Strong coupling in nanophotonics

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Electromagnetic resonances at visible and infrared frequencies can be strongly coupled to the excitations in a material, such as molecular excitons and vibrations, leading to the formation of new polaritonic states of matter that present novel characteristics and may allow to control the properties of the material [1,2].

We present the experimental and theoretical response of strongly-coupled micro and nanophotonic systems ranging from Fabry-Pérot microcavities to plasmonic nanoresonators that confine light to a gap of just a few nanometres. We use these systems to discuss effects such as the limitations imposed by electronic quenching on the coupling strength [3], or the different strong coupling signature that is observed in the inelastic molecular photoluminescence signal and in the elastic extinction spectra [4]. We show that the photoluminescence can be sensitive to the full dynamics of the system [5,6].

We also stress the potential of phonons in Van der Waals materials, e. g. hexagonal hBN, for strong coupling. These phonons can directly interact with electromagnetic modes (Figure 1) [7] or, in a different scheme, the localized phonon polaritons supported by hBN nanostructures can be strongly coupled with molecular vibrations [8,9]. The direct interaction with phonons notably allows for reaching the regime of ultrastrong coupling, where the coupling strength is comparable with the resonant frequencies and new phenomena appear, including the modification of the ground state [10]. We further discuss how the ultimate coupling strength is set only by the material, not by the electromagnetic resonance, and is given by the splitting present in the bulk polariton dispersion.

References

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Figures

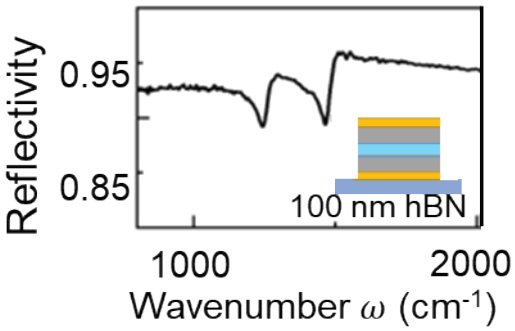

Figure 1: Example of strongly coupled system, consisting in a ~100nm hBN layer inserted in the centre of a Fabry-Pérot microcavity. The reflection dips in the spectra indicate the two polaritonic states.