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Fractal Path Strategies for Efficient 2D DMRG Simulations

Numerical simulations of quantum magnetism in two spatial dimensions are often constrained by the area law of entanglement entropy, which heavily limits the accessible system sizes in tensor network methods. In this work, we investigate how the choice of mapping from a two-dimensional lattice to a one-dimensional path affects the accuracy of the two-dimensional Density Matrix Renormalization Group algorithm. We systematically evaluate all mappings corresponding to a subset of the Hamiltonian paths of the $N \times N$ grid graphs up to $N = 8$ and demonstrate that the fractal space-filling curves generally lead to faster convergence in ground state searches compared to the commonly used "snake" path. To explain this performance gain, we analyze various locality metrics and propose a scalable method for constructing high-performing paths on larger lattices by tiling smaller optimal paths. Our results show that such paths consistently improve simulation convergence, with the advantage increasing with system size.

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