# 9th RQC Seminar

## Sample-efficient learning of quantum many-body Hamiltonians
## ハミルトニアン学習のサンプル複雑性


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The properties of a system of interacting quantum particles (quantum many-body system) are completely determined by the Hamiltonian of the system. With the recent development of experimental techniques, observation of the microscopic structure of quantum systems becomes possible. With this background, the Hamiltonian learning, i.e., estimating the Hamiltonian from observational data, has attracted considerable attention from theoretical and experimental fields in materials science, quantum machine learning, and quantum information theory. On the other hand, most of the currently proposed algorithms for Hamiltonian learning have been heuristic, and guaranteeing accuracy is usually a challenging problem. In the present study, we analyzed sample complexity, i.e., "the number of data sufficient to learn a Hamiltonian up to desired precision." Specifically, we consider a quantum Gibbs distribution with inverse temperature β. The question is how accurately one can estimate the Hamiltonian from the data obtained by measuring the quantum state N times. In classical cases, recent studies have solved this problem qualitatively. However, in quantum cases, the sample complexity has not been solved in spite that there have been various studies on the estimation of the Gibbs state itself. Here, we have solved the sample complexity problem of Hamiltonian learning. We clarified the sufficient and necessary conditions regarding the number of samples to achieve the estimation with the accuracy ε, where the Poly(n) (n: system size) sample complexity is qualitatively optimal. I will provide a more detailed research background and explain the key property (strong convexity) in deriving the sample complexity.


[ References ]


[1] A. Anshu S. Arunachalam T. Kuwahara and M. Soleimanifar Nature Physics 17 931-935 (2021)

[2] V. Dunjko Nature Physics 17 880-881 (2021)