Magnetic field dependent nuclear spin polarization and its backaction on NV coherence times

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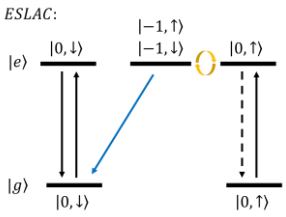
In two level systems [TLS] dephasing time is limited by the spin bath the TLS is coupled to, Nitrogen vacancies [NV] in diamonds are such, and coupled to different types of spin baths. In this work we show how polarizing the nuclear (C13), and electronic (N) spin bath, in the NV's surrounding, affect its coherence times.

Intro

- NVs are surrounded by two main nuclear spin baths, C13 and N.
- These nuclear spins can be polarized using a level anti-crossing, in the excited [ESLAC] or ground [GSLAC] state, of the NV.
- One can reach level anti-crossing by applying an external magnetic field, that matches the ZFS of the relevant optical state.



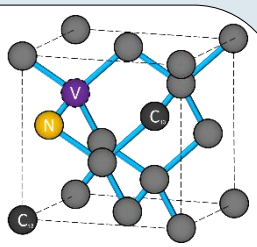
$ZFS\ for\ ESLAC: 1.43GHz$
$\Rightarrow \sim 512.5Gauss$

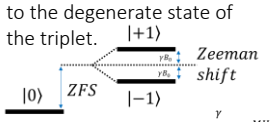
$ZFS\ for\ GSLAC: 2.87GHz$
$\Rightarrow \sim 1025Gauss$

V. Jacques, P. Neumann, J. Beck, M. Markham, D. Twitchen, J. Meijer, F. Kaiser, G. Balasubramanian, F. Jelezko, and J. Wrachtrup. Dynamic Polarization of Single Nuclear Spins by Optical Pumping of Nitrogen-Vacancy Color Centers in Diamond at Room Temperature
Phys. Rev. Lett. 102, 057403 – Published 6 February 2009

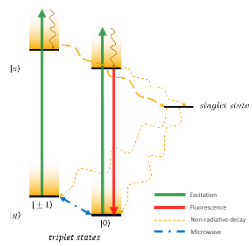
NV center

- The NV is an electronic spin defect in diamond, it can be manipulated in ambient conditions, using optical pumping and microwave [MW].
- Applying external magnetic fields cause Zeeman splitting to the degenerate state of the triplet.

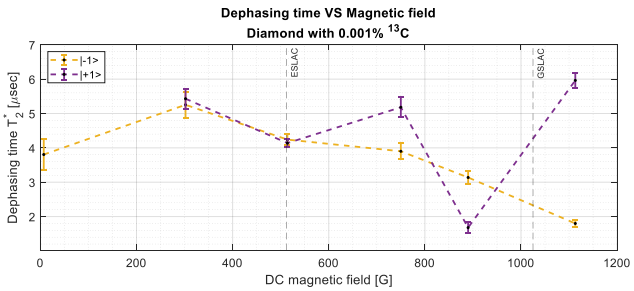




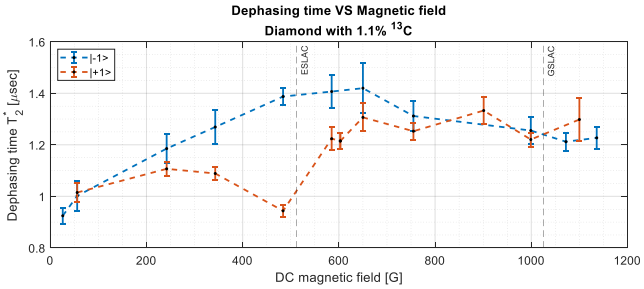
ZFS – Zero field splitting $\quad \gamma = 2.8\left[\frac{MHz}{Gauss}\right]$



Preliminary Results
Measuring the change in T_2^* of NVs



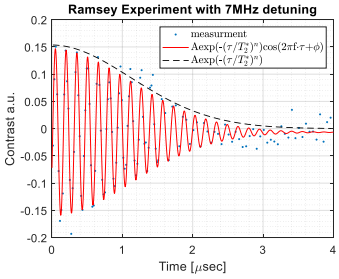
- Dephasing time of single NVs in a diamond with population of 0.001% C13 ($\sim 10^{10} cm^{-2}$) and of N15 ($\sim 10^{10} cm^{-2}$).

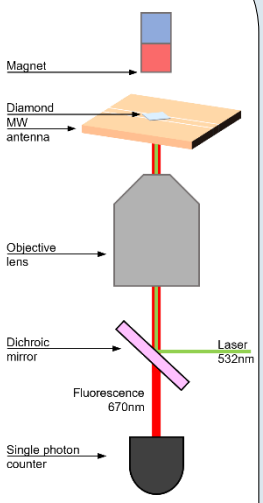


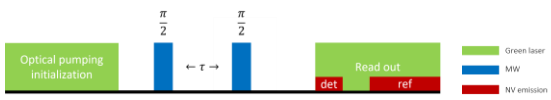
- Dephasing time of single NVs in a diamond with population of 1.1% C13 ($\sim 10^{13} cm^{-2}$) atoms and of N15 ($\sim 10^{10} cm^{-2}$).
- Though the N15 has a nuclear spin bath, the surrounding N that did not result in an NV, add an electronic spin bath.
  This could be the reason we see a different behavior between the two diamonds, since the gyromagnetic is proportional to the mass of the particle.

Methods & experimental setup

- We control the polarization of the spin bath, by changing the Zeeman shift (applying an external magnetic field) of the TLS, at the excited and ground state.
- Then perform a Ramsey sequence, to measure the dephasing time of the TLS.







Ramsey sequence

Future work

- Depolarizing a selected group of spin bath to better understand the effect of different spin population, might also be demonstrated using Hahn-Echo sequence.
- Demonstrating this effect for other spin bath populations with different concentrations.

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