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Preparation of arbitrary quantum states in a microwave resonator

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Two-level systems, or qubits, can be prepared in arbitrary quantum states with exquisite control, just using classical electrical signals. Achieving the same degree of control over harmonic resonators has remained elusive, due to their infinite number of equally spaced energy levels. Here we exploit the good control over a superconducting phase qubit by using it to pump photons into a high- Q coplanar wave guide resonator and, subsequently, to read out the resonator state. This scheme has previously allowed us to prepare and detect photon number states (Fock states) in the resonator [1]. Using a generalization of this scheme [2] we can now create arbitrary quantum states of the photon field with up to approximately 10 photons. We analyze the prepared states by mapping out the corresponding Wigner function, which is the phase-space equivalent to the density matrix and provides a complete description of the quantum state.

[1] MH *et al.*, Nature **454**, 310 (2008)

[2] Law and Eberly, Phys. Rev. Lett. **76** 1055 (1996)