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Can gravity stabilize a topological quantum memory at finite temperature?

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We study the existence of stable topological quantum memory at finite temperature. This aids in tackling the fundamental problematic of storing quantum information for macroscopically significant times without the use of external intervention in the form of error correction. It has been argued before that a gravitational attraction could confine the anyonic excitations in a topological material, thus preventing them from altering the topological information stored in the system. This idea has led Hamma et al. (2009) to propose a model in which the toric code qubits are coupled to a bosonic bath materializing the gravitational force. Although this confinement is well established for ordinary matter, it has not been observed before for Z2-type excitations, i.e., particles whose mass is preserved only modulo 2. We study this question using numerical simulations wich are performed on a continuous lattice in which the thermal processes were limited to creation, annihilation, and diffusion, with the latter being constrained by an additional energy cost. While preliminary data does not indicate the presence of a defect density threshold in the topological phase below which open strings are confined and the topological order remains intact, our results do not dismiss its existence conclusively and warrant further inquiry.

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