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Towards hybrid quantum devices combining superconducting qubits to a spin-ensemble multi-qubit register

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Processing quantum information requires quantum-mechanical systems with long coherence times and that can be easily coupled together to perform logic operations. We report progress on hybrid quantum devices, in which an ensemble of spins provides a long-lived multi-qubit register for superconducting qubits. We design a memory protocol able to store and retrieve on demand the state of a large number of qubits in the spin ensemble [1]. Qubit states are written by resonant absorption of a microwave photon in the spin ensemble and read out of the memory by applying Hahn echo refocusing techniques to the spins. In a first experiment, we demonstrate the write step of the protocol by integrating on the same chip a superconducting qubit, a resonator with tunable frequency, and an ensemble of NV center spins in diamond [2]. In a second experiment, we demonstrate an important building block of the read step, which consists in retrieving multiple classical microwave pulses at the few photon level using Hahn echo refocusing techniques [3]. First experimental results will be presented in the direction of combining these two building blocks for retrieving a field in the quantum regime.

[1] B. Julsgaard et al., PRL 110, 250503 (2013).

[2] Y. Kubo et al., PRL 107, 220501 (2011).

[3] C. Grezes et al., PRX 4, 021049 (2014).