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Randomized Benchmarking of Quantum Gates[1] E. KNILL, D. LEIBFRIED, NIST, R. REICHLE, U. Ulm, J. BRITTON, R. B. BLAKESTAD, J. D. JOST, C. LANGER, R. OZERI, S. SEIDELIN, D. J. WINELAND, NIST —

A key requirement for scalable quantum computing is that quantum gates can be implemented with sufficiently low error. One method for determining the error of a gate implementation is to perform process tomography. However, this is limited by errors in state preparation, measurement and one-qubit gates. It suffers from inefficient scaling with number of qubits and does not detect adverse error-compounding. An additional problem is that experimentally proving that error probabilities are below the desirable 0.0001 is challenging. We describe a randomized benchmarking method that yields estimates of the computationally relevant errors without relying on accurate state preparation and measurement. It also verifies that error behavior is stable when used in long computations. We implemented randomized benchmarking on trapped atomic ion qubits, establishing a one-qubit error probability per π pulse below .01.

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Emanuel Knill
NIST

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