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**Quantum algorithms to simulate many-body physics of correlated fermions** ZHANG JIANG, NASA/Ames Res Ctr, KEVIN SUNG, University of Michigan, KOSTYANTYN KECHEDZHI, NASA/Ames Res Ctr, VADIM SMELYANSKIY, SERGIO BOIXO, Google, inc — Simulating strongly correlated fermionic systems is notoriously hard on classical computers. An alternative approach, as proposed by Feynman, is to use a quantum computer. Here, we discuss quantum simulation of strongly correlated fermionic systems. We focus specifically on 2-dimensional (2D) and linear geometry with nearest neighbor qubit-qubit couplings. We improve an existing algorithm to prepare an arbitrary Slater determinant by exploiting a unitary symmetry. We also present a quantum algorithm to prepare an arbitrary fermionic Gaussian state. Both algorithms are optimal in the sense that the numbers of parameters in the quantum circuits are equal to those to describe the quantum states. Furthermore, we propose an algorithm to implement the 2D fermionic Fourier transformation on a 2D qubit array with only $O(N^{1.5})$ gates and $O(\sqrt{N})$ circuit depth, which is the minimum depth required for quantum information to travel across the qubit array. We also present methods to simulate each time step in the evolution of the 2D Fermi-Hubbard model. Finally, we discuss how these algorithms can be used to determine the ground state properties and phase diagrams of strongly correlated quantum systems the Hubbard model as an example.

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