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Theory of implementation of an impedance-matched Λ system in circuit QED[1] KAZUKI KOSHINO, College of Liberal Arts and Sciences, Tokyo Medical and Dental University, Japan, KUNIHIRO INOMATA, RIKEN Center for Emergent Matter Science, Japan, TSUYOSHI YAMAMOTO, RIKEN and NEC Smart Energy Research Laboratories, Japan, YASUNOBU NAKAMURA, RIKEN and Research Center for Advanced Science and Technology, the University of Tokyo, Japan — In one-dimensional optical setups, light-matter interaction is drastically enhanced by the interference between the incident and scattered fields. Particularly, in an impedance-matched Λ-type three-level system, which has two identical radiative decay rates from the top level and interacts with a semi-infinite one-dimensional field in reflection geometry, a single photon deterministically induces the Raman transition and switches the electronic state of the system. Here we theoretically investigate a circuit QED system composed of a driven superconducting qubit and a resonator in the dispersive regime. We show that the dressed states of this system constitute an impedance-matched Λ system under a proper choice of the frequency and power of the qubit drive. When we apply a resonant probe field to this system, it is down-converted nearly perfectly after a single reflection as long as the probe power is sufficiently weak. This indicates a deterministic quantum dynamics induced by single photons, which is applicable, for example, to the detection of single microwave photons and the bidirectional quantum memory (swapping) between a microwave photon and a superconducting qubit.

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