Observing Zeeman splitting in optically detected magnetic resonance signal of semiconductors containing colour centres for precise magnetometry

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Semiconductors with colour centres have emerged as prominent quantum sensors on the atomic scale [1]. Strong emphasis has been placed on materials with long coherence times at room temperature. As a result, such systems offer a promising platform for nanoscale magnetic field sensing under ambient conditions via optically detected magnetic resonance technique [2].

Optically detected magnetic resonance (ODMR) measurement is based on recording the fluorescence intensity while sweeping the microwave frequency. Excitation with microwave frequency corresponding to the energy difference between ground-state spin sublevels of $|\mathrm{m}_s\rangle = 0$ and $|\mathrm{m}_s\rangle = \pm 1$ leads to reduction of fluorescence intensity, due to spin-dependent relaxation. Therefore, the ODMR response provides a direct and reliable readout of the ground state properties of a given material. In the presence of a static, external magnetic field, the degeneracy of $|\mathrm{m}_s\rangle = \pm 1$ sublevels is lifted as a result of the Zeeman effect. This phenomenon enables quantitative magnetic field measurements [3].

Presented research focuses on wide-bandgap semiconductors, containing colour centres with non-zero spin. The primary focus of this study is placed on nitrogen vacancy centres in diamonds (NV^-), with other materials exhibiting similar properties investigated for comparative evaluation. Our experimental setup consists of a customized, home-built confocal microscope, a 532 nm diode laser and a microwave synthesizer with an optimised planar antenna. Systematic measurements of the magnetic field dependence of the ODMR signal of NV^- and other samples were conducted.

References:

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