Currently, there is great interest in controlling the light emission statistics of nanostructured devices. Candidates suitable as quantum light emitters are semiconductor quantum dots (QDs), as they have atom-like emission characteristics. In contrast to the atom case, they also exhibit typical semiconductor emission properties, often characterized by strong electron phonon interactions, which result in additional emission features [1]. In many cases, it is preferable to eliminate those semiconductor effects as much as possible. In others, however, the additional many particle interactions can be of great advantage, when controlling the quantum emission of a QD.

The system is modeled on a microscopic level regarding the exciton-photon as well as the exciton-phonon interaction. Using an inductive equation of motion method [2], higher order correlations, in particular regarding the phonon system, are incorporated. Here, we focus on the quantum emission of a cavity-coupled semiconductor QD, where the additional electron-LO-phonon coupling introduces the possibility to control the photon statistics in the cavity [Fig. 1 (left)]. Using cavity deunings with respect to the QD transition and pumping the system incoherently, the phonon statistics can be changed in different ways. The interplay of pumping, exciton photon- and phonon interaction, does not only affect the light emission statistics but also the state of the phonon system. Figure 1 (right) shows the excitonic population, the photon number and the phonon number, for a blue detuned cavity mode $\omega_{\text{cav}} = \omega_{\text{QD}} + \omega_{\text{LO}}$. Due to the incoherent pump and an assumed cavity loss $\kappa$, the photon density gets only very little populated. This is due to the fact, that the electronic system is continuously pumped into the excited state. This makes the phonon absorption process, leading to an inverse cavity feeding [3], even more efficient. But, eventually there are no phonons left in the system, and the absorption process is no longer possible. That means no photons are emitted anymore and simultaneously, the phonon system has been cooled down noticeably [inset to Fig. 1b].

This external control of the photon statistics via incoherent pumping, taking advantage of the presence of LO-phonons could be useful for many applications, where either the photon- or the phonon states are to be modeled, i.e., nanodevices, information processing, phonon engineering etc.

References

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