Determining Strain Components in a Diamond Waveguide from Asymmetric ODMR Spectra of NV^- Center Ensembles

M. S. Alam [1], D. Wigger [2], M. Gawełczyk[1], P. Machnikowski[1]

[1] *Institute of Theoretical Physics, Wroclaw University of Science and Technology, Wroclaw, Poland*
[2] *School of Physics, Trinity College Dublin, Dublin 2, Ireland*

The negatively charged nitrogen-vacancy center in diamond (NV^-) has shown great potential in nanoscale sensing and quantum information based on their rich spin physics. Efficient fluorescence detection and interface with light, in general, is crucial for realizing these applications in experiments. Laser-written waveguides in diamond have recently been used to improve the coupling between NV^- centers and light [1]. The NV^- spin states are detected by the optically detected magnetic resonance (ODMR) spectra. However, in the waveguides, these ODMR spectra are found to be consistently asymmetric.

Here, we theoretically simulate the experimentally obtained ODMR signals and find that strain, that could have been introduced in the process of laser writing, can explain the ODMR asymmetry even without invoking built-in electric fields, which differs from previous studies [2-3]. By fitting the theory to experimental signals gathered from different positions on the sample, we quantify all three relevant strain tensor components for full profiles across the waveguide.

Our model consists of NV^- centers interacting with a resonant or near-resonant microwave and the static strain field. We exploit the translational symmetry of the waveguide, which reduces the number of relevant strain components to three. Since yellow diamond samples have a high density of NV^- centers with a uniform distribution along all four possible defect orientations in the crystal, our modeled signal comprises equal contributions from all four possible NV^- center orientations. We numerically calculate individual NV^- centers' eigenstates and corresponding excitation probabilities for microwave-driven transitions. Based on this, we compose the simulated ODMR spectrum from pairs of weighted Lorentzians for each NV^- orientation. Finally, we extract the strain components by fitting the model to the experimental data.

Our results provide reasonable predictions for quantifying the strain distribution in the studied waveguide structures.

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References:
[1]. M. Hoese et al., *Phys. Rev. Applied* **15**, 054059 (2021).
[2]. T. Mittiga et al., *Phys. Rev. Lett.* **121**, 246402 (2018).
[3]. J. Kölbl et al., *New J. Phys.* **21**, 113039 (2019).