Implementing a quantum memory with a frequency and bandwidth-tuneable superconducting resonator

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Among platforms for storing quantum states in the microwave domain, solid state spin ensembles addressed via superconducting circuits stand out for their multimodal storage capability and the second-long coherence time when operated at clock transitions [1].

Successful implementation of a practical memory scheme requires several keys features, such as the ability to tune on-demand the frequency and the bandwidth of the resonator [2]. In this talk, we will present a superconducting circuit architecture accomplishing both, allowing strong coupling to an ensemble of bismuth dopants in silicon. We devise a parametric process to dynamically control the virtual bandwidth of the superconducting circuit by exploiting its kinetic inductance nonlinearity, demonstrating coupling rate tuning range over a factor of 15.

The strong coupling of the spins to the resonator also set radiation loss as the main spin relaxation channel. Combined with nuclear and electronic drives, this Purcell effect enables to polarize the spins dynamically predominantly into a single ground state, allowing us to reach a cooperativity between the resonator and the spin ensemble near unity.

References

[1] Wolfowicz, G. et al. Nature nanotechnology 8, 561–564 (2013).
[2] Julsgaard, B. et al. Phys. Rev. Lett. 110, 250503 (2013).