Tunable unidirectional photon scattering from a pair of superconducting qubits

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The ability to control the direction of scattered light in integrated devices is crucial to provide the flexibility and scalability for a wide range of on-chip applications, such as integrated photonics, quantum information processing and nonlinear optics. In the optical and microwave frequency ranges tunable directionality can be achieved by applying external magnetic fields, that modify optical selection rules [1], by using nonlinear effects [2], or interactions with vibrations [3]. However, these approaches are less suitable to control propagation of microwave photons inside integrated superconducting quantum devices, that is highly desirable. We demonstrate tunable directional scattering with just two transmon qubits coupled to a transmission line based on periodically modulated transition frequency (Fig. 1). By changing the symmetry of the modulation, governed by the relative phase between the local modulation tones, to achieve directional forward or backward photon scattering (Fig. 2). Such a device could be used for the design of topologically protected states, as a part of hardware implementation of Gottesman-Kitaev-Preskill code, and to route microwave radiation for the realization of chiral networks.

References

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Figures

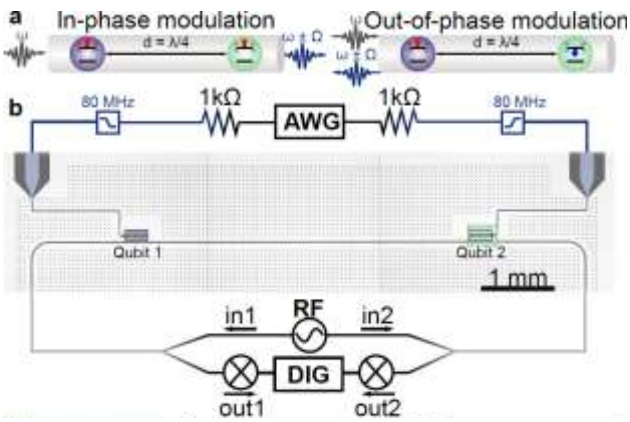

Figure 1: a, Schematic showing the scattering direction for in- and out-of-phase modulations on the qubits' transition frequency. **b**, Optical microscope image of the device and simplified experimental setup.

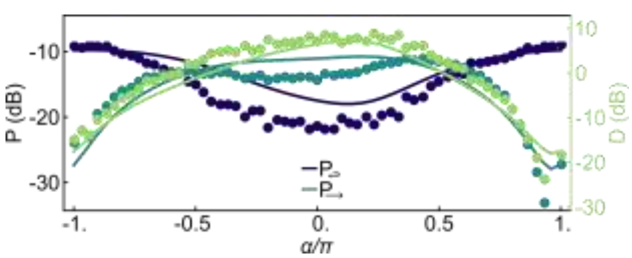

Figure 2: Coherent inelastic scattering spectrum of the Stokes component as a function of relative phase between modulation tones. Points are measured, solid lines are theory. Directivity is shown in green.