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A Self-Correcting Quantum Memory in a Thermal Environment[1]

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— Self-correcting quantum memories, analogously to classical memories, provide robust storage of quantum information without the need of active error correction. While systems with topological ground states have been considered to be promising candidates for the realization of such passive memories, a large class of them was recently proven unstable against thermal fluctuations. We propose here new two-dimensional (2D) spin models unaffected by this result. Specifically, we introduce repulsive long-range interactions in the toric code and establish a memory lifetime polynomially increasing with the system size. We study the dynamics of the quantum memory in terms of diffusing anyons and support our analytical results with extensive numerical simulations. The scaling of the memory lifetime is especially favorable in the presence of a super-ohmic thermal environment. Our findings demonstrate that self-correcting quantum memories can exist in 2D at finite temperatures.

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