Performance of single-mode bosonic codes

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Continuous-variable quantum information processing [1, 2] continues to gain momentum as a viable implementation paradigm for a quantum computer. The early Gottesman, Kitaev, and Preskill (GKP) [3] proposal for encoding a qubit in an oscillator has recently been followed by cat code [4, 5] and binomial code [6] proposals. These codes have yet to be compared using the same error model; we provide such a comparison by determining the entanglement fidelity of all codes with respect to the bosonic pure-loss channel (i.e., photon loss) after the optimal recovery operation [7, 8]. Despite not being designed to protect against the pure-loss channel, GKP codes significantly outperform all other codes for most values of the loss probability. We show that the performance of GKP and some binomial codes increases monotonically with increasing average photon number of the codes. In order to corroborate our numerical evidence of the cat/binomial/GKP order of performance occurring at small loss probabilities, we analytically evaluate the quantum error-correction conditions of those codes. We extend this comparison to two experimentally relevant scenarios: a Kerr nonlinearity and non-demolition parity measurements.


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