This is the first part of two back to back talks with R. Sagastizabal (log number of second talk: MAR17-2016-005903)

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Experimentally simulating the dynamics of quantum light and matter at ultrastrong coupling using circuit QED (1) - implementation and matter dynamics -[1] M. KOUNALAKIS, N.K. LANGFORD, R. SAGASTIZABAL, C. DICKEL, A. BRUNO, F. LUTHI, QuTech and Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands, D.J. THOEN, A. ENDO, Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands, L. DICARLO, QuTech and Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands — The field dipole coupling of quantum light and matter, described by the quantum Rabi model, leads to exotic phenomena when the coupling strength g becomes comparable or larger than the atom and photon frequencies $\omega_{q,r}$. In this ultra-strong coupling regime, excitations are not conserved, leading to collapse-revival dynamics in atom and photon parity and Schrödinger-cat-like atom-photon entanglement. We realize a quantum simulation of the Rabi model using a transmon qubit coupled to a resonator. In this first part, we describe our analog-digital approach to implement up to 90 symmetric Trotter steps, combining single-qubit gates with the Jaynes-Cummings interaction naturally present in our circuit QED system. Controlling the phase of microwave pulses defines a rotating frame and enables simulation of arbitrary parameter regimes of the Rabi model. We demonstrate measurements of qubit parity dynamics showing revivals at $g/\omega_r > 0.8$ for $\omega_q = 0$ and characteristic dynamics for nondegenerate ω_q from $g/4$ to g.

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