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Abstract for an Invited Paper
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Qubits in Cavities for Quantum Optics and Computing[1]

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I will describe a platform for quantum computation and quantum optics using superconducting circuits as both the linear and non-linear elements. One dimensional transmission line cavities realize well-defined microwave linear photon modes, while Cooper-pair boxes act as artificial atoms for use as qubits and strongly non-linear elements [1]. We have observed the coherent interaction between a qubit and a single photon, a feat previously only achievable in atomic systems [2]. Using such a coupling a high quality factor cavity can act as an entanglement bus where real or virtual photons mediate interactions between distant qubits [3]. The qubit-photon coupling is exploited to realize a quantum non-demolition measurement of the qubit state [4] and should also allow for direct measurement of the photon number state of the cavity [5]. Using this measurement technique we have shown >90% visibility and long coherence times (T_1 ~7us T_2* > 500ns) [6]. Off-resonant microwave irradiation is used to adjust qubit-cavity and qubit-qubit detunings for decoherence free control of interaction strengths. Pulsed two photon sideband transitions are shown to mediate off-resonant cavity-qubit interactions, as required to implement non-local two qubit gates. Such techniques could also be used to generate non-classical states of light. We will also discuss initial measurements on two qubits.

[1] A. Wallraff et al. Nature (London) 431, 162 (2004)
[2] A. Blais et al. Phys. Rev. A 69, 062320 (2004)
[3] A. Blais et al. Phys. Rev. A submitted
[4] D. I. Schuster et al. Phys. Rev. Lett. 94, 123602 (2005)
[5] J. Gambetta et al. Phys. Rev. A submitted
[6] A. Wallraff et al. Phys. Rev. Lett. 95 060501 (2005)

[1]In collaboration with A. Wallraff, A. Blais, J. Gambetta, L. Frunzio, J. Schreier, A. Houck, B. Johnson, J. Majer, M. H. Devoret, S. M. Girvin, R. J. Schoelkopf