Using Nitrogen-Vacancy Centers in Diamond to Detect External Electron Spins

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Nitrogen-vacancy (NV) centers in diamond are atomic-scale defects with a spin state that can be manipulated by microwave pulses and read out via optical fluorescence. The spin has remarkably long coherence times, leading to the ability to perform sensitive magnetometry using spin-echo techniques. We are investigating whether NV centers can detect magnetic resonance signals from spins external to the diamond crystal. Near-surface NVs are created using low-energy ion implantation of \(^{15}\)N followed by a high-temperature anneal. A double resonance experiment excites an NV spin echo while using a second microwave frequency to flip electron spins in a sample layer on the surface of the diamond crystal. Preliminary results indicate that electron spins external to the diamond crystal are detected, though some questions remain about the exact nature of the spins. Future work will attempt to extend the detection to nuclear spins for future nanoMRI applications.

Detection of electron spin resonance in the external sample. The NV fluorescence dips when the frequency of the microwave pulse matches the resonance of the sample spins.

A shallow NV center is used in a double-resonance experiment to detect electron spins in a sample layer.