On Performance Quantifiers for Quantum Error Correcting Codes

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A key-problem in quantum information science is doing quantum information processing in a reliable way in the presence of noise. Protecting quantum information transmitted through noisy communication channels is the objective of *quantum error correcting codes*.

It is unreasonable to expect that a single performance measure can fully quantify the effectiveness of either active or passive error correction schemes for arbitrary (independent or correlated) noise models.

In this article, we quantify the code performances by means of two reliable transmission measures, the entanglement fidelity and the code entropy. As a first illustrative example, we consider a Markov correlated dephasing channel and apply the following error correction schemes: the three-qubit phase flip code, the two-dimensional phase-error avoiding code and their concatenation. We explicitly study the performances of such three codes in terms of the two above mentioned measures and discuss the suitability of one code performance quantifier over the other from both a conceptual and a computational viewpoint. Finally, we give an explicit example that shows that it is indeed true that different measures encode different information on the code effectiveness. We apply the five-qubit quantum stabilizer code to both asymmetric and symmetric Markov correlated depolarizing channels. We uncover that while the entanglement fidelity is not affected by asymmetries in the error probabilities, the code entropy is. The relevance of our analysis is twofold: first, it suggests that code performance measures should be carefully chosen, especially when *ranking* different correction schemes applied to the very same error model; second, it shows that certain specific features of an error model (correlations, asymmetries, etc.) may or may not affect a code effectiveness depending on the chosen performance quantifier.

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