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Quantum Random Walks and the Graph Isomorphism Problem[1] KENNETH RUDINGER, JOHN KING GAMBLE, MARK WELLONS, MARK FRIESEN, ERIC BACH, ROBERT JOYNT, S.N. COPPERSMITH, University of Wisconsin-Madison — We investigate the quantum dynamics of particles on graphs ("quantum walk"), with the aim of developing quantum algorithms for determining whether or not two graphs are isomorphic. We investigate such walks on strongly regular graphs (SRGs), a class of graphs with high symmetry. We explore the effects of particle number and interaction range on a walk's ability to distinguish non-isomorphic graphs. We numerically find that both non-interacting three-boson and three-fermion continuous time walks have the same distinguishing power on a dataset of 70,712 pairs of SRGs, each distinguishing over 99.6% of the pairs. We also find that increasing to four non-interacting particles further increases distinguishing power on this dataset. While increasing particle number increases distinguishing power, we prove that any walk of a fixed number of non-interacting particles cannot distinguish all SRGs. We numerically find that increasing particle number and increasing interaction range both result in increased distinguishing power of non-SRGs that are designed to be indistinguishable to the hard-core two-boson walk.

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