

# How Much Information Is In A Quantum State?

Prof. **Scott Aaronson**

University of Texas at Austin

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This colloquium will be held **ONLINE**.

Registration: [https://krs2.riken.jp/m/rqc\\_registration\\_form](https://krs2.riken.jp/m/rqc_registration_form)



To describe an entangled state of  $n$  particles, we formally need an amount of classical information that grows exponentially with  $n$ . But given that almost all the information disappears on measurement, in what sense was it “really there”? In this talk, I’ll first review a career’s-worth results showing that, for many purposes, quantum states can effectively be described with vastly less classical information including my 2004 simulation of quantum advice by classical advice for decision problems, my 2007 “Quantum Occam’s Razor Theorem,” and my 2016 proposal of “shadow tomography” of quantum states (enhanced by my and Rothblum’s 2019 connection to differential privacy). In the other direction, however, I’ll discuss the exponential separation between quantum and randomized communication complexities due to Bar-Yossef, Jayram, and Kerenidis, as well as brand-new work by me, Buhrman, and Kretschmer, which builds on their separation to show that “FBQP/qpoly  $\neq$  FBQP/poly” (unconditionally, there exist relational problems solvable using quantum advice but not classical advice). I’ll end by explaining how that theorem directly suggests a new type of quantum supremacy experiment – one that, in contrast to the recent supremacy experiments by Google, USTC, and Xanadu, would not depend on any unproved computational hardness assumptions, but would seek a direct “experimental witness for the vastness of  $n$ -particle Hilbert space.”

I believe this type of experiment is just now becoming technologically feasible.