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Quantum error correction by low-depth random Clifford circuits

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Abstract

Quantum random encoding is a method of generating quantum error correcting codes (QECCs) by random quantum circuits and is known to have high performance of correcting various noises. While it was originally proposed as a theoretical technique, recent developments, both from theoretical and experimental approaches, have opened the possibility of realizing it by near-term quantum devices. In this work, we show that QECCs generated by one-dimensional log-depth random Clifford circuits can be efficiently decoded and have high performance against stochastic Pauli noise. More specifically, we construct a maximally-likelihood decoder based on the tensor-network method, which works efficiently if the encoding circuit is at most log-depth. Using the decoder, we numerically show that the performance of the code almost matches that of fully random ones if the circuit is at least log-depth. The combination of efficient decoding and high performance against stochastic Pauli noise show that such codes are good candidates for near-term quantum memories.