












A singlet-triplet hole-spin qubit in MOS silicon

Received: 2 January 2024

Accepted: 19 August 2024

Published online: 03 September 2024

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Why Singlet-Triplet? Why holes? Why MOS?

Singlet-Triplet

- + Low B (<5 mT)
- + No GHz (baseband)
- Footprint
- Complex eigenstates

Holes

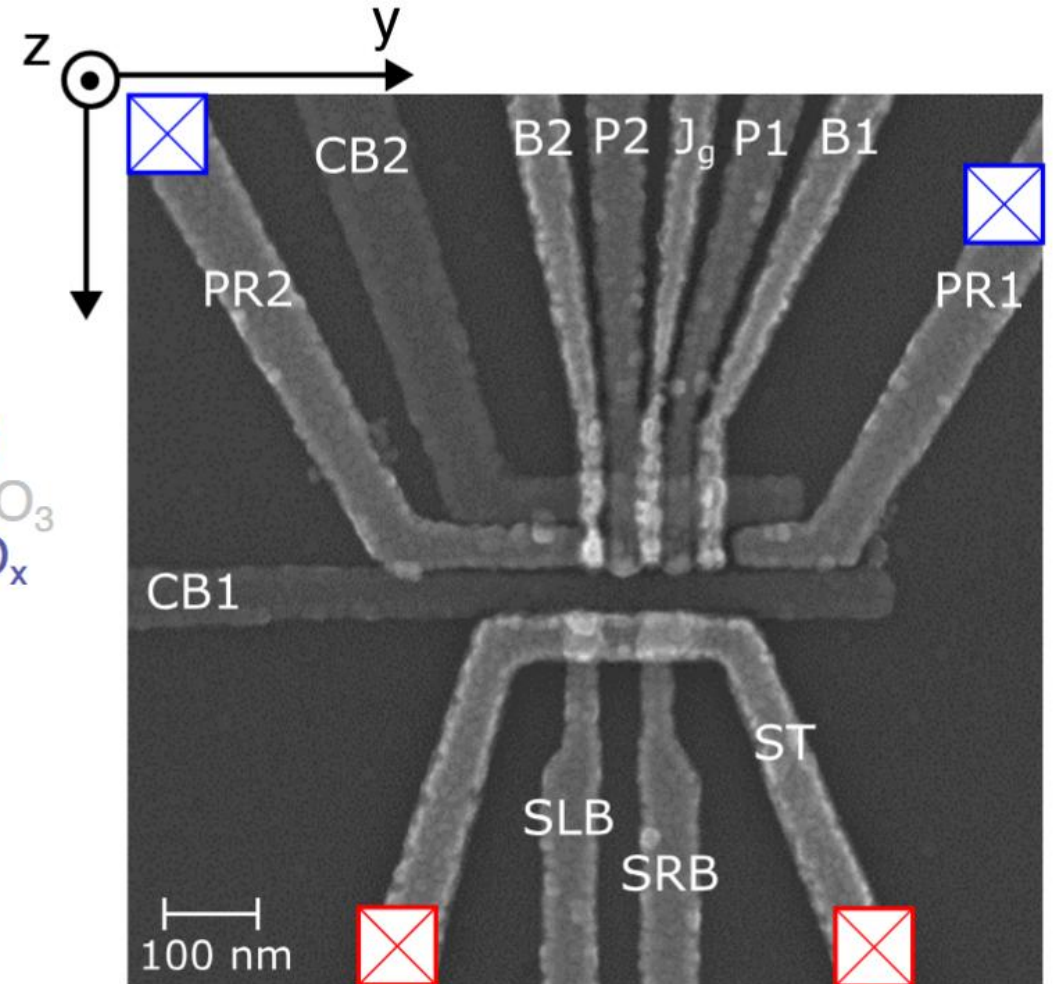
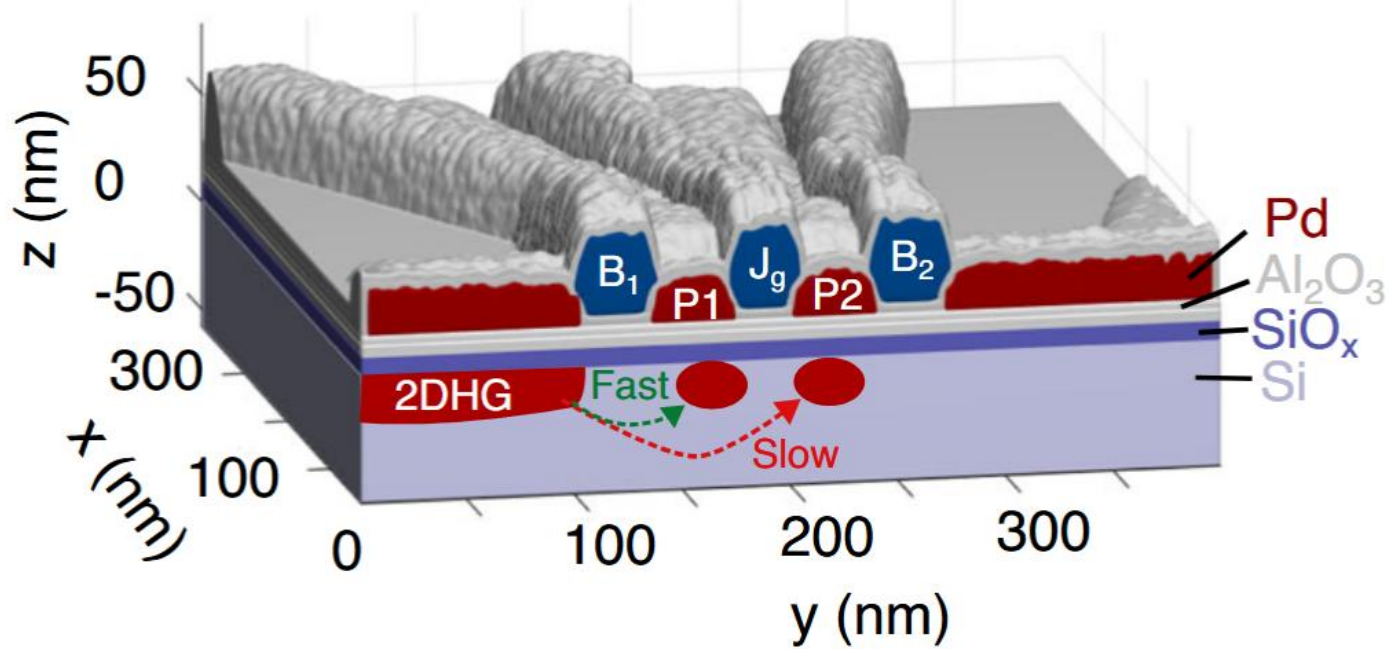
- + Large intrinsic SO
- + Tunable g-factor & SO
- + Suppressed hyperfine
- + Potential sweet spot
- Large intrinsic SO

Silicon MOS

- + Scalable
- + CMOS compatible
- Bad interface
- Charge Noise

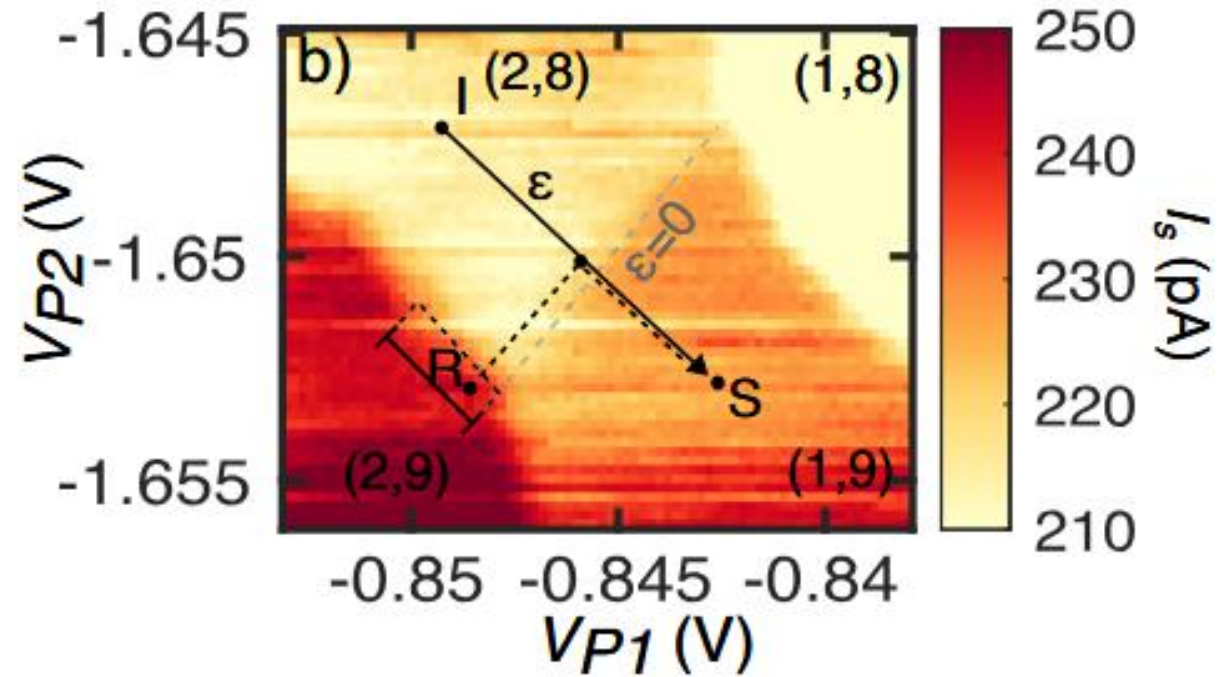
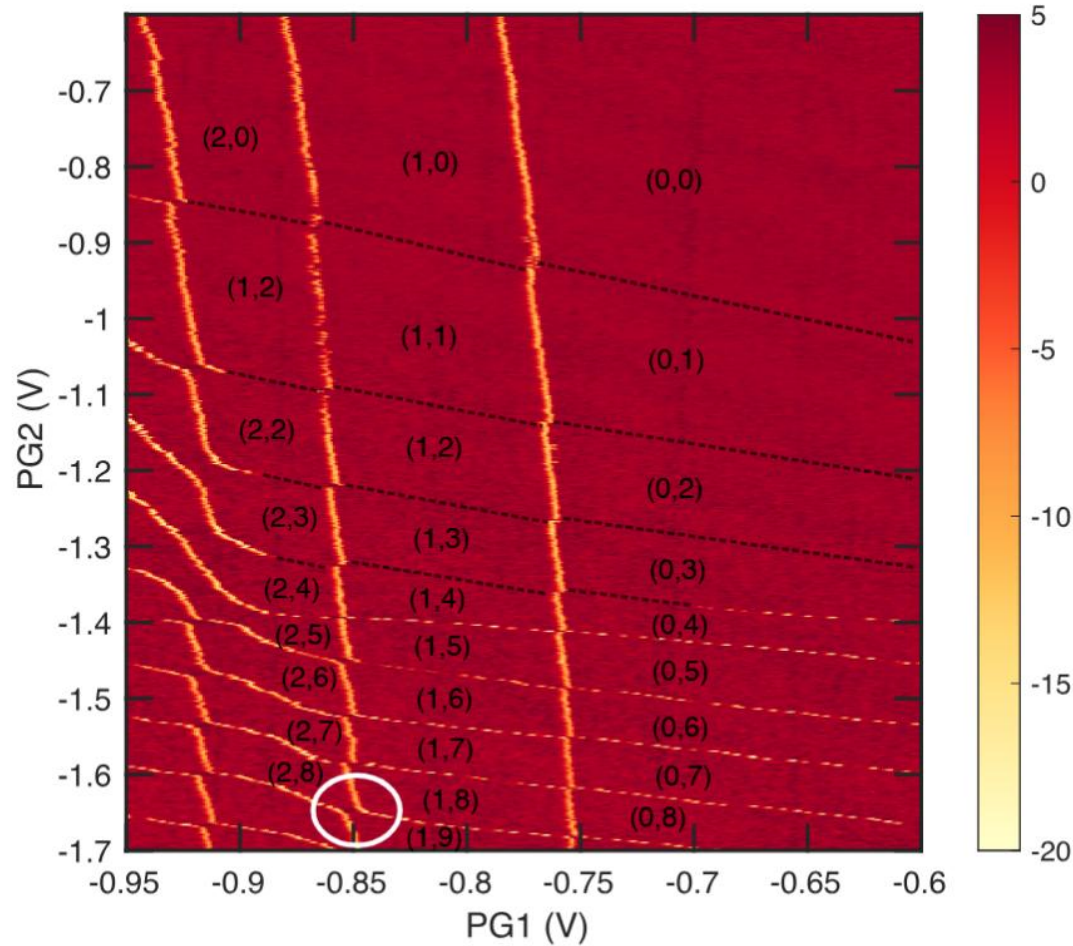
Anisotropic exchange coupling!
Theory predicts leakage error prevention?
ST hole qubit in Silicon MOS not yet shown!

Device & Fabrication

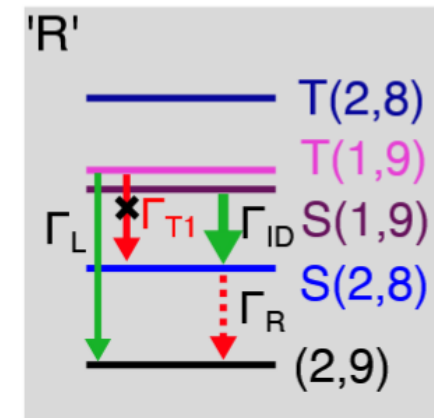
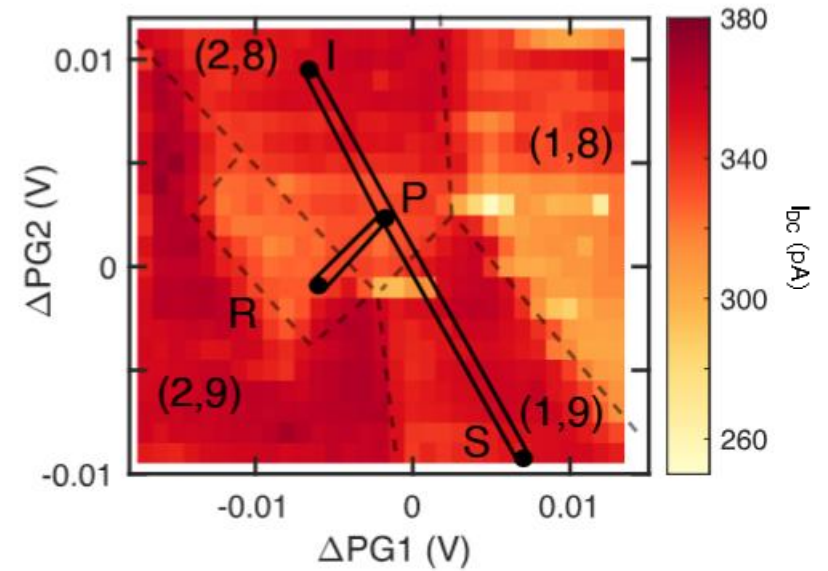
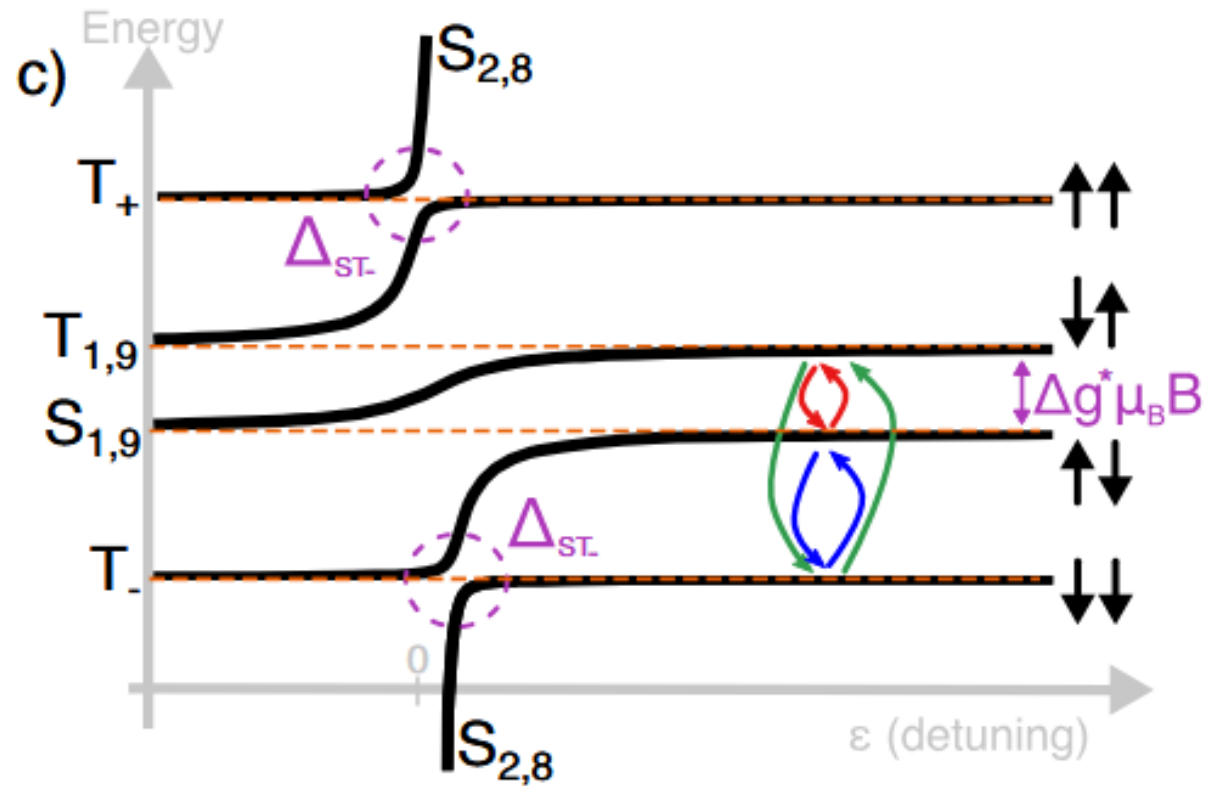


$$\Gamma_L > 10 \text{ MHz}, \Gamma_R < 30 \text{ kHz}, t_c > 1 \text{ GHz}$$

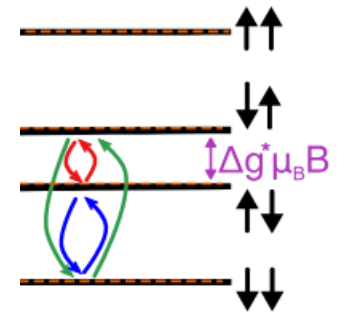
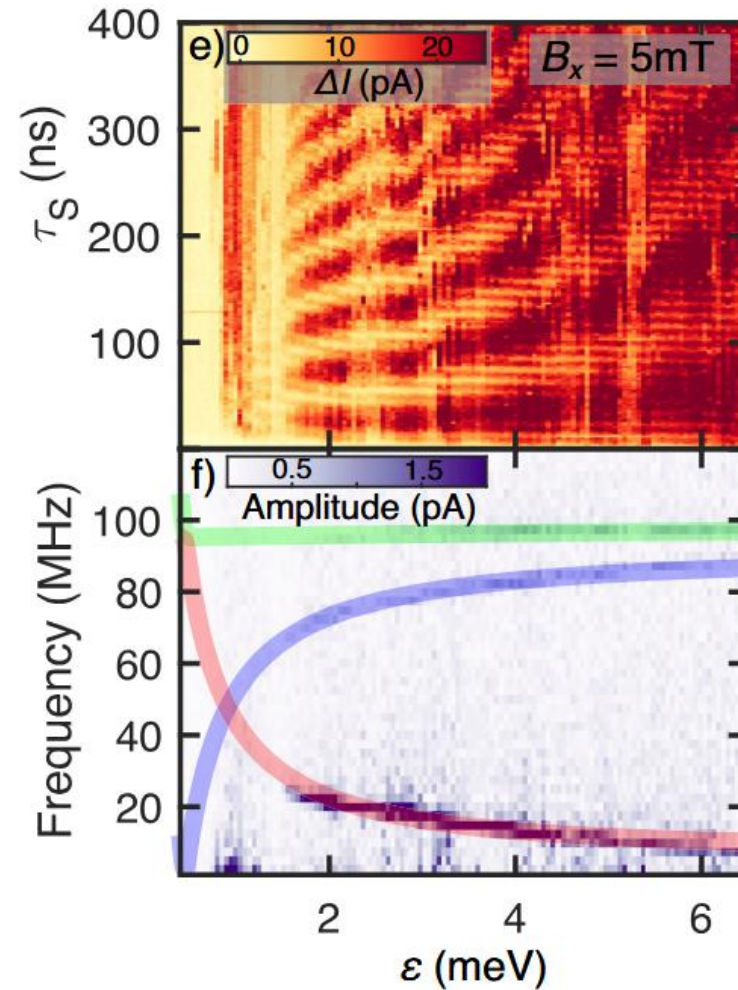
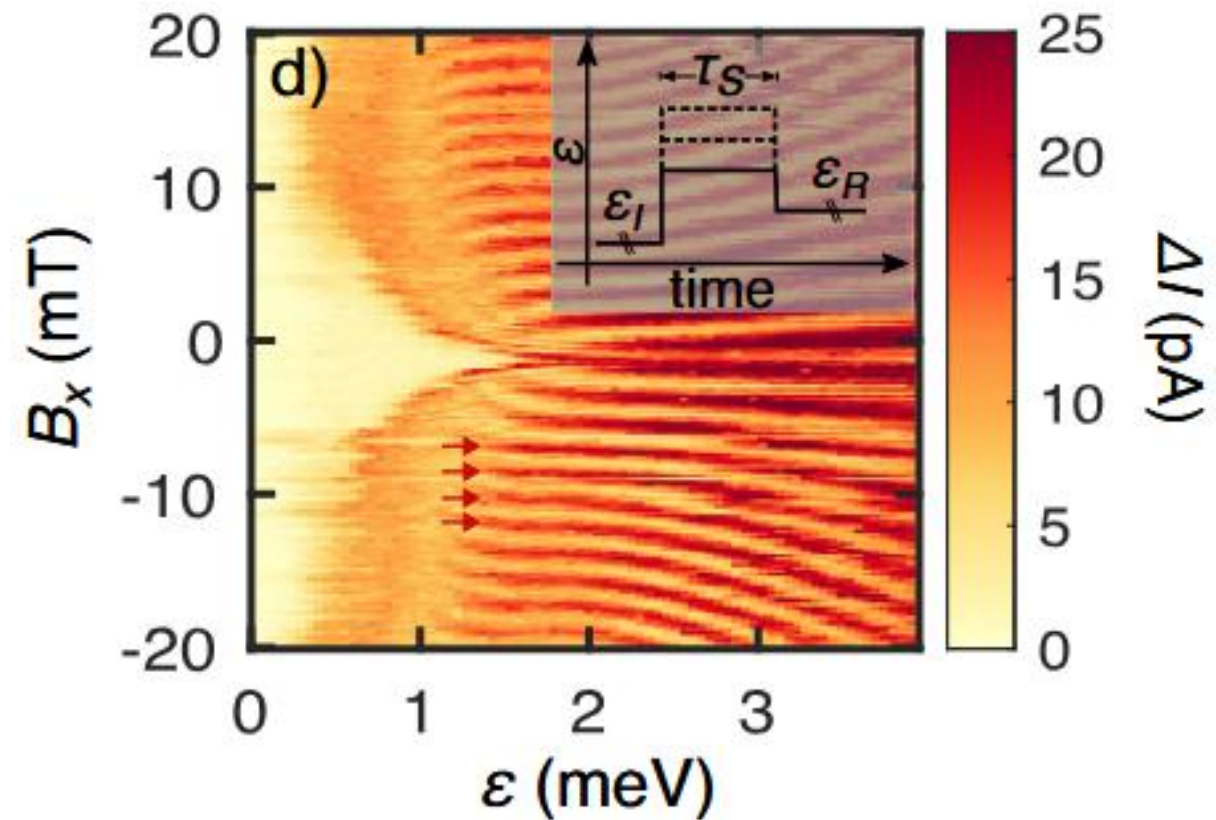
Charge Stability Diagram



Singlet-Triplet & Readout



Magnetopectroscopy



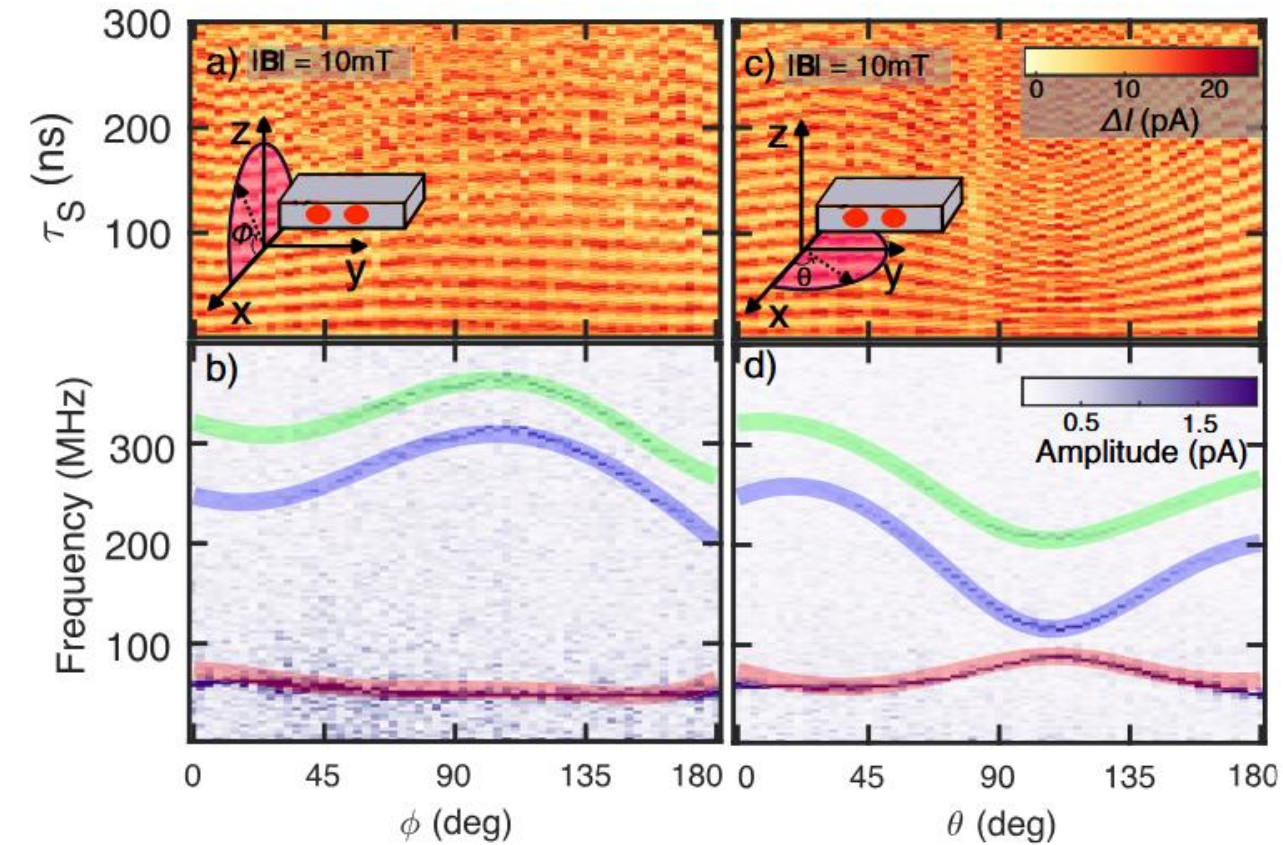
$$t_c = 9 \pm 1 \mu\text{eV}$$

Eff. g-factors:

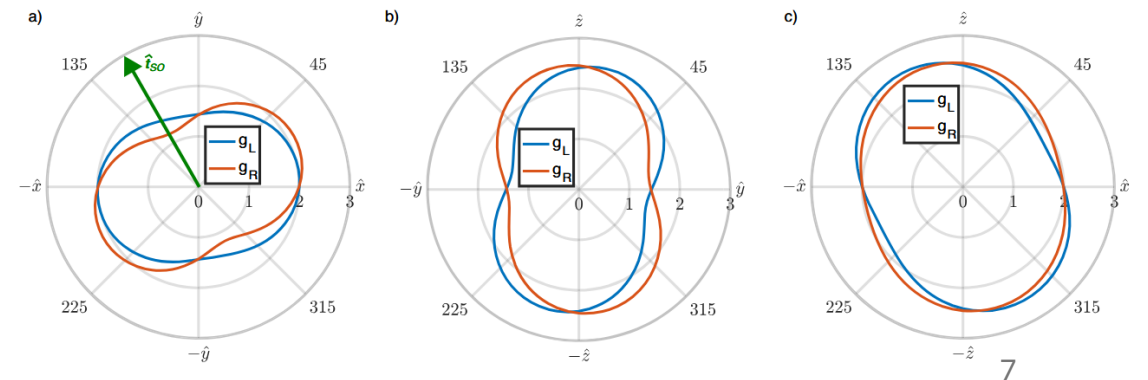
$$0.8 \pm 0.1$$

$$1.2 \pm 0.1$$

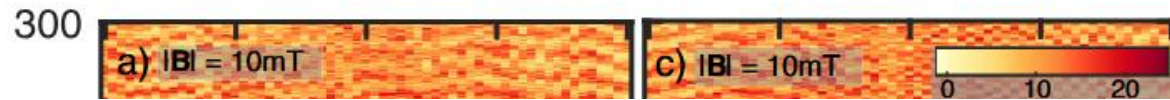
Anisotropic g-tensors



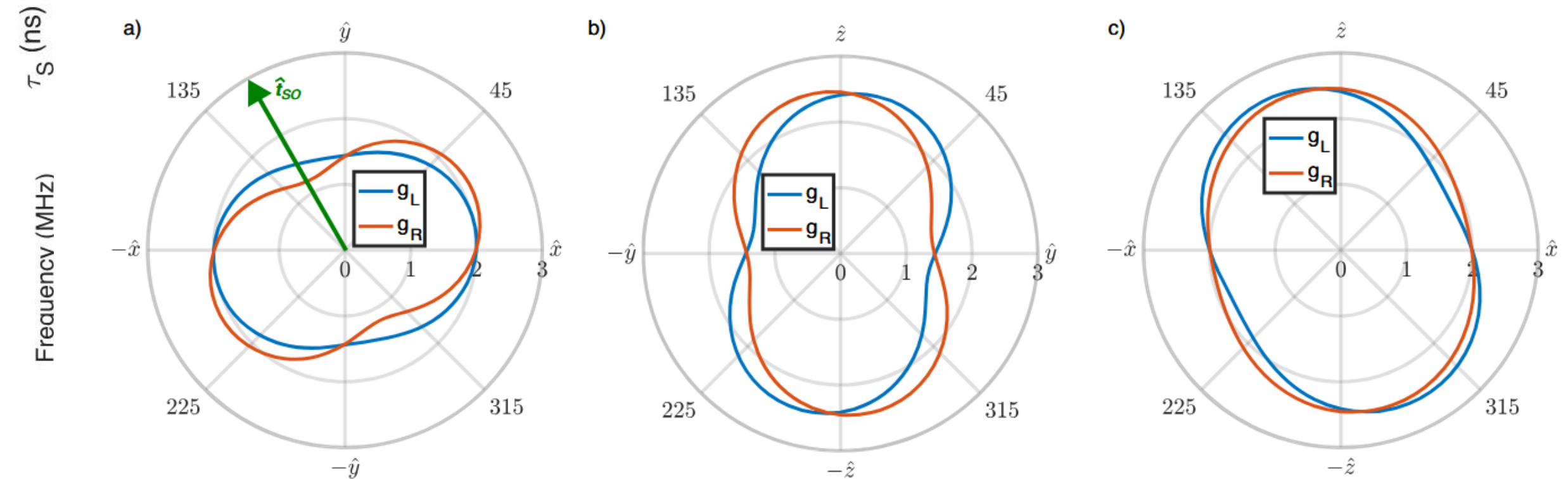
Parameter	Optimal Fit
t_c	$(13.7 \pm 0.1) \mu\text{eV}$
$\vec{t}_{so} = (t_x, t_y, t_z)$	$(-36.9 \pm 2, 107 \pm 4, 0 \pm 10) \text{ neV}$
\vec{g}_L	$\begin{pmatrix} -0.78 & -1.13 & -1.45 \\ -1.13 & 0.85 & -0.27 \\ -1.45 & -0.27 & 1.91 \end{pmatrix}$
\vec{g}_R	$\begin{pmatrix} -0.96 & -0.94 & -1.47 \\ -0.94 & 0.78 & -0.74 \\ -1.47 & -0.74 & 1.82 \end{pmatrix}$



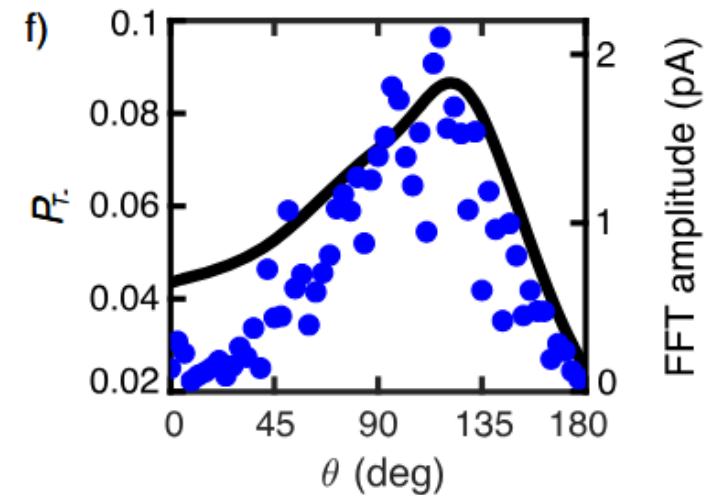
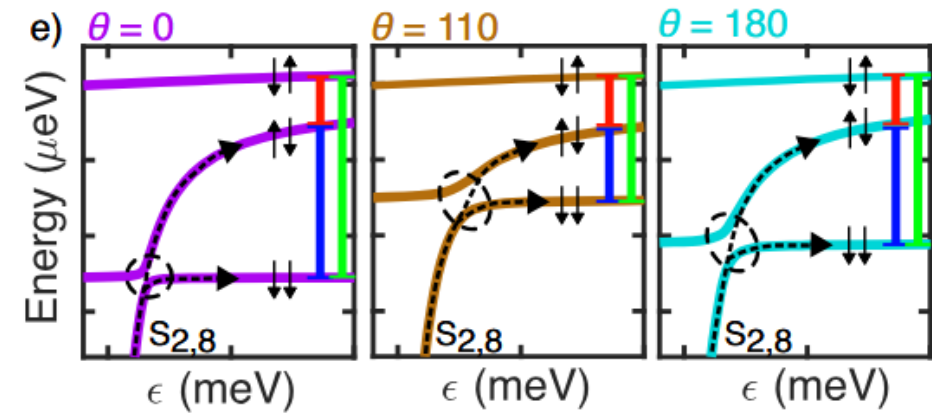
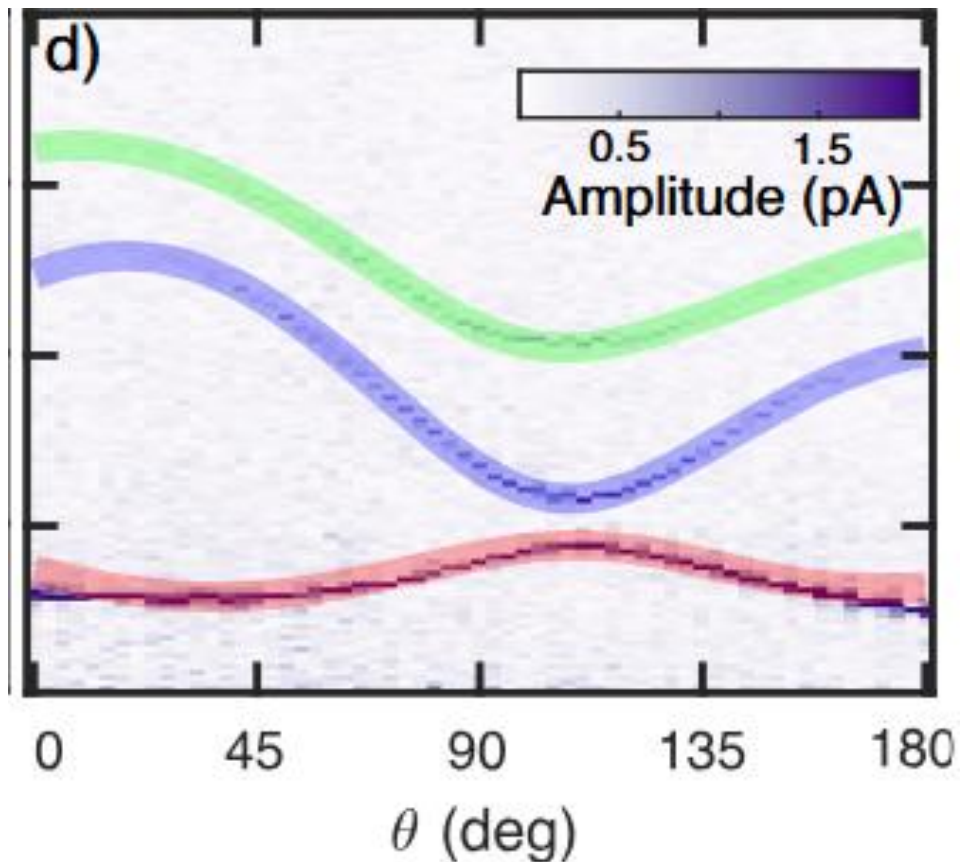
Anisotropic g-tensors



Parameter	Optimal Fit
t_{\perp}	$(13.7 \pm 0.1) \mu\text{eV}$

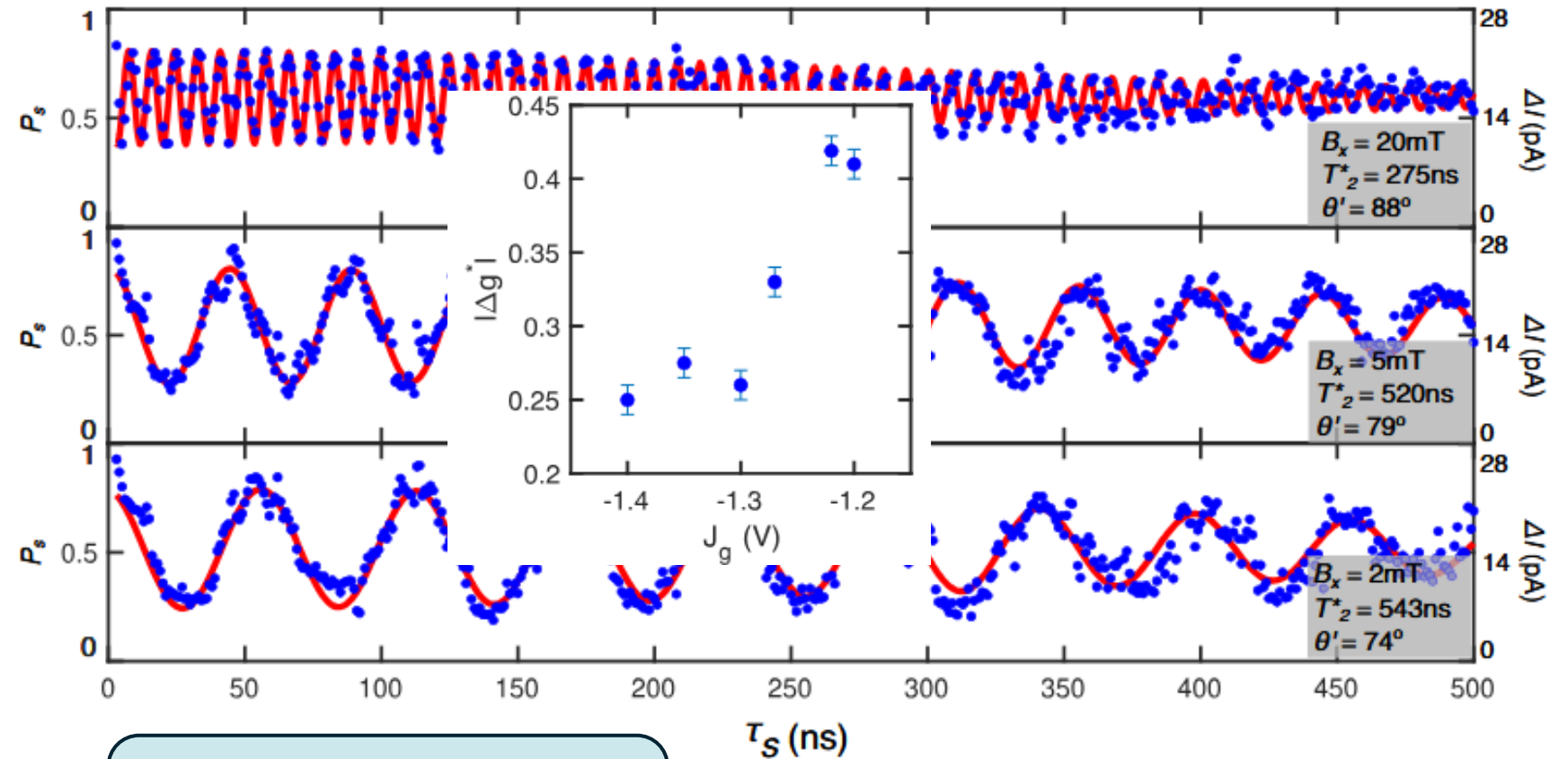
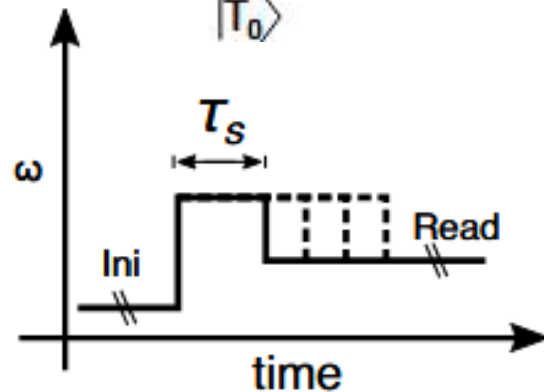
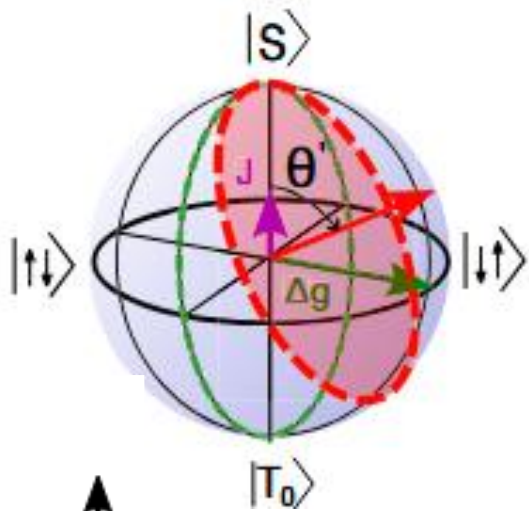


Anisotropic of the FFT amplitudes



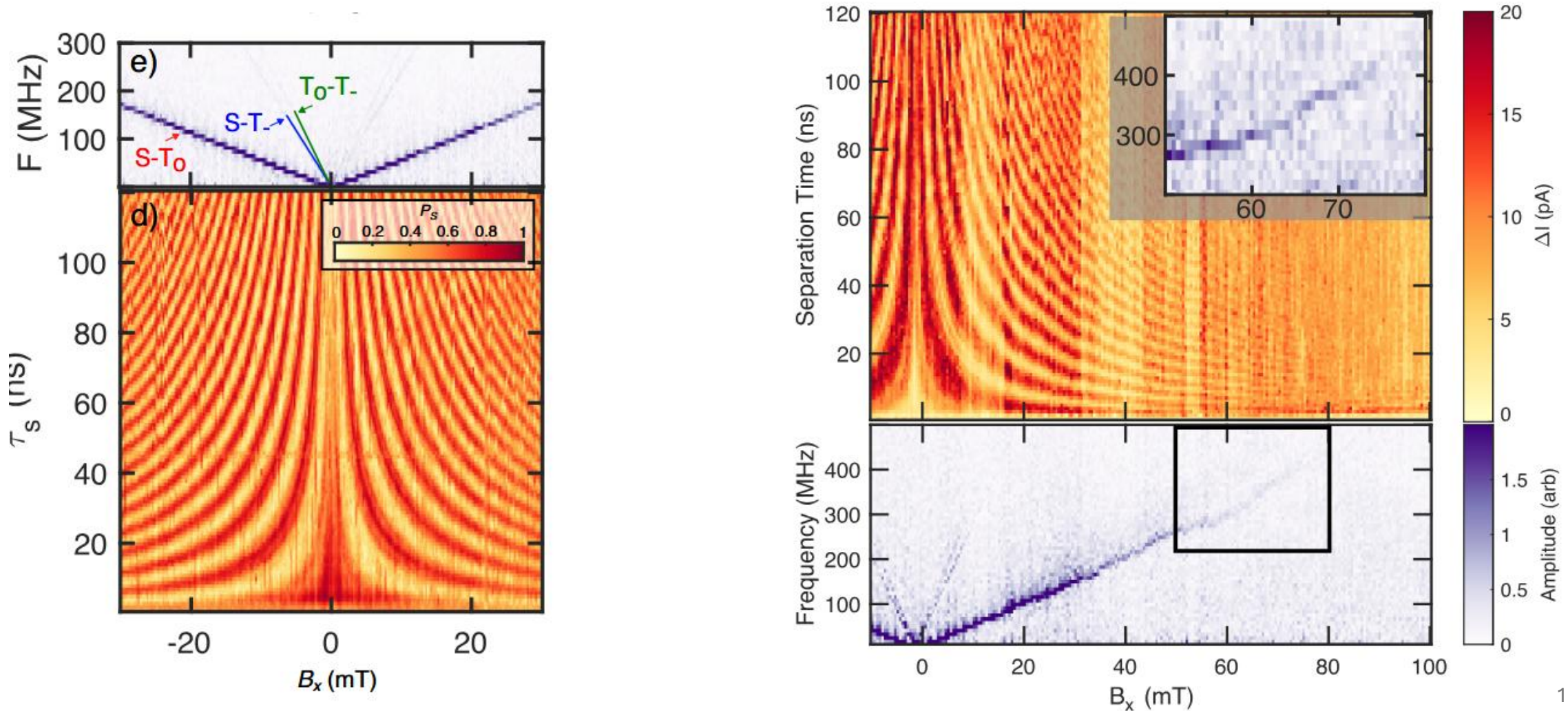
Coherent Δg -driven oscillations

$$H_{ST} = \frac{J}{2} \sigma_z + \frac{\Delta E_Z}{2} \sigma_x$$

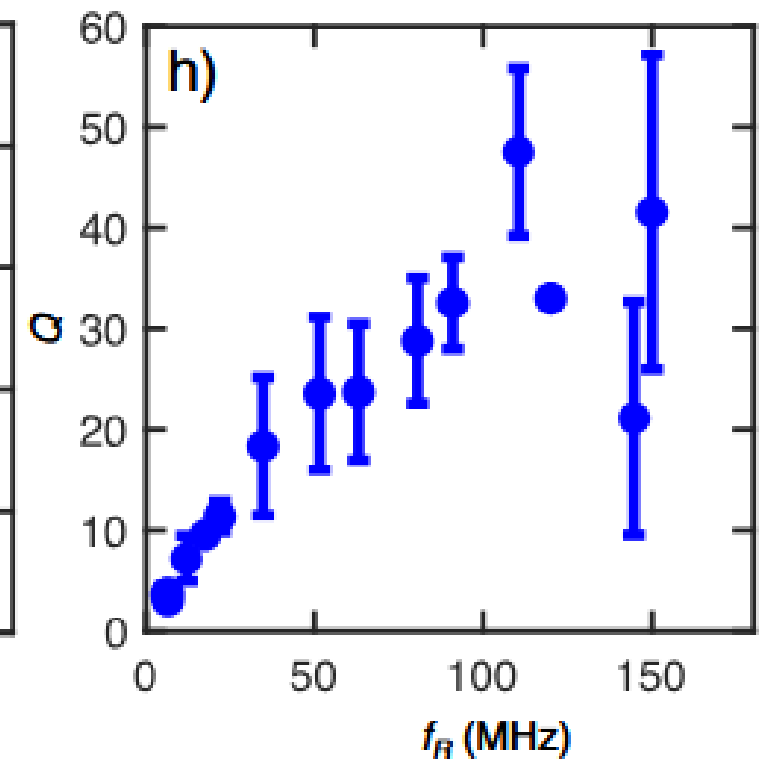
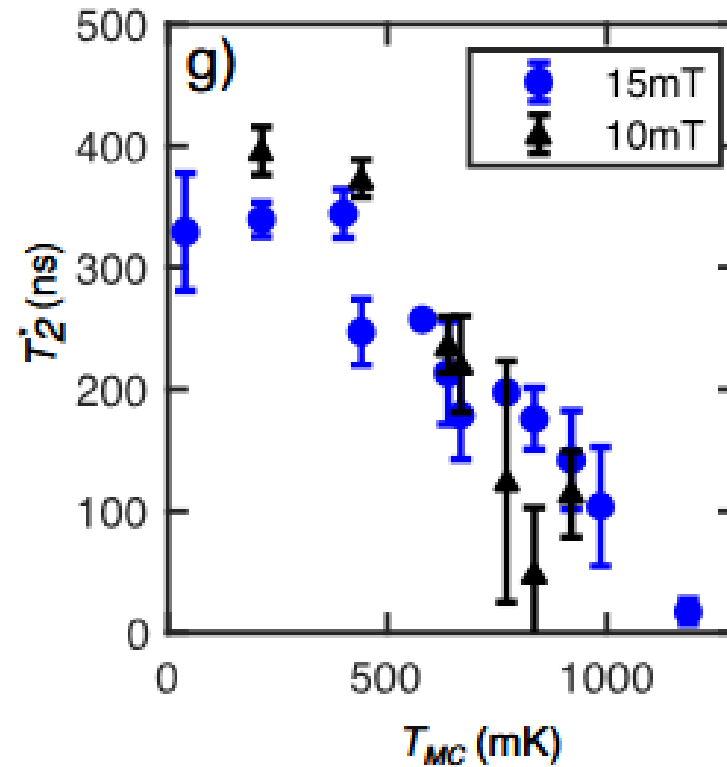
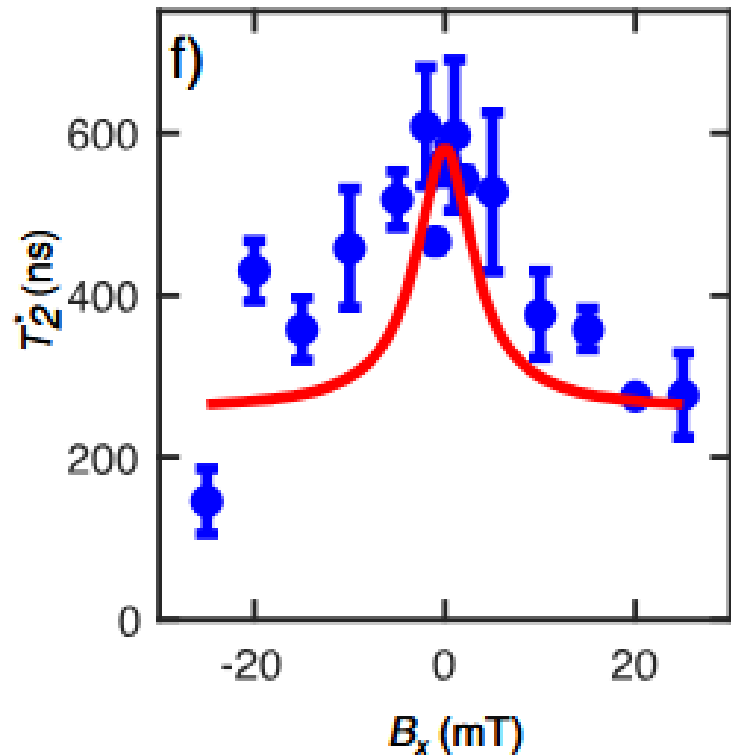


$J = 6 \text{ MHz} @ \epsilon = 1.9 \text{ meV}$
 $|\Delta g| = 0.41$

Coherent Δg -driven oscillations

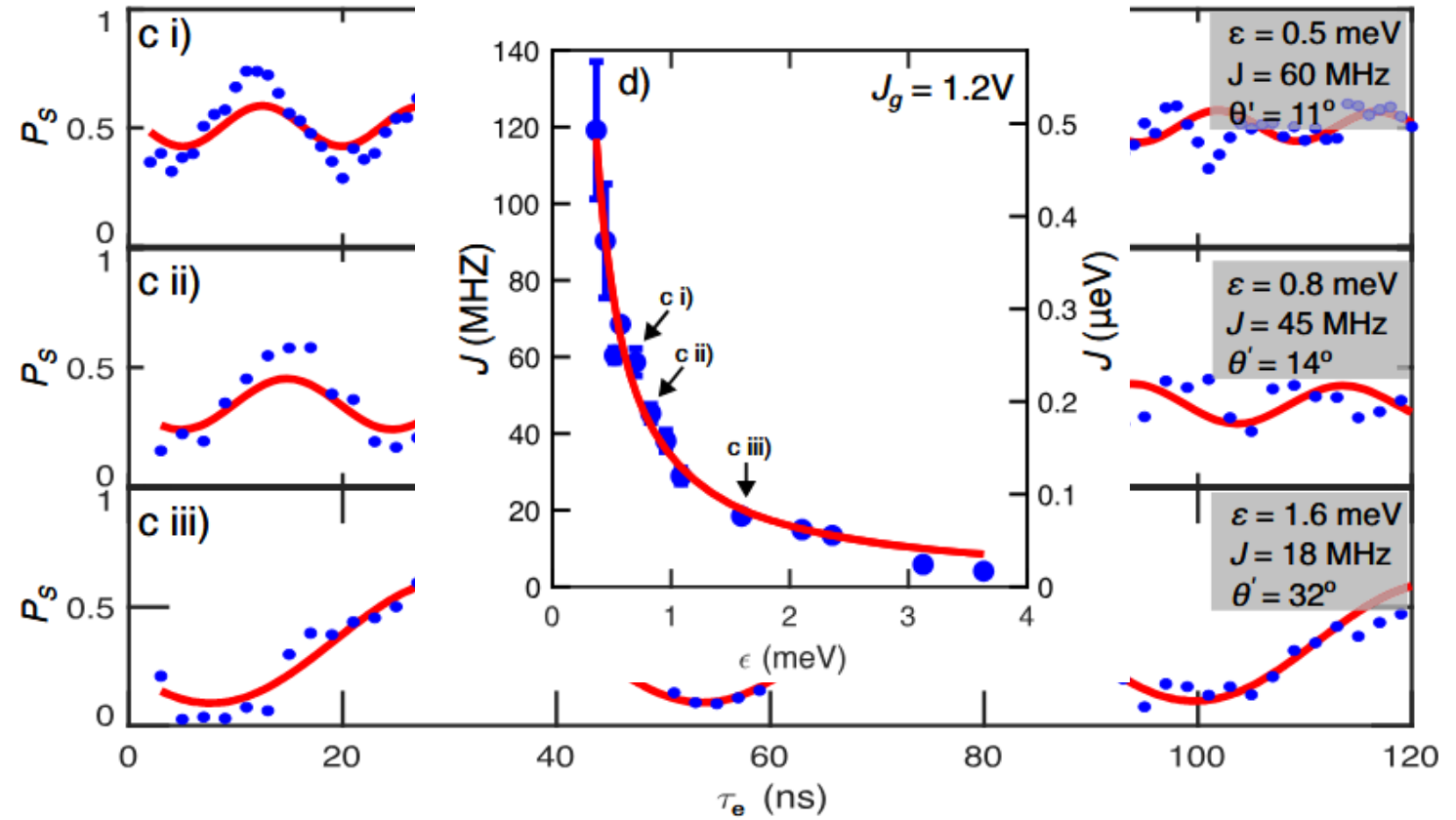
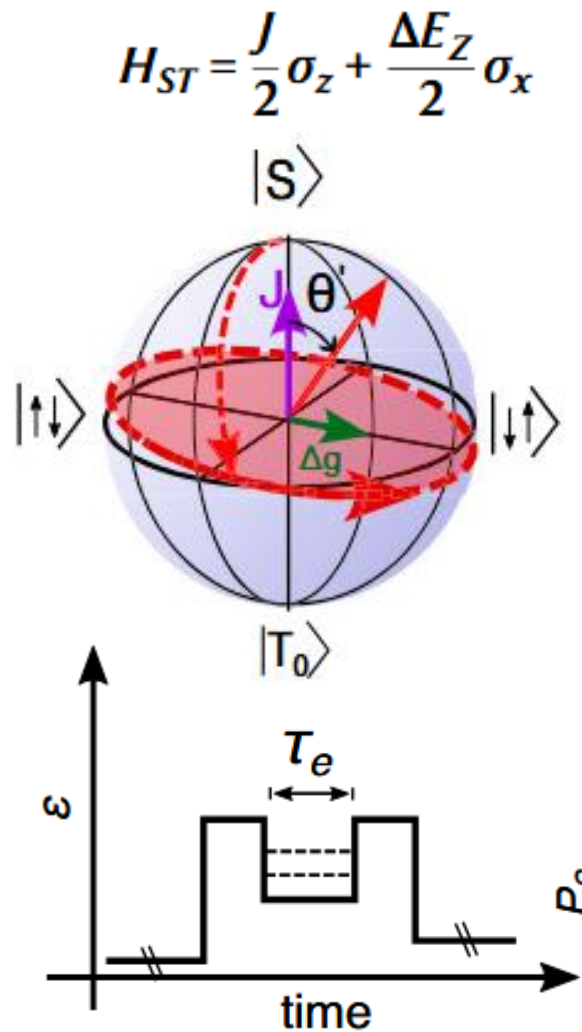


Dephasing

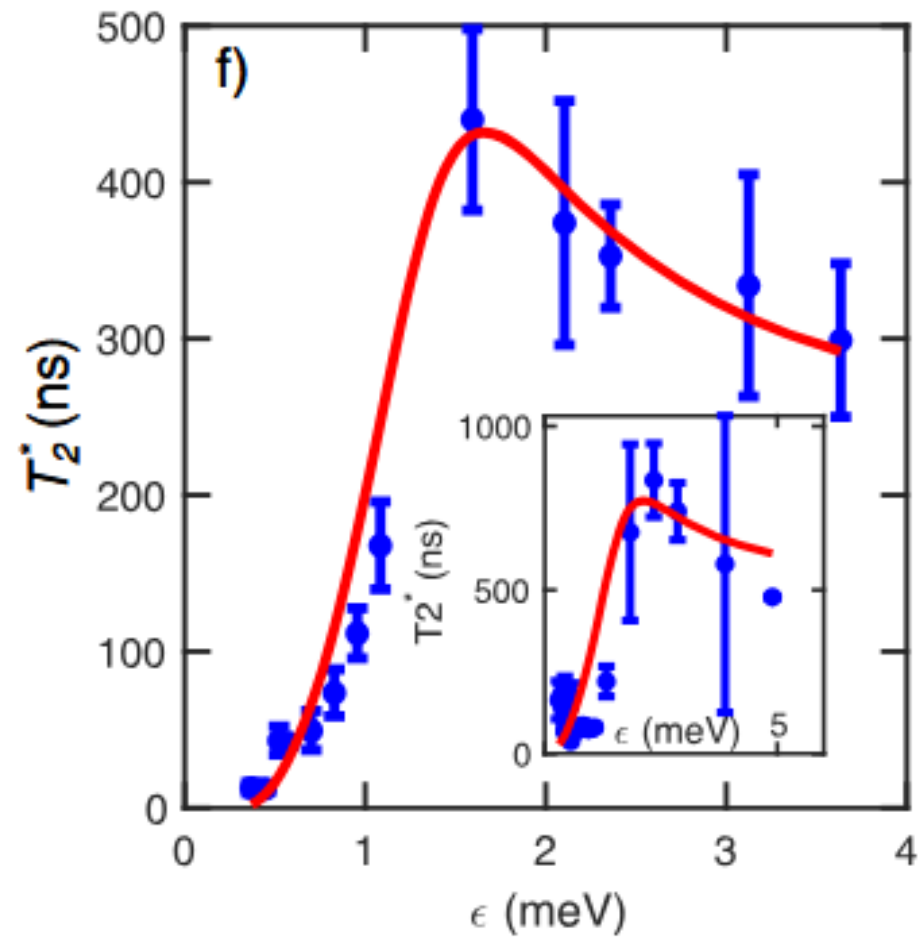
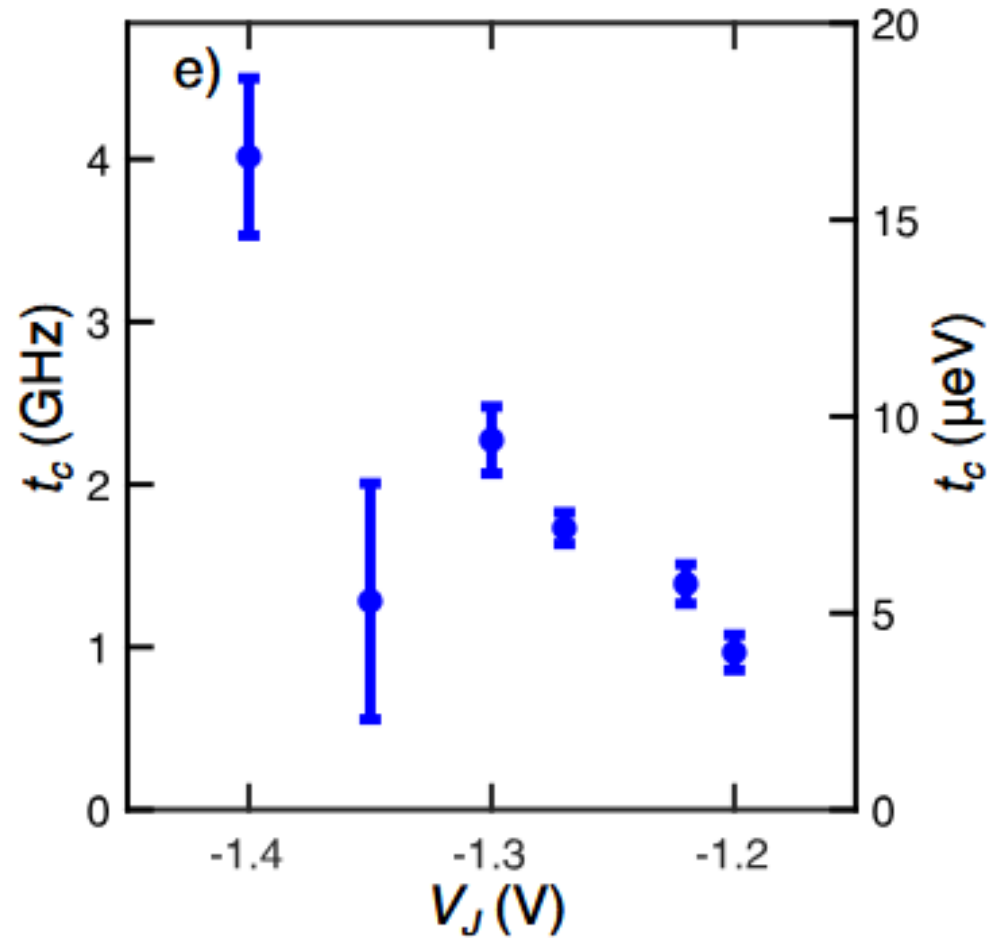


$\delta\epsilon = 30 \mu\text{eV}$ and $\delta\Delta E_z = 4 \text{ neV}$

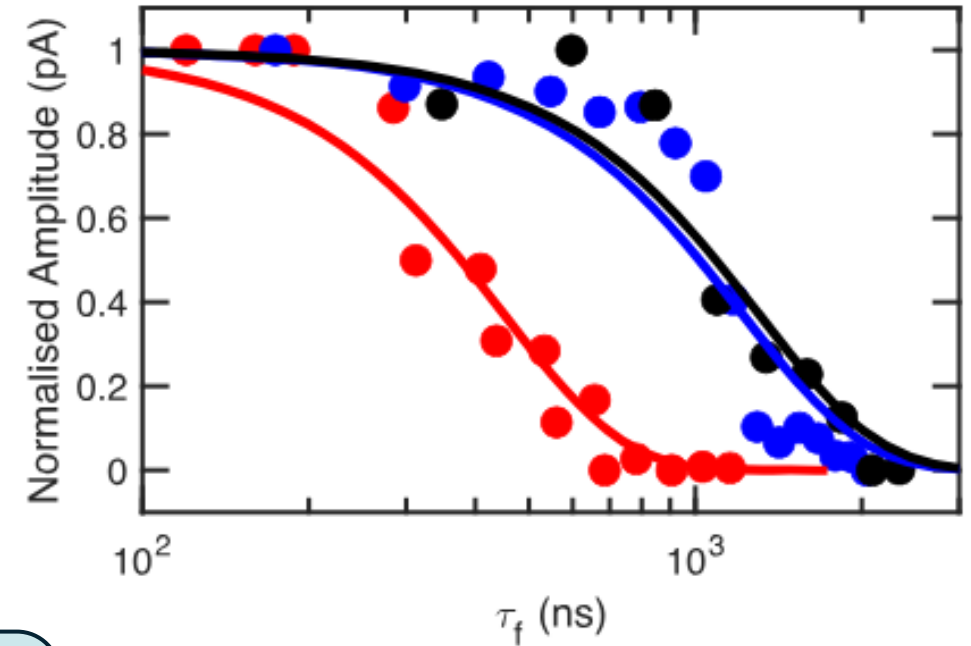
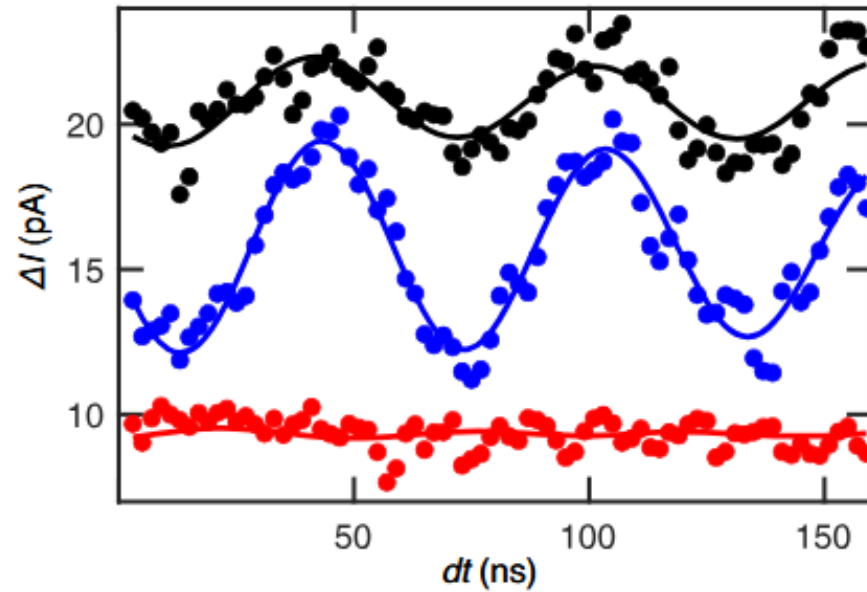
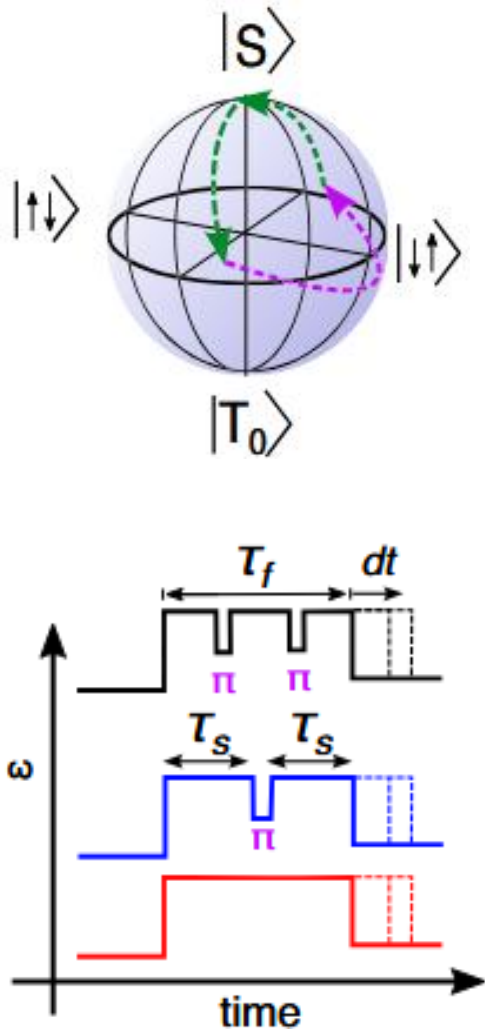
Coherent exchange-driven oscillations



Coherent exchange-driven oscillations



Spin-echo measurement



$T_2^{\text{Echo}} = 550 \pm 50 \text{ ns @ 0 echo}$
 $T_2^{\text{Echo}} = 1220 \pm 150 \text{ ns @ 1 echo}$
 $T_2^{\text{Echo}} = 1300 \pm 200 \text{ ns @ 2 echos}$

Conclusion

- Characterized Anisotropic g-tensors and t_{SO}
- Shown coherent Δg -driven oscillations
- Shown coherent exchange-driven oscillations
- Demonstrated spin echo pulse