Using measurements of two-qubit coherence to localize a fluctuating magnetic moment

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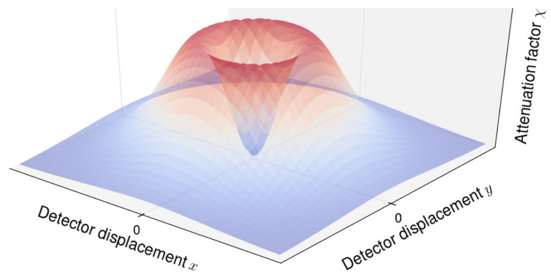
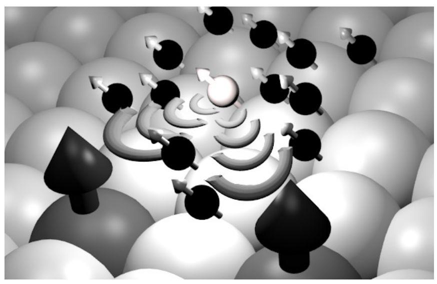
Spin qubits such as NV centers in diamond are currently used as nanoscale-resolution sensors of magnetic field noise generated by nuclear spins of molecules localized in the neighbourhood of the qubit [1,2]. Subjecting the qubit to a periodic sequence of rotations makes it sensitive only to fluctuations of given frequency [3], When the magnitude of the fluctuating magnetic field associated with given source and the form of qubit-source interaction are known, measurement of decoherence of the qubit allows one to find a surface on which the source is localized.

Using more than one qubit it should be possible to pin-point the exact location of the source (cf. the classical triangulation procedure). Here we show that with two qubits, each subjected to a given sequence of rotations, one can localize the fluctuating magnetic moment. The method can be viewed as an application of a general protocol for performing noise cross-correlation spectroscopy with two qubits to the case of two qubits interacting with a precessing magnetic moment. We consider not only the case of qubits localized in predefined spots interacting via dipolar coupling with the moment, but also situations in which we have less *a priori* knowledge about the system, e.g. when the form of the qubit-moment coupling is not known, or when the relative position of the two qubits is not known. We show that source localization is also possible then, provided that we have control over external magnetic field or over the relative position of the two-qubit sensor with respect to the source.

Finally we describe the idea of symmetry detector, capable of narrowing down the possible source location even without any knowledge of the couplings. We emphasize the existence of sensor-source arrangement leading to robust decoherence-free evolution, and provide its geometrical interpretation.





(Left) The spatial map of attenuation factor χ of coherence given by $e^{-T^2\chi}$, where T is the evolution time. (Right) Schematic picture of two detectors interacting with magnetic moments.

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[2] I. Lovchinsky *et al.*, *Science.* **351**, 836 (2016).
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[4] P. Szańkowski, M. Trippenbach, and Ł. Cywiński *Phys. Rev. A* **92**, 123 (2016).