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Large dispersive shift in superconducting flux qubit

TSUYOSHI YAMAMOTO, NEC Corporation, KUNIHIRO INOMATA, RIKEN, YASUNOBU NAKAMURA, JAW-SHEN TSAI, NEC Corporation — We study dispersive readout in superconducting flux qubits which are capacitively coupled to a superconducting cavity with ~ 10 GHz resonant frequency f_r. To discriminate the state of the qubit precisely, large magnitude of the dispersive shift χ is desirable. For the two-level system, χ is given by g^2/Δ where g is the coupling strength and Δ is the detuning between the qubit and the cavity. For the multilevel system such as superconducting qubits, however, this formula is modified due to the contributions from higher levels [1]. It has been pointed out that if f_r lies between 01 and 12 transition frequencies of the qubit (f_{01} and f_{12}, respectively), $|\chi|$ becomes large because of constructive contributions from different levels [1]. Our flux qubit has $f_{01} =$ 5 GHz and $f_{12} =$ 15 GHz at the optimal flux bias, thus satisfying this condition. Moreover, because of the large anharmonicity ($|f_{12} - f_{01}|$) of the flux qubit, we can easily make g as large as ~ 100 MHz, while staying in the deep dispersive limit. Both of these enhance $|\chi|$ and we have obtained χ of 80 MHz at the optimal flux bias, which agrees well with the prediction by the energy band calculation. [1] J. Koch et al., PRA 76, 042319 (2007)

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