Engineering symmetry-selective couplings of a superconducting artificial molecule to microwave waveguides

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Tailoring the decay rate of structured quantum emitters into their environment opens new avenues for nonlinear quantum optics, collective phenomena, and quantum communications. Here we demonstrate a novel coupling scheme between an artificial molecule comprising two identical, strongly coupled transmon qubits, and two microwave waveguides. In our scheme, the coupling is engineered so that transitions between states of the same (opposite) symmetry, with respect to the permutation operator, are predominantly coupled to one (the other) waveguide. The symmetry-based coupling selectivity, as quantified by the ratio of the coupling strengths, exceeds a factor of 30 for both the waveguides in our device. In addition, we implement a Raman process activated by simultaneously driving both waveguides, and show that it can be used to coherently couple states of different symmetry in the single-excitation manifold of the molecule. Using that process, we implement frequency conversion across the waveguides, mediated by the molecule, with efficiency of about 95%. Finally, we show that this coupling arrangement makes it possible to straightforwardly generate spatially-separated Bell states propagating across the waveguides. We envisage further applications to quantum thermodynamics, microwave photodetection, and photon-photon gates.

References

[1] Mohammed Ali Aamir et. al., arXiv: 2202.12209

Figures

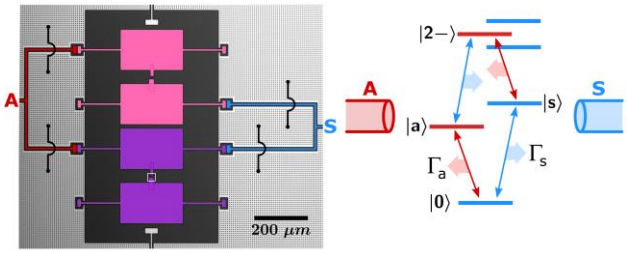

Figure 1: Device architecture and level diagram

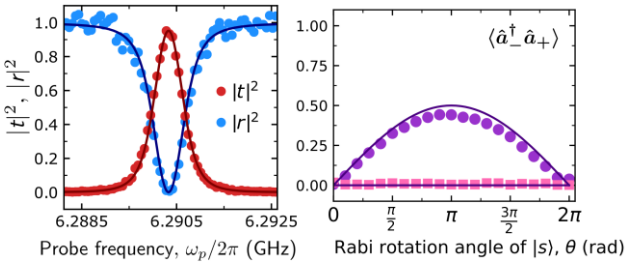

Figure 2: Two demonstrated applications; left – efficient and coherent population transfers between states of opposite symmetries, right – Formation of Bell state of two propagating modes