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Non-equilibrium dynamics of coupled qubit-cavity arrays

The realization of effective photon-photon interactions in various cavity QED architectures has triggered an immense interest in using these light-matter systems for quantum computation and simulation. With unprecedented experimental control of single-cavity systems at hand, a key challenge today is the study of the interplay of strong correlations and collective behaviour in extended light-matter systems. Recent theoretical interest has been on a possible Mott insulator-superfluid transition of polaritons in a coupled-cavity array as described by the Jaynes-Cummings-Hubbard model (JCHM), where each cavity is strongly coupled to a two-level system and photons can hop between cavities. However, most of these studies did not take into account the basic nature of quantum optical setups: drive and dissipation.
In this talk we discuss the coherently pumped JCHM including dissipation via spontaneous emission and cavity loss. We compare exact numerical simulations of a dimer consisting of two coupled cavities with decoupling mean-field theory for an array in infinite dimensions. At weak hopping, we find strong signatures of photon blockade 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 even at infinite hopping strength's, a coherent state emerges in the infinite array, which can be described semi-classically. Pumping above the bottom of the polariton band, may cause tunneling induced bistabilities, which at large hopping strength can be understood in terms of an effective Dicke model. We show that this evolution can be seen in both, the pump frequency dependence of the coherent photon field as measured in heterodyne/homodyne detection as well as in resonance fluorescence spectra.

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