Abstract Submitted
for the MAR11 Meeting of
The American Physical Society

Circuit QED with a Nonlinear Resonator: ac-Stark Shift and Dephasing FLORIAN R. ONG, CEA-Saclay and University of Waterloo, M. BOISSONNEAULT, F. MALLET, A. PALACIOS-LALOY, A. DEWES, A.C. DOHERTY, A. BLAIS, P. BERTET, D. VION, D. ESTEVE, CEA-SACLAY TEAM, U. DE SHERBROOKE TEAM, U. OF QUEENSLAND TEAM — Coupling a superconducting qubit to a superconducting resonator enables to investigate the interaction between light and matter with a unique flexibility of design, and allows to reach coupling regimes hardly accessible otherwise [Wallraff Nature 2004]. In this talk, we discuss the ac-Stark shift and the measurement induced dephasing of a qubit embedded in a *nonlinear* resonator, an architecture that has demonstrated high fidelity single-shot qubit state readout [Mallet Nat. Phys. 2009]. In our experiment, a transmon qubit [Koch PRA 2007] is capacitively coupled to a coplanar waveguide resonator incorporating a Josephson junction that provides a Kerr nonlinearity. We have measured the qubit spectrum while pumping the nonlinear resonator with a microwave tone. Measurements of the qubit frequency shift provide a sensitive probe of the intracavity field, yielding a precise characterization of the resonator nonlinearity. The qubit linewidth has a complex dependence on the pump frequency and amplitude, which is correlated with the gain of the nonlinear resonator operated as a small-signal amplifier. The corresponding dephasing rate is found to be close to the quantum limit for most pump parameters.

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Date submitted: 16 Nov 2010 Electronic form version 1.4