Rydberg atom graphs for adiabatic quantum computations

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Abstract:

Quantum computing draws keen attention recently due to its potential ability to address so-called NP problems which classical computers cannot treat efficiently. Among physical platforms for quantum computers such as trapped ions, superconductors, neutral atoms, etc, Rydberg atom platforms have been rapidly developed in a decade because it is easily scalable. Recently there have been remarkable experimental demonstrations regarding quantum simulations on scalable Rydberg atom platforms [1]. For major applications currently, quantum adiabatic evolution methods are commonly used, to find ground states of a many-body Hamiltonian in systems of more than tens of atoms. Such protocols also can be mapped to quantum algorithms to find the solutions of a combinatorial optimization problem such as the maximum-independent-set (MIS) problem for a given connected graph [2]. Here we show that an arbitrary Rydberg atoms arrangement can implement a graph. We also show that complex graph arrangements can be constructed with auxiliary atomic chains, called Rydberg quantum wires, by coupling distant atoms [3,4]. In our three-dimensional Rydberg atom platform, we experimentally demonstrate that the solutions of the MIS problems of implemented graphs with Rydberg quantum wires can be obtained by adiabatic evolutions. We further discuss the applications of embedding such complex graphs to approach other NP problems such as 3-SAT and prime factorizations.

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