Wavelet correlation noise analysis for qubit operation variable time series

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Abstract [1]

In quantum computing, characterizing the full noise profile of qubits can aid in increasing coherence times and fidelities by developing error-mitigating techniques specific to the noise present. This characterization also supports efforts in advancing device fabrication to remove sources of noise. Qubit properties can be subject to non-trivial correlations in space and time, for example, spin qubits in MOS quantum dots are exposed to noise originating from the complex glassy behavior of two-level fluctuator ensembles. Engineering progress in spin qubit experiments generates large amounts of data, necessitating analysis techniques from fields experienced in managing large data sets. Fields such as astrophysics, finance, and climate science use wavelet-based methods to enhance their data analysis. Here, we propose and demonstrate wavelet-based analysis techniques to decompose signals into frequency and time components, enhancing our understanding of noise sources in qubit systems by identifying features at specific times. We apply the analysis to a state-of-the-art two-qubit experiment in a pair of SiMOS quantum dots with feedback applied to relevant operation variables. The observed correlations serve to identify common microscopic causes of noise, such as two-level fluctuators and hyperfine coupled nuclei, as well as to elucidate pathways for multi-qubit operation with more scalable feedback systems.

References

[1] Amanda E. Seedhouse et al. arXiv preprint arXiv:2309.12542 (2023)

Figures

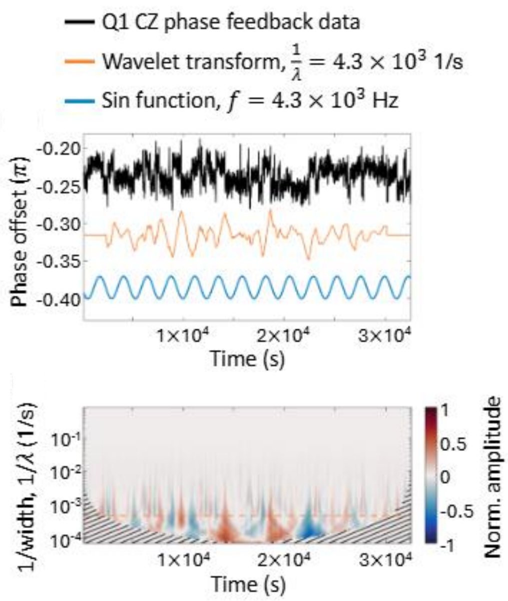

Figure 1: Taken from [1]. (Top) Qubit phase feedback time series (black)decomposed into the Haar wavelet transformation at λ = 2.35 × 103 1/s (red) and the Fourier component of the data at f = 4.26 × 10−4 Hz (blue). The wavelet transformation and Fourier component are scaled and displaced for ease of reading with respect to the data set. (Bottom) The full wavelet transformation of the data normalised to the maximum value. The lined section indicates the cone of influence (ignored data due to boundary effects).