Abstract for an Invited Paper
for the MAR09 Meeting of
The American Physical Society

Controlling Photons, Qubits and their Interactions in Superconducting Electronic Circuits[1]

ANDREAS WALLRAFF, Department of Physics, ETH Zurich

A combination of ideas from atomic physics, quantum optics and solid state physics allows us to investigate the fundamental interaction of matter and light on the level of single quanta in electronic circuits. In an approach known as circuit quantum electrodynamics, we coherently couple individual photons stored in a high quality microwave frequency resonator to a fully controllable superconducting two-level system (qubit) realized in a macroscopic electronic circuit [1]. In particular, we have recently observed the simultaneous interaction of one, two and three photons with a single qubit. In these experiments, we have probed the quantum nonlinearity of the qubit/light interaction governed by the Jaynes-Cummings hamiltonian, clearly demonstrating the quantization of the radiation field in the on-chip cavity. We have also performed quantum optics experiments with no photons at all. In this situation, i.e. in pure vacuum, we have resolved the renormalization of the qubit transition frequency - known as the Lamb shift - due to its non-resonant interaction with the cavity vacuum fluctuations [3].

[1] A. Wallraff et al., Nature (London) 431, 162 (2004)
[2] J. Fink et al., Nature (London) 454, 315 (2008)
[3] A. Fragner et al., Science 322, 1357 (2008)

[1]Work done in collaboration with Johannes Fink, Andreas Fragner, Alexandre Blais, Peter Leek and the ETH Quantum Device Team.