Characterising frequency fluctuations in superconducting qubits

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Non-Markovian noise is an important source of noise in superconducting qubits available today [1]. In this presentation we show that including the effects of non-Markovian noise allows us to have a model that can accurately capture the device physics. We further develop a method to perform experiments on a superconducting qubit quantum computer to resolve qubit frequency fluctuations at different time scales, and show that the frequency fluctuations are the dominant source of observed non-Markovian noise in the device [2]. The methods allow us to see the effects of quasiparticle induced charge parity fluctuations, as well as frequency fluctuations due to two level fluctuators. We analyse the magnitude and rate of charge parity fluctuations, as well as fluctuations in the asymmetric charge parity frequency splitting. The understanding of these non-Markovian noise sources provided by our model and by our experiments can allow us to optimize the calibration of the devices and to further mitigate the effects of noise.

References

[1] Abhishek Agarwal, et al. "Modelling non-Markovian noise in driven superconducting qubits.", arXiv:2306.13021 (2023)

[2] Abhishek Agarwal, et al. " Characterising qubit frequency fluctuations in superconducting qubits." (2024) (in preparation)

Figures

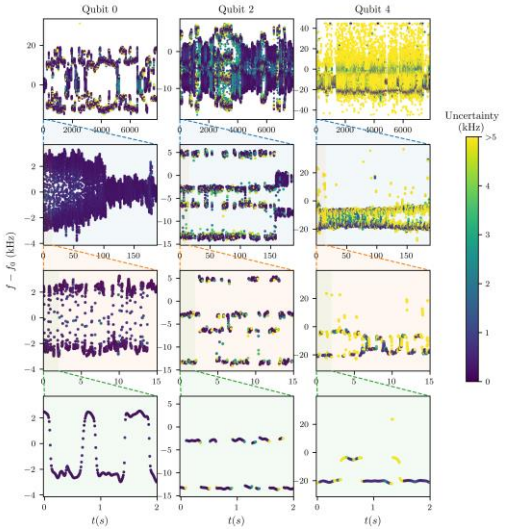

Figure 1: Estimated qubit frequency errors for three qubits (columns) as a function of time for different timescales (rows). Discrete jumps in qubit frequency between two values are visible and explained by charge parity fluctuations. For qubit 2, further jumps are observed and explained by interactions with a two-level-fluctuator.

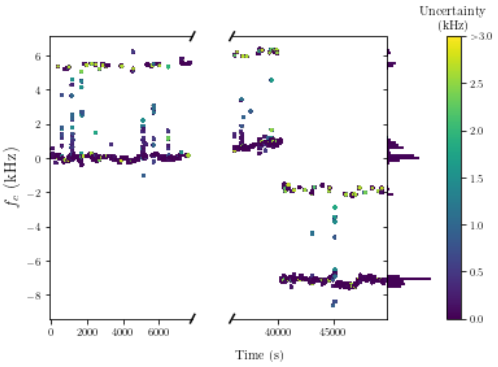

Figure 2: The centre of the frequencies corresponding to the two charge parity states for qubit 0, extracted after disambiguating the different kinds of fluctuations. Jumps in the centre frequency between two values can be seen, corresponding to a two-level fluctuator. A further jump at ~40,000s can be explained by an additional, slower fluctuator.