Non-unitary state preparation for a gauge theory in the presence of noise

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We propose a new variational ansatz for the ground state preparation of the two-dimensional Z2 lattice gauge theory in digital quantum computers. It is similar to the QAOA in the sense that it contains a series of propagators acting over a reference state but one of them performs evolution in imaginary time. This increases the effectivity of the ansatz around the phase transition of the gauge theory and reduces the number of layers required to reach high fidelity. We propose a non-probabilistic implementation for the non-unitary imaginary-time propagator. The performance of this ansatz in absence of noise is demonstrated by showing its ability to approximate the critical exponents of the Z2 lattice theory apart from the usual fidelity arguments. We then introduce noise and determine when it is counterproductive to introduce more layers in the ansatz, depending on the error rate. A lattice with the geometry of the rotated surface code is used in the simulation in order to introduce ground state degeneracy in the topological phase for finite lattices. The proposed ansatz is able to prepare any of the degenerated ground states.

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