Coherent control of a multi-qubit dark state in waveguide quantum electrodynamics

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The coherence properties of an atom or superconducting qubit strongly depend on the electromagnetic environment. Typical circuit QED experiments protect the qubit mode from decay into dissipative modes by placing it into a cavity. Effectively, a reduction of the available mode density reduces the free-space spontaneous emission rate of the qubit. In waveguide QED the qubit is strongly coupled to a continuous mode spectrum, thus it decays rapidly. Collective effects between multiple qubits can be utilized to create subradiant states that decouple from the dissipative waveguide environment. In our experiment we strongly couple two pairs of transmon qubits to the fundamental propagating mode of a rectangular waveguide. We show that the decay of the four qubit dark state is strongly suppressed, exceeding the waveguide-limited lifetimes of the individual qubits by two orders of magnitude [1]. We characterize the dark state by measuring the coherence time in a Ramsey experiment and perform a pulsed spectroscopy into the two-excitation manifold, which can only be accurately modeled by taking into the account the bosonic nature of the transmons [2].

References

[1] Zanner et al., Nature Physics, Issue 3 (to appear) (2022)
[2] Orell et al., arXiv:2112.08134

Figures

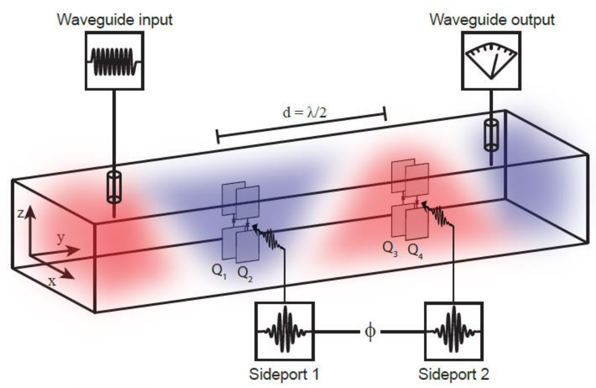

Figure 1: Waveguide QED setup containing 4 transmons and two additional drive ports for local addressing. Additionally, the waveguide transmission can be measured via the waveguide in- and output.

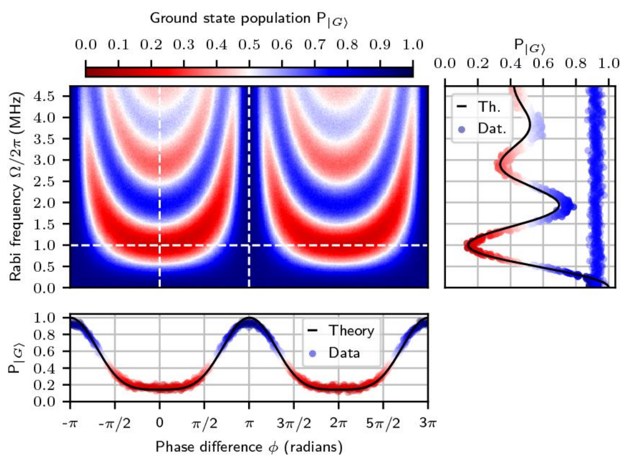

Figure 2: The dark state only shows Rabi oscillations when it is driven with the corresponding phase-relation, that matches the symmetry condition.