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Vibration-induced electrical noise in a cryogen-free dilution refrigerator: Characterization, mitigation, and impact on qubit coherence[1]

ARNE LAUCHT, RACHPON KALRA, JUAN P. DEHOLLAIN, DANIEL BAR, SOLOMON FREER, STEPHANIE SIMMONS, JUHA T. MUHONEN, ANDREA MORELLO, University of New South Wales, Australia — Cryogen-free low-temperature setups are becoming more prominent in experimental science due to their convenience and reliability, and concern about the increasing scarcity of helium as a natural resource. Despite not having any moving parts at the cold end, pulse tube cryocoolers introduce vibrations that can be detrimental to the experiments. We characterize the coupling of these vibrations to the electrical signal observed on cables installed in a cryogen-free dilution refrigerator. The dominant electrical noise is in the 510 kHz range and its magnitude is found to be strongly temperature dependent. We test the performance of different cables designed to diagnose and tackle the noise, and find triboelectrics to be the dominant mechanism coupling the vibrations to the electrical signal. Flattening a semi-rigid cable or jacketing a flexible cable in order to restrict movement within the cable, successfully reduces the noise level by over an order of magnitude. Furthermore, we characterize the effect of the pulse tube vibrations on an electron spin qubit device in this setup. Coherence measurements are used to map out the spectrum of the noise experienced by the qubit, revealing spectral components matching the spectral signature of the pulse tube.

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