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Memory time of 3D spin Hamiltonians with topological order

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It is widely believed that Topological Quantum Order (TQO) is unstable at any non-zero temperature in the 2D geometry. This instability is due to the presence of string-like logical operators capable of moving topological excitations over arbitrarily large distance at no energy cost. Recently it was shown that some TQO models on a 3D lattice do not have string-like logical operators opening a possibility that TQO could be thermally stable in the 3D geometry. We present an argument in favor of such stability by characterizing the energy landscape of stabilizer code Hamiltonians with topological order having no string-like logical operators. We prove that any sequence of local errors mapping a ground state of such Hamiltonian to an orthogonal ground state must cross an energy barrier growing as a logarithm of the lattice size. Implications of this result for the feasibility of self-correcting quantum memory are discussed. In particular, we derive a lower bound on the maximum memory time that can be achieved at a given temperature T. Our lower bound grows exponentially with $1/T^2$. The optimal lattice size maximizing the memory time grows exponentially with $1/T$. These results assume that dynamics of the memory is governed by a Markovian master equation obeying the detailed balance condition.

This is a joint work with Jeongwan Haah (Caltech).

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