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# TITLE: Blockade effects in dipolar exciton-polariton

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Polariton is a hybridized quantum state between photon and exciton (electron-hole bound pair) in a photo cavity embedded with a strong light-matter coupling material. The emergence of hybridized states may enhance the nonlinear optical response of the cavity due to the polariton's correlation effect coming from the Coulomb interaction and Pauli statistics of its exciton character. This correlation effect gives rise to photonic blockade in the cavity which has an important implication for quantum optics applications. As hybridized with an electrically polarized exciton, a dipolar exciton-polariton is formed which offers a stronger blockade effect owing to its strong dipole-dipole interaction of the excitonic part. Dipolar exciton-polariton has been realized in cuprous oxide, $Cu_2O$ [1,2], and two-dimensional materials. Here, we present the theoretical work in modeling the blockade effects of these systems. First, we discuss the observation of strong Kerr-like nonlinearity in the polaritonic device with $Cu_2O$ [1]. In this work, we study the blockade effects of the dipolar polariton, a hybridized state between photon and the *p*-wave Rydberg exciton (Fig. 1a). Intriguingly, we found that Rydberg blockade not only plays the dominant role, but it also leads to strong nonlinear optical response even though with a low-principle quantum number Rydberg states ($n \leq 7$). Next, we briefly discuss the blockade of dipolar polariton with a moiré lattice [3]. In contrast to $Cu_2O$, the dipole moment arises from the charge separation of an interlayer exciton. Depending on the moiré pattern, we find that the strong dipole-dipole interaction between exciton forms three different blockade regimes (Fig. 1b). Particularly, the unconventional fractured regime may explain the strong nonlinear response observed in the moiré polariton [4]. To conclude, the strong photonic blockade of dipolar polaritons may be a promising route to push the realization of the optical nonlinearity at the quantum limit.

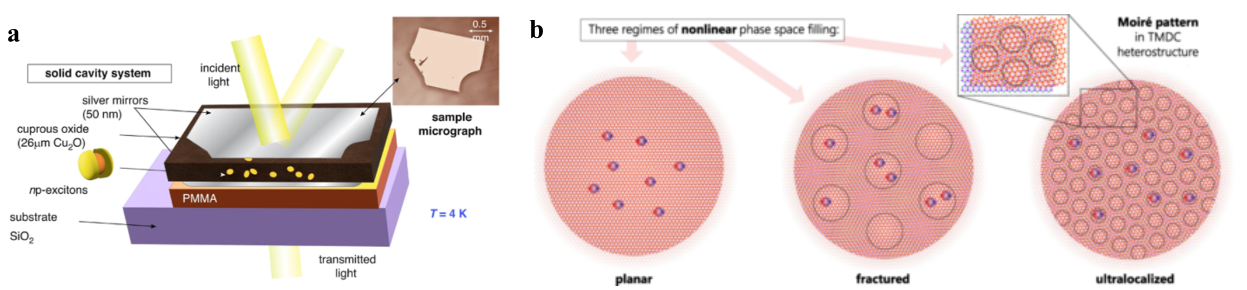


Fig. 1. (a) Schematic setup of the polaritonic device in Ref. [2]. (b) Three regimes of blockade effect in moiré lattice. In planar regime, it is a conventional Wannier-Mott exciton. In fractured regime, each moiré cell can host more than one localized interlayer exciton. The ultralocalized regime corresponds to Frenkel-type exciton where each cell can only occupy one exciton.

## References

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