Non-equilibrium physics of strongly correlated photons

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Motivated by the recent success of engineering strong light-matter interaction in various cavity/circuit QED architectures, there has been a surge of interest in realizing condensed matter-like systems with photonic systems. One of the most exciting questions in this emerging field is whether one can realize a superfluid-Mott insulator (SF-MI) transition of strongly correlated photons. The Jaynes-Cummings-Hubbard Model (JCHM) has been introduced to describe such a quantum phase transition of light in an array of coupled QED cavities, each containing a single photonic mode interacting with a two-level system.

However, most of the theoretical studies of the JCHM did not take into account the basic nature of photonic setups: drive and dissipation. Those explicitly break the U(1) symmetry of the system rendering a SF-MI phase transition impossible.

In this talk we discuss the coherently pumped JCHM including dissipation via spontaneous emission and cavity loss. At weak hopping, we find strong signatures of photon blockade and localization as observed in single-cavity systems. At strong hopping, the state of the driven dissipative array depends on its size. While photons in a dimer remain anti-bunched and localized even at large hopping strength's, a coherent state emerges in the infinite array, where photon blockade is completely destroyed and photons are delocalized across the array. Depending on the laser frequency, the crossover from localization to delocalization can either be smooth or occur abruptly through a tunneling-induced bistability, i.e., a novel first-order non-equilibrium phase transition.

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