Plasmon-enhanced photoluminescence of spatially extended quantum emitters

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The spontaneous emission rate of a light source depends on its environment, in particular on the local photonic density of states. Quantum dots coupled to the optical cavities exhibit strongly enhanced photoluminescence opening a prospect of single photon sources [1]. Similarly, fluorescence of organic molecules can be enhanced by coupling to plasmonic antennas [2]. In both cases, the emitter can be treated as a point-like dipole source owing to its small dimensions in comparison with the dimensions of the optoelectronic element. In less frequently studied case of quantum dots coupled to plasmonic antennas [3], the dimensions of the emitter are comparable to the plasmon field decay lengths and the point-like representation of the emitter is no longer justified.

In our numerical study we discuss the plasmonicaly enhanced photoluminescence of quantum dots in view of finite size of the emitter. We consider two combinations of the dot/barrier material: InAs/GaAs with a spatially direct exciton and InAs/GaAsSb with an indirect exciton [4]. Excitonic wave functions are calculated with eight-band k.p theory with the strain and piezoelectric fields taken into account. The effect of spherical, disk-shaped, ring-shaped, and crescent-shaped gold antennas is simulated with boundary element method. The size, shape, and position of the antennas is optimized for a large emission enhancement. We show that although hindered by the finite size of the emitter, the plasmonic enhancement of the photoluminescence is still possible.

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