Hybrid Circuit Cavity Quantum Electrodynamics with a Micromechanical Resonator

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Résumé

Hybrid quantum systems with inherently distinct degrees of freedom play a key role in many physical phenomena. A strong coupling can make the constituents to lose their individual character and to form entangled states. The properties of these collective excitations can combine the benefits of each subsystem. In the emerging field of quantum information control, a promising direction is provided by the combination between long-lived atomic states and the accessible electrical degrees of freedom in superconducting cavities.

Our recent experiment [1] demonstrates the possibility to integrate circuit cavity quantum electrodynamics with phonons. Besides coupling to a microwave cavity, our superconducting transmon qubit interacts with a resonant phonon mode in a micromechanical resonator, allowing the combination of long lifetime, tunable strong coupling, and ease of access. We observe **mechanical Stark shift**, as well as the splitting of the transmon qubit spectral line into motional sidebands representing transitions between electromechanical dressed states and the qubit. In the time domain, we observe **coherent sideband Rabi oscillations** between the qubit states and phonons. This advance may allow for storage of quantum information in long-lived phonon states, and for investigations of strongly coupled quantum systems near the classical limit.

J.-M. Pirkkalainen, S. U. Cho, Jian Li, G. S. Paraoanu, P. J. Hakonen, and M. A. Sillanp´a´a, *Hybrid circuit cavity quantum electrodynamics with a micromechanical resonator*, Nature **494**, 211–215 (2013).

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