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Multimode Strong Coupling in Circuit QED NEEREJA SUNDARESAN, YANBING LIU, DARIUS SADRI, LASZLO SZOCS, DEVIN UNDERWOOD, MOEIN MALEKAKHLAGH, HAKAN TURECI, ANDREW HOUCK, Princeton University — We present experimental and theoretical studies in the multimode strong coupling (MMSC) regime of cavity quantum electrodynamics (QED). In MMSC, a single atom is simultaneously coupled to a large, but discrete, number of cavity harmonics, with atom-mode coupling strengths comparable to the free spectral range (FSR). This regime is readily accessible in circuit QED, by strongly coupling a transmon qubit to a low fundamental frequency microwave cavity. We present some key results from our original experiment (PRX 5, 021035, 2015), in which a transmon qubit, resonant with the 75th harmonic of a 90 MHz cavity, reached qubit-mode coupling strengths exceeding 30MHz. When this system is coherently driven, we observed complex multimode fluorescence, with the notable formation of ultra-narrow linewidths. To better understand these unique features of multimode resonance fluorescence we developed a quantum formalism, which attributes the spectral linewidth narrowing to the correlated spontaneous emission of doubly dressed states. Finally we will share preliminary experimental results from our continuing study of MMSC, this time from a system where qubit-mode coupling strengths approach and even exceed the FSR.

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