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Leakage Suppression in the Toric Code MARTIN SUCHARA, ANDREW CROSS, JAY GAMBETTA, IBM T. J. Watson Research Center — Quantum codes excel at correcting local noise but fail to correct leakage faults that excite qubits to states outside the computational space. Aliferis and Terhal have shown that an accuracy threshold exists for leakage faults using gadgets called leakage reduction units (LRUs). However, these gadgets reduce the threshold and increase experimental complexity, and the costs have not been thoroughly understood. We explore a variety of techniques for leakage resilience in topological codes. Our contributions are threefold. First, we develop a leakage model that differs in critical details from earlier models. Second, we use Monte-Carlo simulations to survey several syndrome extraction circuits. Third, given the capability to perform 3-outcome measurements, we present a dramatically improved syndrome processing algorithm. Our simulations show that simple circuits with one extra CNOT per qubit reduce the accuracy threshold by less than a factor of 4 when leakage and depolarizing noise rates are comparable. This becomes a factor of 2 when the decoder uses 3-outcome measurements. Finally, when the physical error rate is less than 2×10^{-4} , placing LRUs after every gate may achieve the lowest logical error rate. We expect that the ideas may generalize to other topological codes.

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