Using Path Integrals to Understand Noise Spectra Measured by a Quantum Sensor

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Quantum sensors are part of the new quantum technologies. A big challenge is to use them to describe the structure of macromolecules and their dynamics. In this work we introduce a new approach based on path integrals to characterize the environment of a quantum sensor. We consider a $1/2$ spin as a sensor that experiences decoherence, i.e. decay of its signal, by the effects of the environment characterized by a random field.

The probability distribution of the random field is determined by a differential operator that appears in the path integral and that defines boundary conditions for the derivatives of the field. The inverse of such operator describes the noise spectrum associated with the Fourier transform of the self correlation function of the fluctuating field induced by the environment. This defines simple interpretations to a family of noise spectrums. It also allows us to consider noise generated by non-Markovian environments. This tool allowed us to describe the noise spectrum generated by an environment made of many interacting spins in solid state nuclear magnetic resonance experiments [1-3]. There are not any general descriptions to predict the noise spectra of the noise generated by the environments of a quantum sensor, therefore this contributes to developing tools necessary for the use of this sensors

References

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