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Exploration of the Tavis-Cummings Model with Multiple Qubits in Circuit QED J.M. FINK, ETH Zurich, A. BLAIS, Universite de Sherbrooke, A. WALLRAFF, ETH Zurich, ETH QUANTUM DEVICE TEAM — Superconducting qubits in coplanar waveguide resonators provide an unprecedentedly large dipole coupling strength to microwave frequency photons confined in an on-chip waveguide resonator [1]. In contrast to atoms in traditional cavity QED a controlled number of qubits remain at fixed positions with constant coupling to the cavity field at all times. Utilizing these properties we have performed measurements with up to three independently flux-tunable qubits to study cavity mediated multi-qubit interactions. By tuning the qubits in resonance with the cavity field individually, we demonstrate the square root of N scaling of the collective dipole coupling strength with the number of resonant atoms N as described by the Tavis-Cummings model. To our knowledge this is the first observation of this nonlinearity in a system in which the atom number can be changed one by one in a discrete fashion. In addition, the energies of both bright and dark coupled multi-qubit / photon states are well explained by the Tavis-Cummings model over a wide range of detunings. On resonance we obtain an equal superposition of a photon and a Dicke state with an excitation equally shared among the N qubits.

[1] J. M. Fink et al. *Nature* 454, 315 (2008).

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