

Lipkin model analysis with variational quantum eigensolver

Thursday, 20 August 2020 17:20 (15 minutes)

Even though the quantum computing with fault tolerance is still a rather distant target, we are now entering a significant new era in developing quantum technology. In this circumstance, Noisy Intermediate-Scale Quantum Computing (NISQ) is defined by Preskill in 2018 [1]. NISQ algorithms try to avoid deep circuits and utilize quantum advantages, which are efficiently preparing quantum states. NISQ devices will be useful for exploring many-body quantum physics and also lead to other useful applications. Variational quantum eigensolver (VQE) was proposed as a first practical algorithm for NISQ and the ground-state molecular energy for He-H^+ was calculated [2]. VQE is a hybrid algorithm that uses a variational method and combines quantum and classical computations in order to obtain the minimum eigenvalue of the Hamiltonian H of a given system.

Lipkin model is formulated [3] in order to investigate the validity of varied methods and formalisms proposed for calculating many-body systems. This model is also simple enough to be solved exactly. Therefore, we have adopted this model as a benchmark test for the VQE method. To carry out the VQE algorithm successfully we need to choose variational trial functions, i.e., ansatz appropriately. We tried out two kinds of ansatz: unitary coupled-cluster (UCC) ansatz [4] and structure learning (SL) ansatz [5]. UCC ansatz is often used for analyzing molecular systems and developed from coupled-cluster theory [6]. SL ansatz is a method for simultaneously optimizing the structure and variational parameters of quantum circuits. The calculations were performed with numerical simulations on a classical computer. Consequently, we obtained consistent results between the exact ground-state energies and the energies with UCC and SL ansatz in the Lipkin model.

[1] J. Preskill, *Quantum* **2**, 79 (2018)

[2] A. Peruzzo *et al.*, *Nat. Commun.* **5**, 4313 (2014)

[3] H. J. Lipkin *et al.*, *Nucl. Phys.* **62**, 188 (1965)

[4] P. J. J. O'Malley *et al.*, *Phys. Rev. X* **6**, 031007 (2016)

[5] M. Ostaszewski *et al.*, arXiv: 1905.09692 (2019)

[6] F. Coester *et al.*, *Nucl. Phys.* **17**, 477 (1960)

Field of your work

Theoretical nuclear physics

Primary author: Mr ASAHI, Chikaoka (Department of Physics, The University of Tokyo)

Co-author: LIANG, Haozhao (RIKEN)

Presenter: Mr ASAHI, Chikaoka (Department of Physics, The University of Tokyo)

Session Classification: Young Scientist Session 4