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Non-Markovianity in Randomized Benchmarking HARRISON BALL, ARC Centre for Engineered Quantum Systems, School of Physics, The University of Sydney, NSW 2006 Australia, TOM M. STACE, ARC Centre for Engineered Quantum Systems, University of Queensland, Brisbane 4072, Australia, MICHAEL J. BIERCUK, ARC Centre for Engineered Quantum Systems, School of Physics, The University of Sydney, NSW 2006 Australia — Randomized benchmarking is routinely employed to recover information about the fidelity of a quantum operation by exploiting probabilistic twirling errors over an implementation of the Clifford group. Standard assumptions of Markovianity in the underlying noise environment, however, remain at odds with realistic, correlated noise encountered in real systems. We model single-qubit randomized benchmarking experiments as a sequence of ideal Clifford operations interleaved with stochastic dephasing errors, implemented as unitary rotations about σ_z. Successive error rotations map to a sequence of random variables whose correlations introduce non-Markovian effects emulating realistic colored-noise environments. The Markovian limit is recovered by turning off all correlations, reducing each error to an independent Gaussian-distributed random variable. We examine the dependence of the statistical distribution of fidelity outcomes on these noise correlations, deriving analytic expressions for probability density functions and related statistics for relevant fidelity metrics. This enables us to characterize and bear out the distinction between the Markovian and non-Markovian cases, with implications for interpretation and handling of experimental data.

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