

Title: On the complexity and verification of Random Circuit Sampling (joint work with A. Bouland, B. Fefferman and U. Vazirani)

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News Article: <https://news.berkeley.edu/2018/10/29/berkeley-computer-theorists-show-path-to-verifying-that-quantum-beats-classical/>

Journal Version (Nature Physics 2018): <https://www.nature.com/articles/s41567-018-0318-2>

ePrint: <https://arxiv.org/abs/1803.04402>

Abstract: A critical milestone on the path to useful quantum computers is the demonstration of a quantum computation that is prohibitively hard for classical computers—a task referred to as quantum supremacy. A leading near-term candidate is sampling from the probability distributions of randomly chosen quantum circuits, which we call random circuit sampling (RCS). RCS was defined with experimental realizations in mind, leaving its computational hardness unproven. Here we give strong complexity-theoretic evidence of classical hardness of RCS, placing it on par with the best theoretical proposals for supremacy.

Specifically, we show that RCS satisfies an average-case hardness condition, which is critical to establishing computational hardness in the presence of experimental noise. In addition, it follows from known results that RCS also satisfies an anti-concentration property, namely that errors in estimating output probabilities are small with respect to the probabilities themselves. This makes RCS the first proposal for quantum supremacy with both of these properties. Finally, we also give a natural condition under which an existing statistical measure, cross-entropy, verifies RCS, as well as describe a new verification measure that in some formal sense maximizes the information gained from experimental samples.