# Enhanced Spin Coherence in an Optically-Active GaAs Quantum Dot

**Giang N. Nguyen**[1]
C. Spinnler[1], L. Zhai[1], A. Javadi[1], C.A. Schrader[1], M. Wyss[2], J. Ritzmann[3], H.-G. Babin[3], A.D. Wieck[3], A. Ludwig[3], M.R. Hogg[1], R.J. Warburton[1]

[1]*Department of Physics, University of Basel, Switzerland*
[2]*Swiss Nanoscience Institute, University of Basel, Switzerland*
[3]*Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany*

giang.nguyen@unibas.ch

Semiconductor quantum dots [1-4] are promising candidates for photonic quantum technologies such as cluster state generation [5,6] or distant spin-spin entanglement [7,8]. However, the magnetic noise from the host nuclei poses a drawback for spin-photon applications as it leads to fast spin decoherence. While the workhorse system is an InGaAs quantum dot in GaAs, progress has been made recently on droplet-etched GaAs quantum dots. On the one hand, the demonstration of two-photon interference with indistinguishability V > 90% for photons from remote quantum dots validates excellent photonic properties [9]. On the other hand, success on electron spin decoupling from the host nuclei affirms a highly homogeneous nuclear ensemble and $T_2^{CPMG} > 100$ µs [10].

In this work, we use all-optical cooling [11,12] of the host nuclei of a GaAs quantum dot to tackle the problem of a short electron spin coherence time $T_2^*$. Ramsey interferometry probes the electron coherence time, acting simultaneously as a gauge of the nuclei's temperature. We find a 20-fold increase in coherence time from 3.9 ns to 78.0 ns after Rabi cooling [9] and a 155-fold increase up to $T_2^* = 608$ ns after feedback cooling [10] (see Fig. 1). This corresponds to a narrowing of the nuclei Overhauser distribution from 104.6 MHz to 0.71 MHz approaching the regime of single nuclear-spin excitations.

Our work shows that a GaAs quantum dot produces coherent photons and hosts a coherent spin. The coherence is maintained for times much longer than the radiative decay time - all at a convenient wavelength. These are ideal properties for a coherent spin-photon interface.

References

[1] N. Somaschi, *et al.*, *Nat. Photon.*, **10**, 340-345 (2016)
[2] H. Wang, *et al.*, *Nat. Photon.*, **13**, 770-775 (2019)
[3] R. Uppu, *et al.*, *Science Adv.*, **6**, eabc8268 (2020)
[4] N. Tomm, *et al.*, *Nat. Nanotechnol.*, **16**, 399-403 (2021)
[5] N. Coste, *et al.*, *arXiv:2207.05981* (2022)
[6] D. Cogan, *et al.*, *Nat. Phot*. (2023)
[7] A. Delteil, *et al.*, *Nat. Phys.*, **12**, 218-223 (2016)
[8] R. Stockill, *et al.*, *Phys. Rev. Lett.*, **119**, 010503 (2017)
[9] L. Zhai, *et al.*, *Nat. Nanotechnol.*, **17**, 829-833 (2022)
[10] L. Zaporski, *et al.*, *Nat. Nanotechnol.*, (2023)
[11] D. Gangloff, *et al.*, *Science*, **364**, 62-66 (2019)
[12] D. Jackson, *et al.*, *Phys. Rev. X*, **12**, 031014 (2022)

Figures

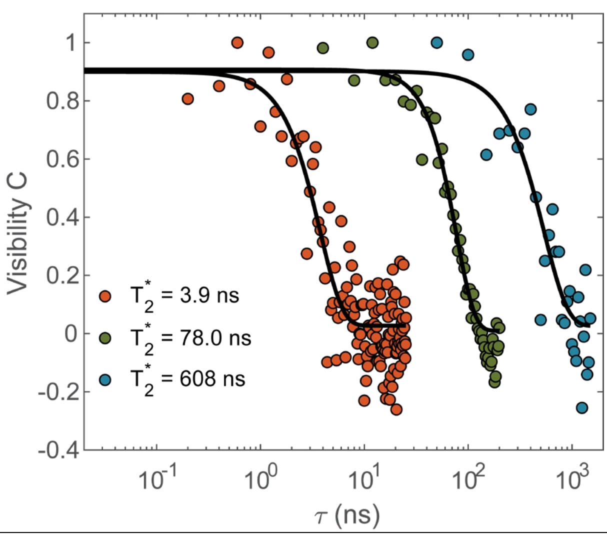


**Figure 1:** Ramsey visibility before cooling (red), after Rabi cooling (green), and after feedback cooling (blue).