Self-Induced Superradiant Masing

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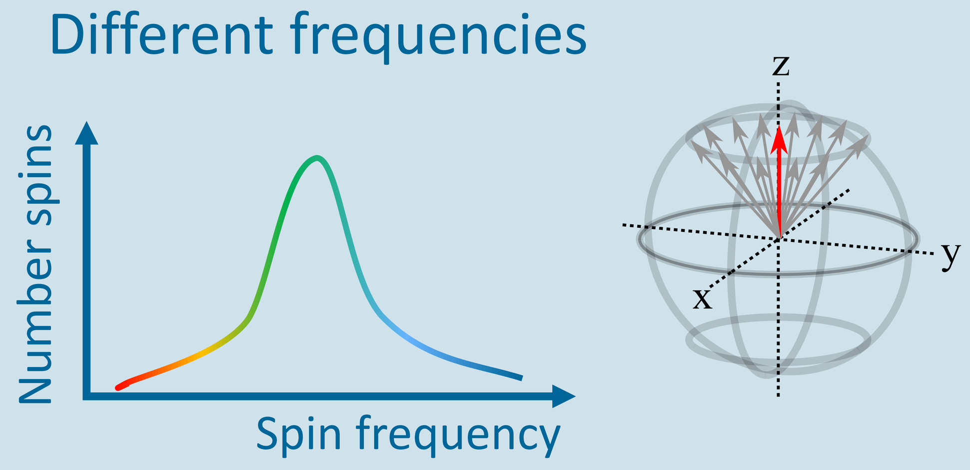
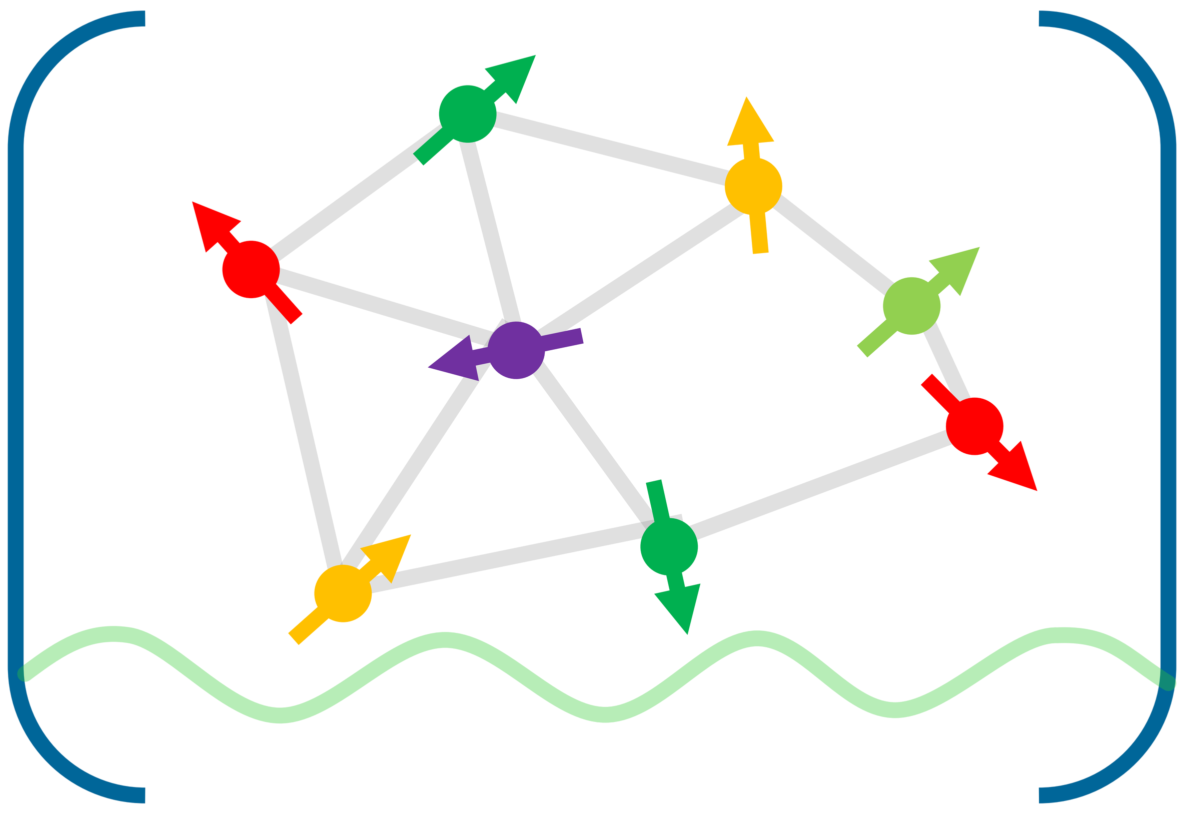
NV Centers in Diamond

- Ensemble of nitrogen vacancy (NV) centers in microwave cavity
- Inhomogeneous broadening: Different frequencies



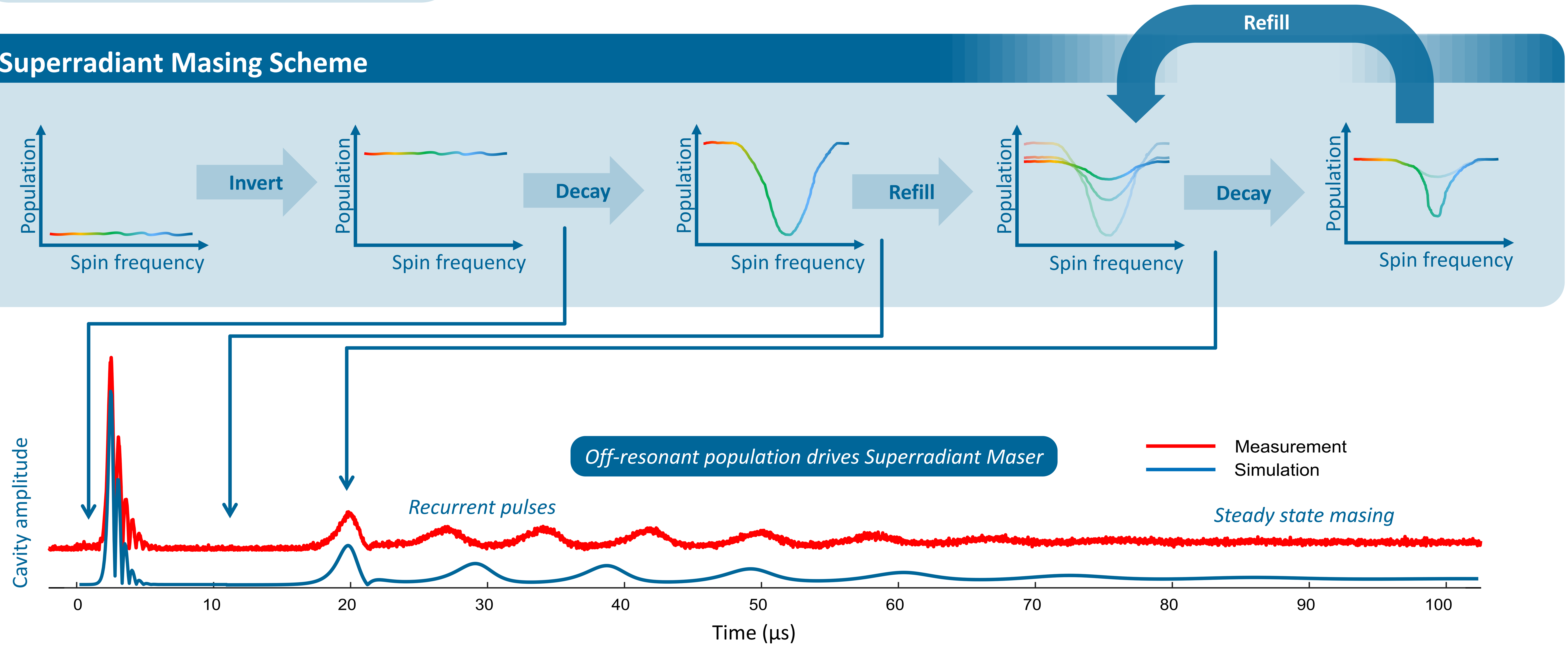


Dipole-dipole Interactions

- High density: Relevant spin-spin interactions
- Typically: Source of **decoherence** for NVs

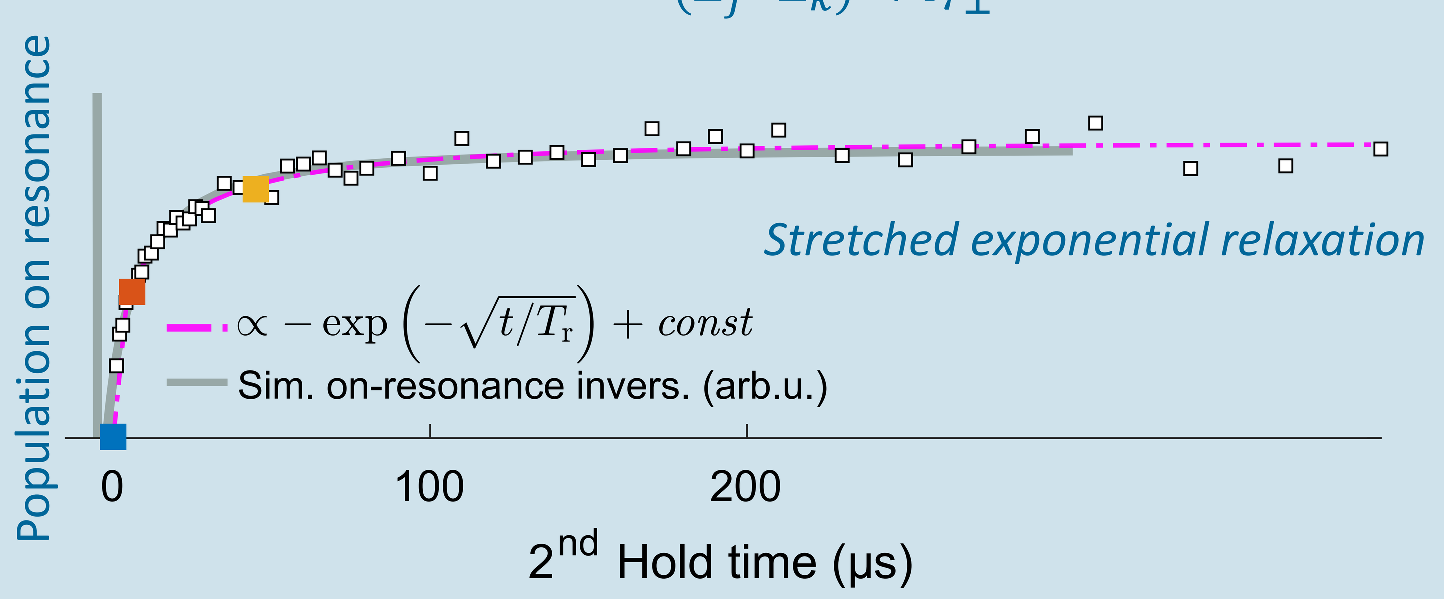
But:
Spin-spin interactions can also drive a ***Superradiant Maser***!

Superradiant Masing Scheme

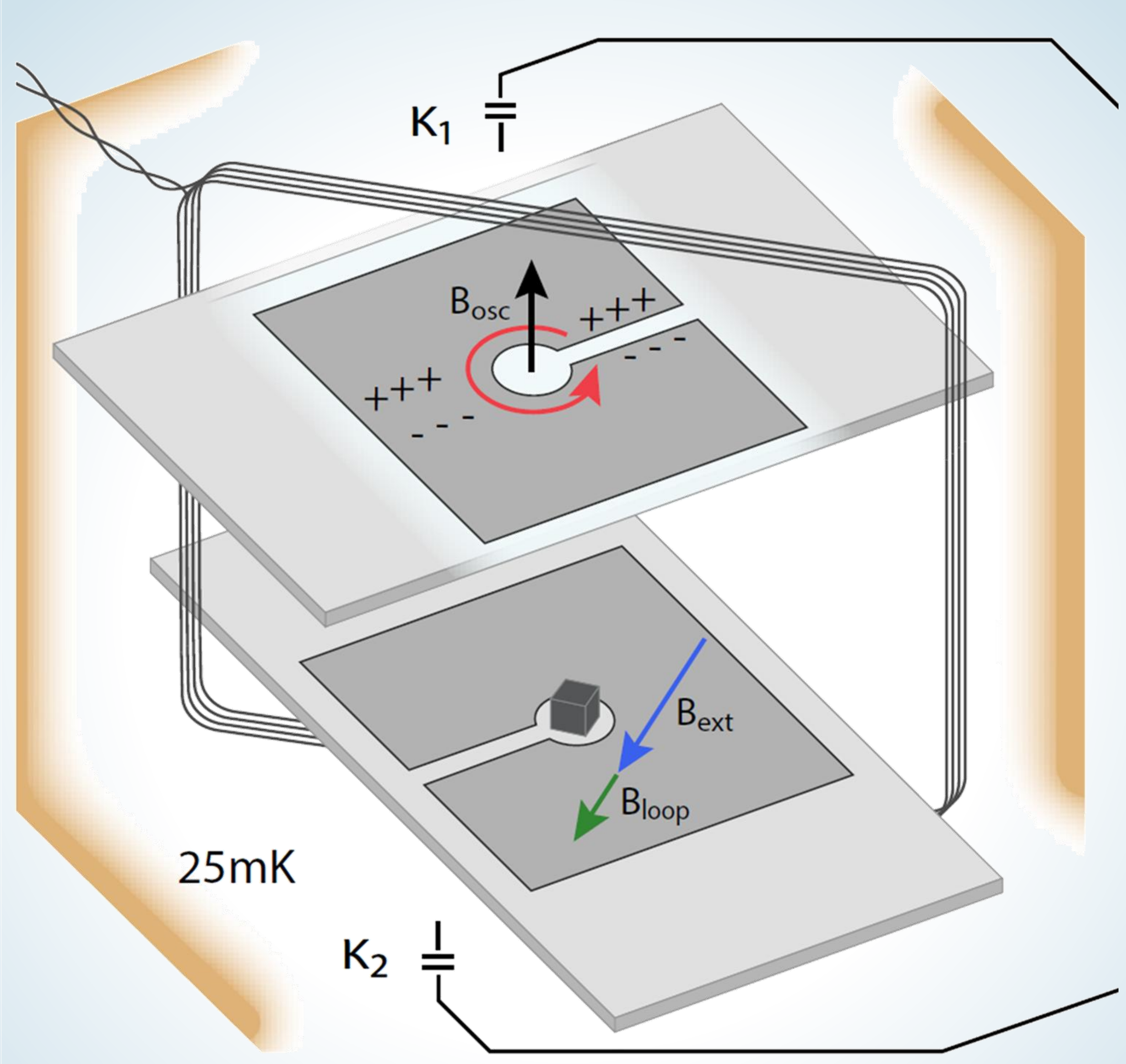


Refilling Dynamics

Equilibration dynamics: $\partial_t n_j = -\sum_k \frac{4\gamma_\perp |J_{jk}|^2}{(\Delta_j-\Delta_k)^2+4\gamma_\perp^2}(n_j-n_k), \quad J_{jk}\sim\frac{1}{r_{jk}^3}$



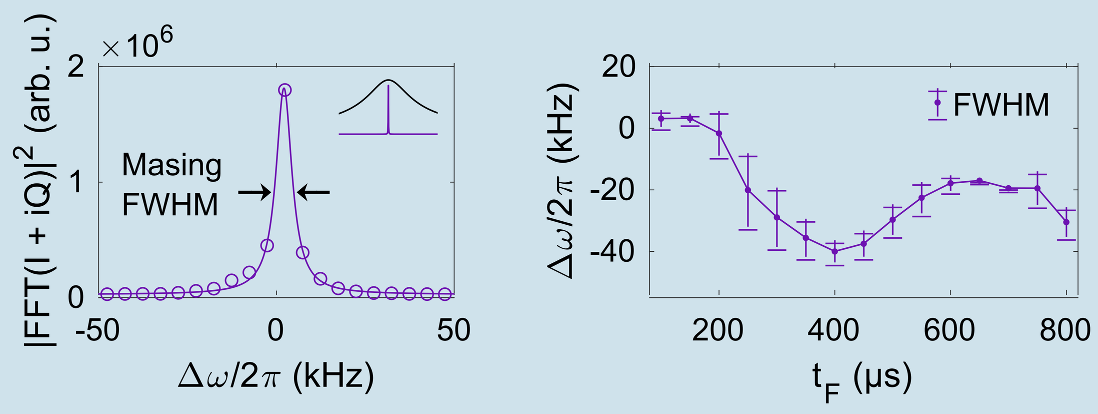
Experimental Setup



- $\sim 10^{12}$ NV centers in superconducting resonator
- Magnetic tuning of spin transition frequencies

Emission Characteristics of Maser

- FFT in 200 µs window
- Superradiant masing: Reduced linewidth as to spin and cavity paramters $\gamma_\perp, \kappa$



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References
W. Kersten, N. de Zordo, O. Diekmann, et al., Nat. Phys. (accepted)
W. Kersten, N. de Zordo, O. Diekmann, et al., PRL **131**, 043601 (2023)