Coherent Dynamics of a flux-qubit coupled to a harmonic oscillator

P. Bertet[1], I. Chiorescu[1*], K. Semba[2], Y. Nakamura[3] C. J. P. M. Harmans[1], J. E. Mooij[1]

[1] Quantum Transport Group, Kavli Institute of Nanosciences, Delft University of Technology, Lorentzweg 1,2628CJ, Delft, The Netherlands
[2] NTT Basic Research Laboratories, Atsugi-shi, Kanagawa 243-0198, Japan
[3] NEC Fundamental Research Laboratories, 34 Miyukigaoka, Tsukuba, Ibaraki 305-8501, Japan
** Present address : Department of Physics and Astronomy, Michigan State University, East Lansing, MI-48824, USA*

Superconducting circuits containing Josephson junctions are very promising candidates for the implementation of solid-state quantum bits or qubits [1]. Complex single-qubit operations have already been reported [2,3], as well as coherent dynamics of two coupled qubits [4] and realization of a quantum gate [5]. Coupling a qubit to a harmonic oscillator is interesting from a fundamental point of view to generate and study non-classical states of the oscillator, and is relevant in quantum information as well, since coupling many qubits via a harmonic oscillator has been proposed [6]. Here we present recent measurements demonstrating the coupling of a flux-qubit to the plasma mode of the DC Squid which at the same time is used to measure the qubit state. This coupling is manifested by the appearance of two side-band resonances around the bare qubit peak. By performing two-pulse experiments, we demonstrate that these additional resonances are indeed excitations of the coupled system. We also observe Rabi oscillations between the coupled |qubit,Squid> states, thus demonstrating entanglement between the states of two superconducting circuits. We use the qubit to measure intrinsic properties of the plasma mode : temperature, relaxation time. Conversely, we also measure the qubit's state via the plasma mode. These results indicate that complex manipulation of entangled states similar to cavity QED or trapped-ions experiments is within reach with superconducting circuits.

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