Exploring Ground States of Ferm Hubbard Model on Honeycomb Lattices with Counterdiabaticity

Jialiang Tang[1], Ruoqian Xu[1], Yongcheng Ding[1,2], Xusheng Xu[3], Yue Ban[4], Manhong Yung[5,6,7,8], Axel Perez-Obiol[9], Gloria Platero[10], Xi Chen[1,11]

[1] Department of Physical Chemistry, University of the Basque Country UPV/EHU, Apartado 644, 48080 Bilbao.
[2] Department of Physics, Shanghai University, 200444 Shanghai, China.
[3] Department of Physics, State Key Laboratory of Low-Dimensional Quantum Physics, Tsinghua University, Beijing 100084, China.
[4] Departamento de Fisica, Universidad Carlos III de Madrid, Avda. de la Universidad 30, 28911 Leganes, Spain.
[5] Department of Physics, Southern University of Science and Technology, Shenzhen 518055, People's Republic of China.
[6] Shenzhen Institute for Quantum Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, People's Republic of China.
[7] Guangdong Provincial Key Laboratory of Quantum Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, People's Republic of China.
[8] Shenzhen Key Laboratory of Quantum Science and Engineering, Southern University of Science and Technology, Shenzhen 518055, People's Republic of China.
[9] Barcelona Supercomputing Center (BSC), Barcelona 08034, Spain.
[10] Instituto de Ciencia de Materiales de Madrid (CSIC), Cantoblanco, E-28049 Madrid, Spain.
[11] EHU Quantum Center, University of the Basque Country UPV/EHU, Barrio Sarriena, s/n, 48940 Leioa, Biscay, Spain.

tang13419@gmail.com

The ground state of Fermi-Hubbard model is of relevance to essential material characteristics in the systems such as artificial graphene and high-temperature superconductors [1-2]. In this talk, we present the exploration of the ground state properties of this model on a honeycomb lattice structure using quantum counterdiabatic (CD) algorithms with shallower circuit depth and fewer qubit numbers [3]. Our study focuses on variational quantum algorithms, specifically leveraging CD algorithms to design shallow quantum circuits capable of simulating larger honeycomb lattices, shown in Fig. 1.

We demonstrate the efficacy of the CD algorithm through a comparative analysis of its performance against Hamiltonian variational ansatz (HVA) on a triangular honeycomb lattice with 26 qubits, as depicted in Fig. 2. Moreover, we introduce noise into the quantum circuits. Notably, our findings indicate that the counterdiabatic-inspired ansatz outperforms in accurately determining the ground energy.

This study sheds light on the potential of variational quantum algorithms in probing quantum materials, particularly within the complex landscape of noisy intermediate-scale quantum computing.

References

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Figures

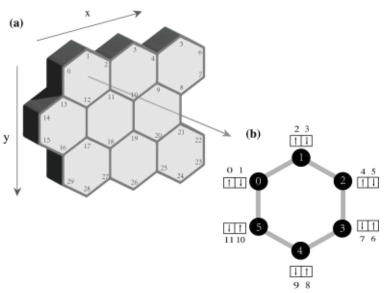

Figure 1. A schematic diagram of the Fermi-Hubbrd model: regular hexagonal honeycomb structure is used to describe the lattices.

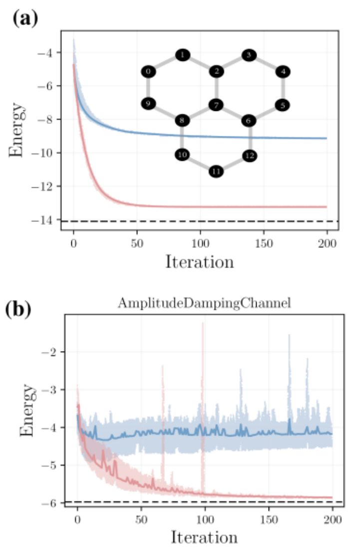

Figure 2. Energy as a function of iteration. (a): The blue solid line is HV ansatze, the red solid line is CD inspired ansatz. The black dash line shows the exact ground energy. Shaded regions present the upper quartile and lower quartile of ten instances. (b): System energy corresponding to 1×1 honeycomb lattice structure with amplitude damping noise.