Usage Report for Fiscal Year 2018

Project Title: Extracting hadronic observables from quantum annealing

Name:

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1. Background and purpose of the project, relationship of the project with other projects

The purpose of this project is to study the possibility of using quantum annealing to solve systems of equations. This is a new project, and there are no related projects connected to this.

2. Specific usage status of the system and calculation method

The original purpose of the allocation for Hokusai was to confirm the results of the D-Wave quantum annealer with DMRG. This code is own code developed by collaborators.

3. Result

We have concluded that the algorithm proposed for quantum annealing indeed works as intended, and is shown explicitly to solve systems of linear equations. The algorithm works as suggested, and was generalized to solve systems of polynomial equations.

4. Conclusion

The scaling of the algorithm has characteristics that are in direct contract with classical algorithms, and may possibly be useful as quantum annealers improve in the future to accommodate larger problem sizes.

5. Schedule and prospect for the future

The method can be generalized and be applied to solve Eigenvalue problems. In addition, it is also interesting to explore the efficacy of this algorithm on digital annealers such as the one produced by Fujitsu, to see if real-world near-term applications are possible.

6. If no job was executed, specify the reason.

After application of Hokusai, I found a faster way to verify the correctness of the algorithm other than using DMRG. Since the solution of a small linear system can be trivially obtained from conjugate gradient, I was able to infer the ground-state spin configuration of the corresponding Ising Model given to the quantum annealer. As such, I was able to confirm the validity of the algorithm for more complex problems without relying on DMRG. And as a result, Hokusai was not needed to run the DMRG routine.

Fiscal Year 2018 List of Publications Resulting from the Use of the supercomputer

[Paper accepted by a journal]

https://arxiv.org/abs/1812.06917

Quantum annealing for polynomial systems of equations

Submitted to NPJ-QIS (Dec 20 2018)

Manuscript under consideration

[Oral presentation]

Qubits North America 2018

September 2018 Knoxville, TN

RIKEN-Berkeley QIS 2019

January 2019 Berkeley, CA

[Others (Book, Press release, etc.)]

iTHEMS paper of the week

https://ithems.riken.jp/en/news/quantum-annealing-for-polynomial-systems-of-equations

The research involved and writing of this paper also inspired me to organize and host the first joint RIKEN and Berkeley workshop on Quantum Information Science.

https://ithems.riken.jp/en/news/summary-of-riken-berkeley-workshop-on-quantum-information-science-rb19

http://rb19.lbl.gov