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Error-thresholds for qudit-based topological quantum memories

RUBEN S. ANDRIST, Santa Fe Institute, JAMES R. WOOTTON, Department of Physics, University of Basel, HELMUT G. KATZGRABER, Department of Physics and Astronomy, Texas A&M University — Extending the quantum computing paradigm from qubits to higher-dimensional quantum systems allows for increased channel capacity and a more efficient implementation of quantum gates. However, to perform reliable computations an efficient error-correction scheme adapted for these multi-level quantum systems is needed. A promising approach is via topological quantum error correction, where stability to external noise is achieved by encoding quantum information in non-local degrees of freedom. A key figure of merit is the error threshold which quantifies the fraction of physical qudits that can be damaged before logical information is lost. Here we analyze the resilience of generalized topological memories built from d-level quantum systems (qudits) to bit-flip errors. The error threshold is determined by mapping the quantum setup to a classical Potts-like model with bond disorder, which is then investigated numerically using large-scale Monte Carlo simulations. Our results show that topological error correction with qutrits exhibits an improved error threshold in comparison to qubit-based systems.

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