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Hybrid Quantum Information Processing with Superconducting Circuits and Rydberg Atoms MATTHEW BECK, JOSHUA ISAACS, DONALD BOOTH, MARK SAFFMAN, ROBERT MCDERMOTT, University of Wisconsin - Madison — Hybrid approaches to quantum information processing exploit the strengths of disparate quantum technologies to realize performance that exceeds what can be reached with any single technology on its own. Here we describe steps toward realization of a hybrid superconducting circuit Rydberg atom quantum architecture that will marry a fast, high-fidelity superconducting quantum processor with a long-lived quantum memory based on trapped Rydberg atoms. The key challenge is development of a high-fidelity microwave photon Rydberg atom interface. We have designed superconducting thin-film microwave resonators that allow trapping of single Rydberg atoms at a voltage antinode, where coupling to the zero-point fields of the resonator is strongest. We discuss the dependence of resonator quality factor and achievable coupling factor on device geometry. Finally, we present preliminary results of experiments to couple Rydberg atoms and superconducting linear resonators in a custom liquid helium cryostat.

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