# Probing Multiphoton Dressed States of a Superconducting Qubit

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There has been great interest in the new field of circuit QED, where the interaction of photons and matter are studied in the context of superconducting qubits. In this work, we create dressed states of a superconducting qubit, the single Cooper-pair box (SCB), with an intense microwave ( 7 GHz) drive. The dressed states represent the hybridization of the qubit and photon degrees of freedom. We directly measure a class of states, longitudinal dressed states (LDS), that have received little experimental attention in the past. We measure them over a wide range of drive strengths, including the extreme driving regime where the driving field is much stronger than the polarizing field. In the more typical case of transverse dressed states, a strong static field is used to polarize the qubit. A relatively weak ac field, aligned perpendicular to the polarizing field, is then used to drive it. In our experiment, the driving field is aligned parallel to the polarizing field leading to a qualitatively different energy diagram. By embedding the circuit in an rf resonator ( 650 MHz), we can directly probe the dressed states. When the dressed states are off resonance, we see a purely reactive response, analogous to the quantum capacitance. On resonance, we see that the dressed qubit absorbs energy from the resonator. For some conditions, we also see evidence of population inversion in the dressed states, indicated by amplification of the reflected rf field and a negative quantum capacitance. All these effects can be explained by including relaxation in the dressed state picture.