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Randomized Benchmarking as a Simulation of the Ising Model
BRYAN FONG, HRL Laboratories, LLC — We show how the decay of randomized benchmarking under non-Markovian dephasing can be cast as a solution to the partition function of an Ising model, with the power spectral density providing the range of coupling and the dephasing time providing the effective inverse temperature. We compute the expected randomized benchmarking sequence fidelity assuming free evolution under Hamiltonian Gaussian noise interleaved between perfect instantaneous Clifford pulses. For a single qubit system we show that the expected sequence fidelity is given by the partition function of a long-range coupled spin-one Ising model, with each site in the Ising model corresponding to a free evolution interval. The covariance of error phase angles accumulated in different free evolution intervals gives the coupling constants of the Ising model, while the ratio of the noise-driven characteristic decay time to the free evolution time determines the effective temperature for the partition function. With a leaked state coupled to the qubit subspace, the benchmarking sequence fidelity is given by the partition function of a vector Potts model. In both cases, the sequence fidelity as a function of sequence length varies from exponential decay for uncorrelated noise to power law decay for quasi-static noise.

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