Simulating the Hubbard-Holstein model on Quantum Computers

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The digital simulation of an electron-phonon system, and more in general of fermion-boson systems, on quantum computers in the NISQ era is a difficult task, since it's not clear how to generalize current state of the art methods, i.e. VQE, for such systems. To circumvent this problem, we aim to develop a scheme capable of performing digital-analog simulations of similar models. We propose an hybrid architecture based on superconducting qubits and resonators with the purpose of employing the Variation Cluster Approximation, which requires the measurement of Green's functions. In particular, in this instance, we present the circuit for the time evolution of the two-site Hubbard-Holstein model with no spin.



Figure 1: Evolution of the density operators for electrons (on the left) and phonons (on the right), comparison between the analytical time evolution (black line) and the circuit (red dots)