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Engineering non-equilibrium light-emitting states in plasmonic nanocavities via interplay of coherent and dissipative interactions[1]

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In quantum plasmonics, highly polarizable metal nanostructures supporting surface plasmon modes provide a source of strong enhancement in the photon local density of states. This has an effect similar to that of low-Q optical microcavities. Technological flexibility in design and fabrication of plasmonic cavities sets the stage for their applications as light emitting devices ranging from quantum-single-photon through coherent multi-photon sources. Provided strong coupling between the surface plasmons and quantum emitters (e.g., fluorescent dyes or semiconductor nanostructures) a low threshed coherent light emission can occur at room temperature from a state such Bose-Einstein condensate of exciton-plasmon-polaritons. Taking advantage of direct coherent and environment mediated dissipative interactions between the surface plasmons and quantum emitters, a reach phase diagram of non-equilibrium light-emitting states can be recovered. Using a driven-dissipative plasmonic Dicke model, we explore the non-equilibrium phase diagram with respect to these interactions. The analysis shows that the non-equilibrium superradiant and regular lasing states can be recovered in the dissipative coupling regime and a new anomalous lasing phase appears. Calculated photon emission spectra are demonstrated to carry distinct signatures of these phases. Furthermore, we employ numerical modelling of surface-plasmon response and plasmon interactions with semiconductor quantum dots in a metal nano-antenna and plasmonic lattices to demonstrate experimental feasibility of anomalous and regular lasing regimes.

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