Applications of exciton-polaritons in hybrid light-matter coupled systems

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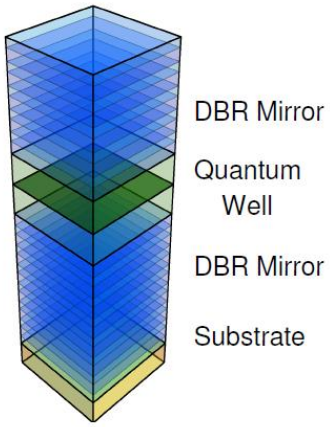
Exciton-Polaritons in semiconductor microcavities are hybrid states of light and matter exhibiting a mix of electronic and photonic properties [1], including: strong nonlinearity; low dephasing; ultrafast dynamics; sensitivity to electric and magnetic fields; and a rich spin dynamics. These properties have led to the study of a number of fundamental effects, namely: Bose-Einstein condensation, the optical spin Hall effect, bistability, and pattern formation.



The mixed properties of exciton-polaritons are also promising for the construction of a new generation of polaritonic devices. In this presentation I will review recent theoretical developments in this field and highlight future directions open for further research. In particular, I will focus on optical circuits, quantum light-sources and terahertz frequency sources.

Optical circuits require special attention to overcome dissipation and disorder in the system. A complete theoretical architecture of polaritonic circuits has been constructed based on a mechanism of bistability [2], while mechanisms of topological polaritons [3], immune to scattering with disorder, have been identified. Neural network architectures will also be discussed [4].

For quantum light-sources, such as single-photon sources, exciton-polaritons were for a long time considered unpromising due to their strong dissipation that exceeds nonlinear interaction strengths. However, an unconventional blockade mechanism based on quantum interference circumvents this problem in coupled mode systems [5]. Systems with nonlinear interactions between modes are predicted to allow for triggered single photon generation [6].

Finally, the efficiency of terahertz radiation generation will be considered in the framework of a bosonic cascade, where an optical photon generates multiple terahertz photons [7].

Figure: Schematic of a planar semiconductor microcavity. Optical modes are confined by distributed Bragg reflector mirrors, which enhances their coupling to quantum well excitons, resulting in new hybrid quasiparticles known as exciton-polaritons.

References

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