Experimentelle Physik 2

Seminar Festkörperphysik (CMP Seminar)

Aktuelle Probleme der Festkörperphysik für Studenten und Mitarbeiter
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Feasibility of superradiance in quantum dot arrays

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Superradiance is the collective spontaneous emission of a system of many radiative dipoles [1]. Recently, behaviors characteristic for superradiance were reported for arrays of closely packed self-assembled colloidal lead halide perovskite quantum dots (QDs) [2,3]. The main obstacle which hinders formation of a superradiant state is the inhomogeneous broadening of the optical transitions implying variances of the resonant frequencies from one emitter to another. At first glance, in order to form a superradiant state, variances of the resonant frequencies for participating emitters should be within the radiative linewidth, which for exciton transitions in lead halide perovskite QDs is on the order of few micro-eV. However, along with the long-range interaction through the transverse electro-magnetic field, exciton radiative dipoles are subjects of short-range dipole-dipole interactions. We show that this interaction allows one to relax the strict resonant conditions for formation of the superradiant state. Yet, the dipole-dipole interaction between excitons in lead halide perovskite QDs is at least two orders of magnitude weaker than reported in literature [3] and, for closely packed QDs, amounts to a few tenths of a meV. We further show that the retardation effect inhibits superradiance and limits the number of emitters participating in the superradiant state. This number also depends on the configuration and dimensionality of the array.

[1] R.H. Dicke, Phys. Rev. **93**, 99 (1954).
[2] G. Raino et al., Nature **563**, 671 (2018).
[3] D.D. Blach et al., Nano Lett. **22**, 7811 (2022).