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Superconducting qubits coupled to resonant cavities[1]

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Coupling of superconducting qubits to resonant cavities and mechanical oscillators has opened new possibilities for quantum information processing and for the realization of quantum optics in solid-state devices. Together with steady improvements in superconducting qubits [1], this is due to the qubit-resonator coupling which can readily be made very large with respect to all dissipation rates. As a result, these solid-state systems can reach new parameter regimes currently unexplored in atomic based quantum optics [2]. A resonant cavity can also be used as quantum bus allowing entanglement to be generated controllably between qubits coupled to the same cavity, and regardless of the distance separating the qubits [3]. Because of the relatively large size of these cavities, this allows to couple and entangle multiple qubits, opening new avenues for scalable solid-state quantum computation. In this talk, I will review some of the key properties of superconducting qubits and how they can be strongly coupled to various types of resonant cavities. Focusing on superconducting charge qubits coupled to transmission line resonators, I will explain how the quantum state of the qubits can be coherently manipulated and probed by microwave irradiation of the resonator [4]. I will also present some of the recent theoretical proposals for the generation of entanglement in this system [5].

[1] J. Koch, et al. Phys. Rev. A 76, 042319 (2007).
[2] D. I. Schuster, et al. Nature 445, 515 (2007).
[3] J. Majer, et al. Nature 449, 443 (2007).
[4] J. Gambetta, et al. arXiv:0709.4264 (2007).
[5] A. Blais, et al. Phys. Rev. A 75, 032329 (2007).

[1]Work done in collaboration with A. Wallraff, M. Devoret, S.M. Girvin, R.J. Schoelkopf and the Yale circuit QED team.