Quantum optical phenomena in two-dimensional materials

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Atomically thin materials have emerged as a robust platform for manipulating and exploiting light at the nanoscale thanks to a wide variety of polaritonic modes, ranging from plasmons in thin metals and doped graphene to excitons in transition metal dichalcogenides and phonons in ionic insulators. The electromagnetic behavior of these modes can be well understood in terms of effective surface conductivities, which capture their strong dependence on temperature and external static electric and magnetic fields. Recent advances have also been produced in the synthesis of thin noble-metal films [1,2], which open a new regime of nanometallic plasmonics. In this talk, we overview the general characteristics of the optical response of these materials, which can be understood in terms of simple theoretical models. We also discuss more sophisticated models, aiming at the exploration of genuinely quantum-mechanical effects. We further review recent advances in the control of ultrafast and nonlinear optical processes [3,4], as well as potential applications in light modulation [5,6] and quantum-optics [7]. The in/out coupling problem between external light and strongly confined polaritons remains a major challenge, for which we propose innovative solutions [8,9]. We conclude with emerging directions in the design of polaritonic materials relying on quantum phase effects [10].

References

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