determining the CPs for each one of the ten formulations. We then discuss many numerical examples of time evolution dynamics for our scattering quantum walks. For the calculations we use few Γs, as the Discrete Fourier Transform (DFT) and Grover matrices.