Continuous Wave Noise Spectroscopy Beyond the Weak Coupling Limit

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The optimization of dynamical decoupling and quantum error correction for a particular qubit realization is based on a detailed knowledge of the noise properties. Spectroscopy of single-axis noise using dynamical decoupling pulse sequences has garnered much recent attention. In this work we consider noise spectroscopy based on a continuous-wave (CW) on-resonance driving field. Standard CW noise spectroscopy is limited to the weak coupling regime, in which the generalized Bloch equation (GBE) and filter function approaches are valid. We present a technique for extending the range over which the spectral density of the noise $S(\omega)$ can be reliably reconstructed to beyond the weak coupling limit, i.e. to frequencies small compared to the noise strength. The technique utilizes a numerical calculation of the short-time signal decay under the zeroth order average Hamiltonian to iteratively correct the estimated $S(\omega)$ at low frequencies. The results demonstrate faithful extraction of colored noise spectra to zero frequency, whereas naive application of the GBE fitting can significantly underestimate the low frequency noise power.

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