Parametric excitation of a superconducting qubit due to a nonadiabatic modulation of Lamb shift

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The investigation of responses of quantum systems on nonadiabatic modulation of their parameters is of interest both from the viewpoint of realization of various fundamental QED effects and for purposes of quantum computation. Indeed, high-speed gates can induce various nonstationary QED effects related to vacuum amplification and parametric generation of excitations from vacuum via counter-rotating wave processes which are usually neglected. Both the understanding and the control of such effects is of great importance. One of such phenomena is the dynamical Lamb effect, induced by a nonadiabatic modulation of atomic level Lamb shift [1], which was initially predicted for a natural atom placed into a cavity with time-dependent parameters. We here study the dynamical Lamb effect and accompanying quantum phenomena for the case of a coupled superconducting qubit-resonator system under variation of either the coupling energy [2, 3] or resonator frequency. Energy dissipation is taken into account. We reveal various dynamical regimes in which dynamical Lamb effect can be effectively suppressed or enhanced in comparison with other channels of a parametric qubit excitation. We also find that the effect of energy dissipation on the dynamics of such systems can be highly nontrivial. One of the most striking results is that photon generation from vacuum can be strongly enhanced due to the qubit relaxation, which opens a new channel for such a process.

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