# Addressing a spin-ensemble for storing microwave quantum states

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Abstract

Superconducting qubits are strong candidates for quantum information processing, yet their scalability is currently a challenge.
Multimode quantum memories have been proposed to alleviate the resource requirement of quantum architectures [1]. Such memories could be also used in quantum repeaters to improve long-distance quantum communication[2] or be a resource for improved quantum sensing[3]. They require high storage density, long-coherence time and the ability to write and read on-demand an arbitrary register.

Ensembles of electron spins for microwave quantum state storage combines three advantages. Firstly, they can offer extended storage times compared to superconducting qubits. For instance, the coherence of electronic and nuclear spins of donors in silicon can last seconds at clock transition sweet-spots where the impact of spin-spin interactions is significantly reduced[4], [5]. Then, they present a compact footprint. Finally, similarly to optical memories, protocols exist for creating multimode storage[6], [7].

The main challenge in realizing these proposals is to achieve strong, adjustable coupling between the spin and superconducting circuit. By exploiting a kinetic inductive non-linearity, we present a device where we can active a parametric process to dynamically control the virtual bandwidth of the resonator, demonstrating coupling rate tuning range over a factor of 5 and thus enabling catch-and-release of microwave photons. Using a $Si^{28}$ silicon sample, we measure a coherence time of 450 ms at one of the clock transitions of Bismuth donors. We explore more specifically two microwave spin transitions. We determine their coupling to the microwave resonator, and observe we are close to a regime of unit cooperativity. We can therefore assess the ability of the system to implement a complete quantum memory protocol.

References

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