Quantum Information – Problem Set 2

Advanced Quantum Mechanics – KU Leuven
Lecturer: Aidan Chatwin-Davies (aidan.chatwindavies@kuleuven.be)

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Problem 1: Quantum Supremacy

Here is what physicist John Preskill has to say about quantum supremacy [1]:

> *In 2012, I proposed the term "quantum supremacy" to describe the point where quantum computers can do things that classical computers can't, regardless of whether those tasks are useful. With that new term, I wanted to emphasize that this is a privileged time in the history of our planet, when information technologies based on principles of quantum physics are ascendant.*

In the fall of 2019, Google reported to have achieved quantum supremacy in Ref [2]. However, the claim was not met with unanimous approval; in particular, the main rebuttal came from a team at IBM, who argued that "on the Summit supercomputer at Oak Ridge National Laboratories, [Google's] circuits can be simulated with high fidelity to arbitrary depth in a matter of days" [3].

Your task is to assess Google's and IBM's claims and answer the following question: Is Google's result of Oct. 2019 a demonstration of quantum supremacy or not? Provide justification and clarification as necessary while keeping your answer succinct (i.e. a few paragraphs long). You are encouraged to work in small groups and to submit a single answer that you decide upon together. In addition to the primary references referred to above, blog posts by the Google team [4] and the IBM team [5] may help you to get started.

References

[1] J. Preskill, "Why I Called It 'Quantum Supremacy'," Oct, 2019. https://www.quantamagazine.org/john-preskill-explains-quantum-supremacy-20191002/.

[2] F. Arute et al., "Quantum supremacy using a programmable superconducting processor," *Nature* **574** no. 7779, (2019) 505–510, arXiv:1910.11333 [quant-ph].

[3] E. Pednault, J. A. Gunnels, G. Nannicini, L. Horesh, and R. Wisnieff, "Leveraging secondary storage to simulate deep 54-qubit sycamore circuits," arXiv:1910.09534 [quant-ph].

[4] J. Martinis, "Quantum Supremacy Using a Programmable Superconducting Processor." https://ai.googleblog.com/2019/10/quantum-supremacy-using-programmable.html.

[5] E. Pednault, J. Gunnels, D. Maslov, and J. Gambetta, "On 'Quantum Supremacy'." https://www.ibm.com/blogs/research/2019/10/on-quantum-supremacy/.