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Atomic physics and quantum optics using circuits behaving as tunable artificial atoms

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Abstract. Superconducting (SC) circuits can behave like atoms making transitions between a few energy levels. Such circuits can test quantum mechanics at macroscopic scales and be used to conduct atomic-physics experiments on a silicon chip. Examples of this, that we have studied theoretically [1], include the following: SC qubits for photon generation and for lasing; 2-1 photon coexistence; cooling qubits and their environment; using SC qubits to probe nearby defects; hybrid circuits involving both charge and flux qubits; quantum tomography in SC circuits; preparation of macroscopic quantum superposition states of a cavity field via coupling to a SC qubit; generation of nonclassical photon states using a SC qubit in a microcavity; cluster states; using these circuits as quantum analog emulators of Kitaev lattices; controllable scattering of photons inside a one-dimensional resonator waveguide; the Dynamical Casimir effect, and controllable couplings among qubits. Some of these results will be reviewed in this talk.

PDF files of our publications are available online at:
http://dml.riken.jp and also at: http://www.umich.edu/~nori/

A few reviews related to this topic are listed below:

[1] J.Q. You, F. Nori, *Atomic Physics and Quantum Optics using Superconducting circuits*, *Nature*, **474**, 589 (2011). Nine-pages-long paper. [PDF][Link]
[2] J.Q. You, F. Nori, *Superconducting circuits and quantum information*, Physics Today **58** (11), 42-47 (2005). [PDF][Link]
[3] I. Buluta, F. Nori, *Quantum Simulators*, Science **326**, 108 (2009). [PDF][Link]
[4] I. Buluta, S. Ashhab, F. Nori, *Natural and artificial atoms for quantum computation*,
[5] [arXiv]. arXiv:1002.1871v2 . *Reports on Progress in Physics*, in press (2011).
[6] S.N. Shevchenko, S. Ashhab, F. Nori, *Landau-Zener-Stuckelberg interferometry*, Phys. Reports **492**, 1 (2010). [PDF][Link][arXiv]
[7] J. Ma, X. Wang, C. P. Sun, F. Nori, *Quantum spin squeezing*, (2010). [arXiv]. arXiv:1011.2978v2. *Physics Reports*, in press (2011).
[8] A.V. Rozhkov, G. Giavaras, Y.P. Bliokh, V. Freilikher, F. Nori, *Electronic properties of mesoscopic graphene structures: Charge confinement and control of spin and charge transport*, *Phys. Reports* **503**, 77 (2011). [PDF][Link][arXiv]
[9] P.D. Nation, J.R. Johansson, M.P. Blencowe, F. Nori, *Stimulating uncertainty: Amplifying the quantum vacuum with superconducting circuits*, (2011). [arXiv] arXiv:1103.0835v1. For *Rev. Mod. Physics.*