Error mitigation and quantum-assisted simulation in the error corrected regime

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Abstract

We consider quasi-probability based error mitigation in the error corrected regime of quantum computation. In this regime, Clifford operations can be made fault-tolerant, but the Gottesman-Knill theorem tells us that they can be efficiently simulated with a classical computer [2]. In order to achieve universality one needs the addition of magic quantum states, whose fault-tolerant preparation requires complex distillation protocols, and are thus the noisiest component [3].
In this context, we develop a general framework to discuss the value of the available, noisy magic resources, relative to those ideally required. We introduce a quantity, the Quantum-assisted Robustness of Magic (QROM), which measures the overhead of simulating the ideal quantum computation with the available noisy components through quasiprobability-based methods. This extends error mitigation techniques, originally developed for Noisy Intermediate Scale Quantum (NISQ) devices [4], to the case where qubits are logically encoded. The QROM shows how the addition of noisy magic resources allows one to boost classical quasiprobability simulations of a quantum circuit and enables the construction of explicit protocols, interpolating between classical simulation and an ideal quantum computer.

References

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Figures

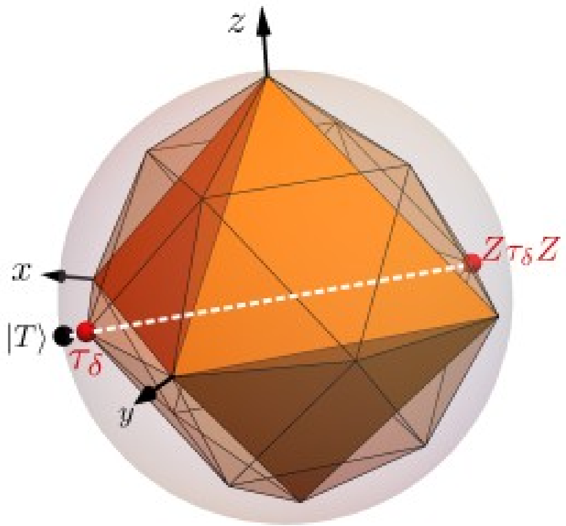

Figure 1: Graphical representation of the QROM for one qubit in the Bloch sphere.