Locking electron spins into magnetic resonance by electron-nuclear feedback

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Overview:

- ESR experiments with electron-nuclear feedback

- nuclear field adjusts itself → electron spin remains in ESR resonance even if system is brought out of resonance condition

- consequence: narrowing of the nuclear field distribution by a factor of 10
**Electron Spin Resonance:**

Double dot in Pauli spin blockade
→ spin can be flipped by an oscillating magnetic field when $\hbar f_{ac} = g \mu_B B_{ext}$
→ blockade is lifted

Koppens et al. 2006
**Electron spin resonance locking during frequency sweeps:**

![Graphs showing ESR frequency locking](image)

ESR frequency remains locked to the excitation frequency when the excitation frequency is swept past the nominal resonance condition. → counteracting field \( B_{\text{eff}} \)

\[
h_f = |g|\mu_B(B_0 + B_{\text{eff}}(B_0, f))
\]
Electron spin resonance locking during magnetic field sweeps:

After ESR condition is first met, the electron spin remains locked into magnetic resonance even though the resonance condition is shifted.
Magnetic field sweeps for different RF powers

B-field can be swept over a few 100 mT without losing resonance.
Nuclear spin polarization rate for one dot:

\[ \frac{dx}{dt} = \Gamma_p(x) - \frac{1}{\tau_n} x \]

Width of nuclear polarization distribution:

\[ \sigma_{ESR} = \sigma \cdot \sqrt{\frac{B_1}{B_{N}^{max}}} \]

\[ B_1 \approx 1 \text{mT} \]
\[ B_{N}^{max} \approx 10^2 \text{mT} \]

→ narrowing by a factor of 10