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Hybrid Quantum Information Processing with Superconductors and Neutral Atoms[1]

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Hybrid approaches to quantum information processing (QIP) aim to capitalize on the strengths of disparate quantum technologies to realize a system whose capabilities exceed those of any single experimental platform. At the University of Wisconsin, we are working toward integration of a fast superconducting quantum processor with a stable, long-lived quantum memory based on trapped neutral atoms. Here we describe the development of a quantum interface between superconducting thin-film cavity circuits and trapped Rydberg atoms, the key technological obstacle to realization of superconductor-atom hybrid QIP. Specific accomplishments to date include development of a theoretical protocol for high-fidelity state transfer between the atom and the cavity; fabrication and characterization of high-Q superconducting cavities with integrated trapping electrodes to enhance zero-point microwave fields at a location remote from the chip surface; and trapping and Rydberg excitation of single atoms within 1 mm of the cavity. We discuss the status of experiments to probe the strong coherent coupling of single Rydberg atoms and the superconducting cavity.

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