Nitrogen-vacancy ensemble magnetometry based on pump absorption

We demonstrate magnetic-field sensing using an ensemble of nitrogen-vacancy centers by recording the variation in the pump-light absorption due to the spin-polarization dependence of the total ground-state population. Using a 532 nm pump laser, we measure the absorption of native nitrogen-vacancy centers in a chemical-vapor-deposited diamond placed in a resonant optical cavity. For a laser pump power of 0.4 W and a cavity finesse of 45, we obtain a noise floor of ~100 nT/√Hz spanning a bandwidth up to 125 Hz. We project a photon shot-noise-limited sensitivity of ~1 pT/√Hz by optimizing the nitrogen-vacancy concentration and the detection method.
We demonstrate magnetic field sensing by recording the variation in the pump light absorption with nitrogen-vacancy center ensemble. At a frequency of 10 mHz we obtain a noise floor of ~30 nT/√Hz.
Optimised frequency modulation for continuous-wave optical magnetic resonance sensing using nitrogen-vacancy ensembles

Magnetometers based on ensembles of nitrogen-vacancy centres are a promising platform for continuously sensing static and low-frequency magnetic fields. Their combination with phase-sensitive (lock-in) detection creates a highly versatile sensor with a sensitivity that is proportional to the derivative of the optical magnetic resonance lock-in spectrum, which is in turn dependant on the lock-in modulation parameters. Here we study the dependence of the lock-in spectral slope on the modulation of the spin-driving microwave field. Given the presence of the intrinsic nitrogen hyperfine spin transitions, we experimentally show that when the ratio between the hyperfine linewidth and their separation is ≥ 1/4, square-wave based frequency modulation generates the steepest slope at modulation depths exceeding the separation of the hyperfine lines, compared to sine-wave based modulation. We formulate a model for calculating lock-in spectra which shows excellent agreement with our experiments, and which shows that an optimum slope is achieved when the linewidth/separation ratio is ≥ 1/4 and the modulation depth is less then the resonance linewidth, irrespective of the modulation function used.

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Pump-Enhanced Continuous-Wave Magnetometry Using Nitrogen-Vacancy Ensembles

Ensembles of nitrogen-vacancy centers in diamond are a highly promising platform for high-sensitivity magnetometry, whose efficacy is often based on efficiently generating and monitoring magnetic-field dependent infrared fluorescence. Here we report on an increased sensing efficiency with the use of a 532-nm resonant confocal cavity and a microwave resonator antenna for measuring the local magnetic noise density using the intrinsic nitrogen-vacancy concentration of a chemical-vapor deposited single-crystal diamond. We measure a near-shot-noise-limited magnetic noise floor of 200 pT/√Hz spanning a bandwidth up to 159 Hz, and an extracted sensitivity of approximately 3 nT/√Hz, with further enhancement limited by the noise floor of the lock-in amplifier and the laser damage threshold of the optical components. Exploration of the microwave and optical pump-rate parameter space demonstrates a linewidth-narrowing regime reached by virtue of using the optical cavity, allowing an enhanced sensitivity to be achieved, despite unoptimized collection efficiency of about 0.2 ppb.

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