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Hybrid quantum information processing with atoms, photons and superconducting circuits

Hybrid quantum computation exploits the unique strengths of disparate quantum technologies, enabling realization of a scalable quantum device capable of both fast gates and long coherence times. We propose a quantum interface for creating hybrid entanglement between neutral atoms, superconducting circuits and optical photons. The interface is mediated by coupling superconducting circuits to Rydberg excited single atoms using chip-based coplanar waveguide microwave cavities. We have developed a simple gate scheme to enable entanglement of an atomic qubit with a microwave photon, with fidelity calculations based on realistic parameters giving Bell-state preparation fidelity exceeding 0.999 on μs timescales. Experimental progress towards the coherent excitation of a single atom above a coplanar waveguide in a 4 K cryostat at the University of Wisconsin-Madison will be presented, along with an overview of a newly established experiment at the University of Strathclyde focused on quantum networking of hybrid systems.

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