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Modelling non-Markovian noise in driven superconducting qubits

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Friday, 21 July 2023 @ 14h00 SAST
Venue: Physics Seminar Room, Stellenbosch University, and online

ABSTRACT

Non-Markovian noise can be a significant source of errors in superconducting qubits. We develop gate sequences utilising mirrored pseudoidentities that allow us to characterise and model the effects of non-Markovian noise on both idle and driven qubits. 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), which we show to be equivalent to the qubit-TLS model in certain regimes. When running our noise characterisation circuits on a superconducting qubit device we find that purely Markovian noise models cannot reproduce the experimental data. Our model based on a qubit-TLS interaction, on the other hand, is able to closely capture the observed experimental behaviour for both idle and driven qubits. We investigate the stability of the noise properties of the hardware over time, and find that the parameter governing the qubit-TLS interaction strength fluctuates significantly even over short time-scales of a few minutes. Finally, we evaluate the changes in the noise parameters when increasing the qubit drive pulse amplitude. We find that although the hardware noise parameters fluctuate significantly over different days, their drive pulse induced relative variation is rather well defined within computed uncertainties: both the phase error and the qubit-TLS interaction strength change significantly with the pulse strength, with the phase error changing quadratically with the amplitude of the applied pulse. Since our noise model can closely describe the behaviour of idle and driven qubits, it is ideally suited to be used in the development of quantum error mitigation and correction methods.

BIOGRAPHY

Abhishek Agarwal is a Higher Scientist at the National Physical Laboratory (NPL) in the United Kingdom. He graduated with a degree in Physics and Philosophy from University of Oxford (MPhysPhil) in 2020 and has since been working at NPL. His research interests include modelling noise in quantum computers and developing quantum algorithms for materials simulations.

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