MAR16-2015-003518

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

**Estimating the coherence of noise**

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To harness the advantages of quantum information processing, quantum systems have to be controlled to within some maximum threshold error. Certifying whether the error is below the threshold is possible by performing full quantum process tomography, however, quantum process tomography is inefficient in the number of qubits and is sensitive to state-preparation and measurement errors (SPAM). Randomized benchmarking has been developed as an efficient method for estimating the average infidelity of noise to the identity. However, the worst-case error, as quantified by the diamond distance from the identity, can be more relevant to determining whether an experimental implementation is at the threshold for fault-tolerant quantum computation. The best possible bound on the worst-case error (without further assumptions on the noise) scales as the square root of the infidelity and can be orders of magnitude greater than the reported average error. We define a new quantification of the coherence of a general noise channel, the unitarity, and show that it can be estimated using an efficient protocol that is robust to SPAM. Furthermore, we also show how the unitarity can be used with the infidelity obtained from randomized benchmarking to obtain improved estimates of the diamond distance and to efficiently determine whether experimental noise is close to stochastic Pauli noise.