Giant Artificial Atoms and Waveguide QED

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Abstract

We present a demonstration of "giant artificial atoms" realized with superconducting qubits in a waveguide QED architecture. The superconducting qubits couple to the waveguide at multiple, well-separated locations. In this configuration, the dipole approximation no longer holds, and the giant atom may quantum mechanically self-interfere. This system enables tunable qubit-waveguide couplings with large on-off ratios and a coupling spectrum that can be engineered by design. Multiple, interleaved qubits in this architecture can be switched between protected and emissive configurations, while retaining qubit-qubit interactions mediated by the waveguide. Using this architecture, we generate a Bell state with 94% fidelity, despite both qubits being strongly coupled to the waveguide. We furthermore use an artificial molecule comprising two qubits to demonstrate directional photon emission with 97% fidelity (a chiral waveguide). Such waveguide QED technologies are applicable to quantum interconnects and support architectural modularity.

References

[1] B. Kannan, et al., Nature Physics (2023)
[2] B. Kannan, et al., Nature 583 (2020)

Figures

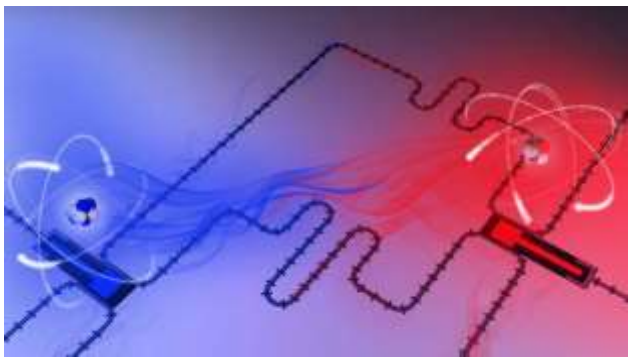

Figure 1: Illustration of two giant atoms interacting with one another via a 50-Ohm waveguide while isolated from the 50-Ohm environment via quantum interference.

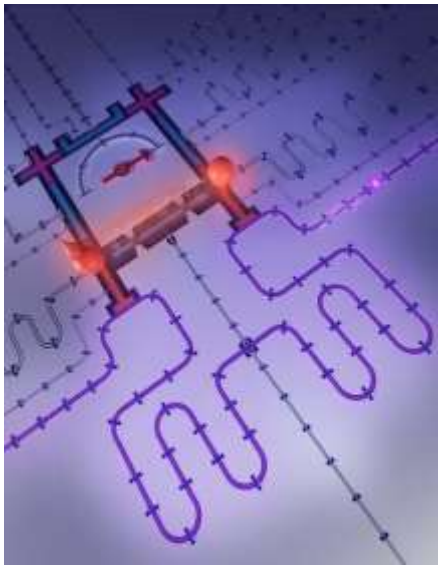

Figure 2: Illustration of direction emission of a directional (chiral) photon to a waveguide from two qubits entangled in a Bell state.