Modelling non-Markovian noise in superconducting qubits

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Non-Markovian noise can be a significant source of errors in superconducting qubits. It is caused by ubiquitous effects such as quasiparticle induced charge parity fluctuations, as well as frequency fluctuations induced by two level systems or other defects. We develop a method based on mirrored pseudo-identity gates to characterise the non-Markovian noise in idle and driven qubits [1]. We compare three approaches to modelling the observed noise: (i) a Markovian noise model, (ii) a model including interactions with a two-level system (TLS), (iii) a model utilising the post Markovian master equation (PMME). We show that the Markovian noise model fails to capture the experimental behaviour, and that only by including the non-Markovian components one can describe the experiments. We further present fast time-resolved characterization techniques that allow us to indicate the physical origin of the non-Markovian noise. We find large changes of the dominating noise contributions, such as qubit frequency fluctuations, over both long time-scales of hours and days, and also over very short micro-seconds time-scales.

[1] A. Agarwal, L. P. Lindoy, D. Lall, F. Jamet, I. Rungger, “Modelling non-Markovian noise in driven superconducting qubits”, Quantum Sci. Technol. (2024).