Theory of Spin Center Sensing of Diffusion

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Defects in solids with spins (also known as spin centers) have been shown as promising room temperature solid-state qubits with the ability to be optically initialized and interrogated[1]. Additionally, they have also been demonstrate to be great non-evasive quantum sensors due to their high energy levels sensitivity to both magnetic and electric fields. In general, static electromagnetic fields can be inferred from the shift of the emitted spin center photoluminescence, while dynamical fluctuating fields (generating noise) are inferred from the change of the spin center coherence times[2].

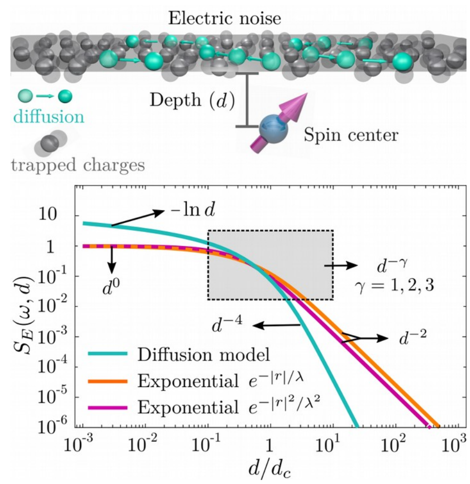

Fig. 1 Electric noise spectral density for different correlation functions of the electronic surface density.

Here we study the electric noise in spin defects due to both fluctuation of the surface charged density and the electrostatic potential at the surface of our crystal [3]. Surprisingly, we show in Fig. 1 that the depth dependence of the electric noise spectral density is strongly influenced by the two-point correlation function of both the charged particles' positions, rather than solely by the character of the charge fluctuators, e.g., point-like or dipole. Furthermore, we are able to recognize the fingerprints and signatures of diffusion phenomena of charged particles through the spin defect's T1 and T2. This is seen on both the defect spin decay and dephasing containing a crossover as function of time around the characteristic correlation time of the fluctuators, determined by the diffusion coefficients (Fig. 2). Hence, spin defects can also be used for sensing of diffusion phenomena and extraction of its corresponding correlation time and diffusion constant.

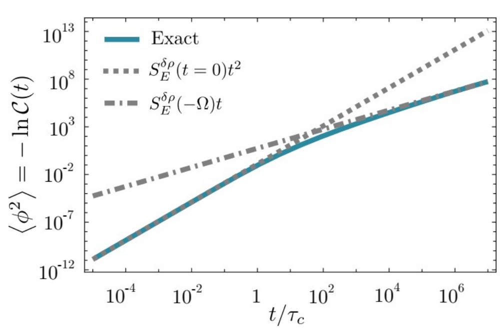

Fig 2 Average probe coherence as a function of time.

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