Quantum Optics of Nano-Structures

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Nano-structures, specially quantum dots (QDs), have been used as the sources of quantum light. QDs are low dimensional structures which permit a small number of charges to be isolated. In these nano-structures, the quantum confinement possesses an important role. Because of the quantum confinement, the QD possesses the energy states similar to the energy states of atomic system. In this way, these structures act similar the artificial atoms, with the emission wavelength of the radiation defined by a specific energy-level transition. QDs inherently emit a single photon at each excitation. The population of the QD energy levels can be controlled electrically or optically. This means that the QD can be used for on-demand production of photons. In addition, semiconductor QDs may be used as the source of polarized entangled photons. Moreover, semiconductor QDs are known as the source of non-classical light. In spite of the similarities between the QD resonances and atomic transitions, there are crucial differences between them. Phonon interaction and the many-body nature of the solid-state systems distinguish the QD-based system from their atomic counterparts. In the present contribution, we investigate the phonon effects on the quantum light emitted from the semiconductor QDs. A better understanding of phonon-induced effects (one of the sources of decoherence) leads to more insight into the fundamental physics of an all-solid-state source of light.

Moreover, in recent years, it is proposed that one can control and change the optical features of QDs in the context of hybrid systems through surface plasmons. The presence of conductor bodies in the vicinity of an emitter changes some optical properties of the emitter. Since semiconductor QDs are in contact with other devices, they will experience an open evolution. One way to improve the functionality of QDs, as the sources of quantum light, is their coupling to surface plasmons. In this lecture we will study the role of the surface plasmons in the process of quantum light emission from the QDs.