Low-frequency noise in silicon spin-qubit devices

Peter Stano

RIKEN Center for Emergent Matter Science, 2-1 Hirosawa, Wako-shi

I talk about low-frequency noise in Zeeman energies of electron spin qubits. I first present our advances in the methodology for extracting the noise Power Spectral Density (PSD) plots based on Bayesian estimation theory [1]. Among other things, it allows one to assign meaningful error bars on points in such plots. I also mention a novel spectroscopy method to directly access the qubit-energy noise in mid-range frequencies, say 10 Hz - 10 kHz.
I then go through several findings from applying these methods to experimental data obtained in RIKEN from a few devices in two Si/SiGe wafers:
- In the natural-silicon wafer, the charge noise was often comparable to hyperfine noise [2].
- In the purified-silicon wafer, the charge noise was dominant and made the noise spectra non-universal.
- In both, charge noise leads to sizable correlations [2] across quantum dot arrays beyond the nearest-neighbor pairs [3]. For large qubit-qubit distances, the strength of the correlated noise will have a polynomial tail [3].

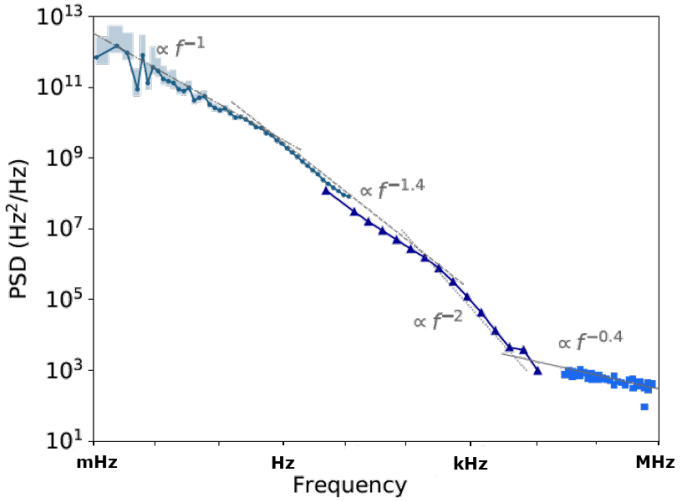

Figure: Power Spectral Density (PSD) of a spin-qubit-frequency noise from a natural silicon device [unpublished data from RIKEN].

[1] A. Gutierrez-Rubio et al., *Bayesian estimation of correlation functions,* Phys. Rev. Research **4**, 043166 (2022).
[2] J. Yoneda, et al., *Noise-correlation spectrum for a pair of spin qubits in silicon,* Nature Physics (2023).
[3] J. S. Rojas-Arias, et al., *Spatial noise correlations beyond nearest-neighbor in 28Si/SiGe spin qubits,* Phys. Rev. Applied 20, 054024 (2023).