Quantum control of the tin-vacancy spin qubit in diamond

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Group-IV color centers in diamond are a promising light-matter interface for quantum networking devices [1,2]. The negatively charged tin-vacancy center (SnV) is particularly interesting, as its large spin-orbit coupling offers strong protection against phonon dephasing and robust cyclicity of its optical transitions towards spin-photon entanglement schemes [3,4]. Here, we demonstrate multi-axis coherent control of the SnV spin qubit via an all-optical stimulated Raman drive between the ground and excited states. We use coherent population trapping and optically driven electronic spin resonance to confirm coherent access to the qubit at 1.7 K, and obtain spin Rabi oscillations at a rate of $\Omega/2\pi = 3.6(1)$ MHz. All-optical Ramsey interferometry reveals a spin dephasing time of $T_2^* = 1.3(3)$ μs and two-pulse dynamical decoupling already extends the spin coherence time to $T_2 = 0.33(14)$ ms. Combined with transform-limited photons [5] and integration into photonic nanostructures [6], our results make the SnV a competitive spin-photon building block for quantum networks

Figures

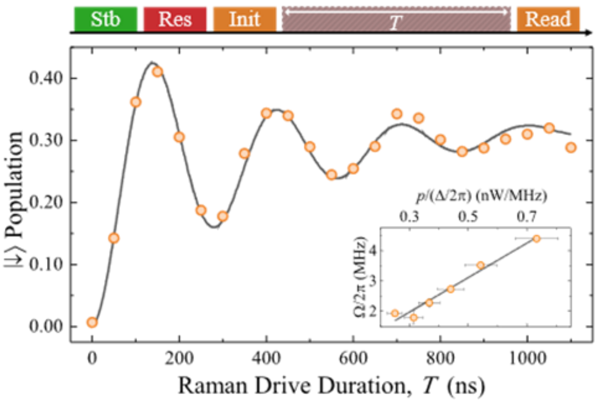

Figure 1: Coherent spin qubit control: down state population (orange circles) as a function of the Raman drive duration T with the pulse sequence shown at the top. The black curve is a fit to a 2-level model under a master equation formalism. Inset: Ω as a function of p/Δ with a linear fit to the data (solid curve).

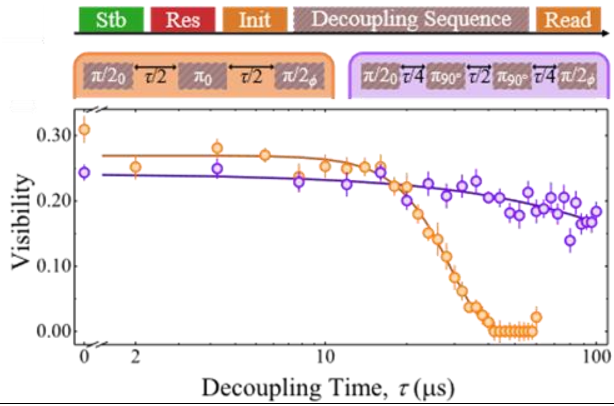

Figure 2: Dynamical decoupling: pulse sequence (top) with two implementations: (left) Hahn echo, (right) CPMG-2. The phase φ of the second π/2 pulse is variable and visibility a/b is obtained from fitting the function a cos(φ) + b at each delay time τ , plotted as a function of τ.

References

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