Microwave hole-burning spectroscopy and coherent population oscillations in NV$^-$ color centers in diamond

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Nitrogen-Vacancy (NV$^-$) color centers in diamond attract much attention of many research groups and have many applications in physics, biophysics and quantum information [1]. NV$^-$ type defect is characterized by a nonzero electron spin (S = 1) which allows it to be optically pumped (spin polarized) by green light, probed via microwave (MW) resonance spectroscopy, and optically detected.

We present results of our research on two-field (two-frequency) microwave spectroscopy in ensemble of nitrogen-vacancy (NV$^-$) color centers in diamond. We focus on the case where two microwave fields drive the same transition between two NV$^-$ ground state sublevels, $m_s = 0 \leftrightarrow m_s = +1$, (Fig.1a). In this case, the observed spectra exhibit a complex narrow structure (Fig.1b) composed of three Lorentzian resonances positioned at the pump-field frequency [2-3]. The resonance widths and amplitudes depend on the population and coherence lifetimes of the levels involved in the transition. We attribute the spectra to coherent population oscillations induced by the two nearly degenerate microwave fields. We present recent developments of the theory and it's verification in the experiments with various samples of NV ensembles. The observations can be useful for detailed investigation of the NV relaxation mechanisms.

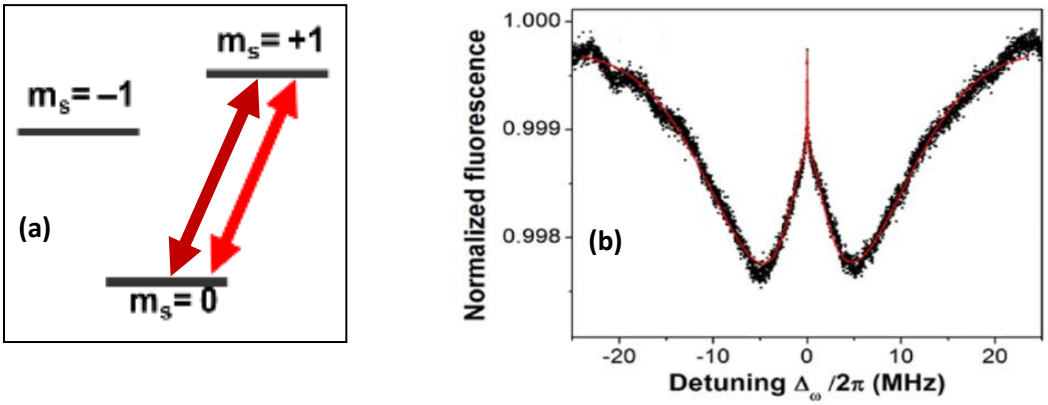

Fig. 1. **(a)** magnetic sublevels of the NV$^-$ ground state $^3A_2$ in a non-zero magnetic field with transitions induced by two (pump and probe) MW fields. **(b)** NV$^-$ fluorescence intensity vs. the probe frequency scanned around the $m_s = 0 \leftrightarrow m_s = +1$ transition for pump field tuned to the center of that transition (from Ref.3). Red line shows the theoretical lineshape. The resonance shape reflects contributions associated with different relaxation rates.

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References

[1] e.g. M.W. Doherty, N.B. Manson, P. Delaney, F. Jelezko, J. Wrachtrup, L.C.L. Hollenberg, Phys. Rep. **528**, 1-45 (2013) and the references therein

[2] P. Kehayias, M. Mrozek, V. M. Acosta, A. Jarmola, D. S. Rudnicki, R. Folman, W. Gawlik, and D. Budker, Phys. Rev. B **89**, 245202 (2014)

[3] M. Mrozek, A. M. Wojciechowski, D. S. Rudnicki, J. Zachorowski, P. Kehayias, D. Budker and W. Gawlik, Phys. Rev. B **94**, 035204 (2016)

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