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Probing the quantum fluctuations of a nonlinear resonator with a superconducting qubit

PATRICE BERTET, CEA Saclay

Coupling a superconducting quantum bit to a superconducting resonator offers the opportunity to investigate the interaction between light and an atom in regimes hardly accessible otherwise [1]. Making the resonator nonlinear has enabled important recent progress in the readout of qubits. Indeed, when pumped by a microwave field of well-chosen amplitude and frequency, nonlinear resonators (NRs) provide parametric amplification close to the quantum limit. In other drive conditions, the intra-cavity field can take two stable values between which the resonator can switch stochastically. Both regimes have been shown to yield a high-fidelity qubit readout [2,3]. Qubits can also be used to obtain interesting insight into the physics of NRs. In this work we use a transmon qubit [4] coupled to such a pumped NR as a probe of its quantum fluctuations. The qubit-NR coupling is manifested by the appearance around the qubit spectral line of two sidebands that we interpret as processes in which the driven resonator fluctuations are effectively cooled down or heated with the assistance of the qubit. The ratio of the sidebands amplitudes gives thus a direct experimental access to the pumped NR effective temperature which is found to be in quantitative agreement with the theory, bringing a clear support to the quantum description of a driven nonlinear resonator [5].

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