Quantum walk simulation of quantum field theories with extra dimensions

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We will discuss the possibility of using quantum walks (QWs) to simulate quantum field theories with extra dimensions. First, we consider a 2D alternate QW on a cylinder [1]. We concentrate on the motion along the open dimension, thus looking at the closed coordinate as a small or "hidden" extra dimension. The dynamics of the QW that is obtained after tracing out the small dimension shows the contribution of several components, which can be understood from the study of the dispersion relations for this problem. In the continuous space-time limit, the different components manifest as a set of Dirac equations, with each quasi-momentum providing the value of the corresponding mass, a situation that reminds the tower of solutions that is obtained in Kaluza-Klein type theories. Next, we analyze the properties of a two and three dimensional QW which is inspired by the idea of a brane-world model put forward by Rubakov and Shaposhnikov [2]. We translate this model into an alternate QW with a coin that depends on the external field, with a dependence which mimics a domain wall solution [3]. The walker becomes localized in one of the dimensions, not from the action of a random noise on the lattice, but from a regular dependence in space. On the other hand, the resulting quantum walk can move freely along the "ordinary" dimensions.

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