Quantum optics with propagating microwaves in superconducting circuits.

In recent years, much effort has been invested to using superconducting artificial atoms to explore quantum optics in new parameter regimes. In this talk, I will address advances on quantum optics with propagating microwaves. In the first sets of experiments, we embed a transmon artificial atom in an open transmission line. When a weak coherent state is on resonance with the atom, we observe extinction of up to 99% in the forward propagating field We also study the statistics of the reflected radiation, and we demonstrate photon antibunching in the reflected signal by measuring the second-order correlation function. By applying a second control tone, we observe the Autler-Townes splitting and a giant cross-Kerr effect. Furthermore, we demonstrate fast operation of a single-photon router using the Autler-Townes splitting. In the second sets of experiment, we embed a transmon at a distance from the end (mirror) of a transmission line. By tuning the wavelength of the atom, we effectively change the normalized distance between atom and mirror, allowing us to effectively move the atom from a node to an antinode of the vacuum fluctuations. We probe the strength of vacuum fluctuations by measuring spontaneous emission rate of the atom.