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Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Wubs, M., Jørgensen, M. A., Pandey, D., Leitherer-Stenger, N., & Xiao, S. (2023). *Modeling Collective Light Emission by a few Solid-State Quantum Emitters*. Abstract from 2023 International workshop on Nonlinear Optics and Plasmonics, Lecce, Italy.

Modeling Collective Light Emission by a few Solid-State Quantum Emitters

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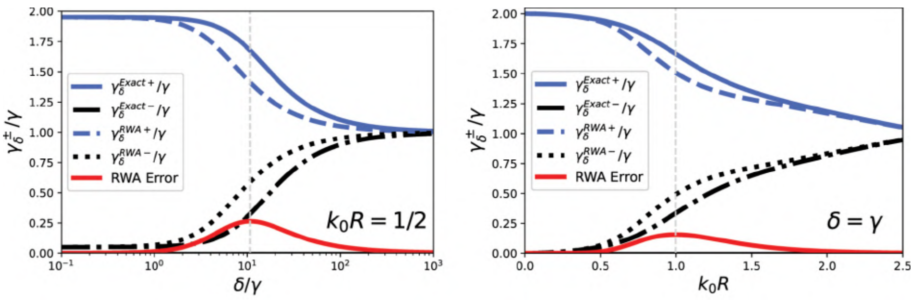
We present recent results on collective emission (superradiance and subradiance) by quantum emitters. The first part is about the effect of making the rotating-wave approximation. This is a very common approximation and already Dicke made it in his seminal work on superradiance [1]. While single-emitter spontaneous emission rates are the same whether the approximation is made, this does not hold for collective emission rates: for two identical emitters, the sub- and superradiance decay rate are still the same whether ones makes the approximation or not, but for two slightly detuned emitters or for three or more identical emitters, the collective rates that one finds will generally be different, and the difference can be considerable [2], as illustrated for the case of two detuned emitters in the Figure.



(a) (b)

Figure 1: The collective decay rates (in units of free-space decay rate γ) of two atoms in the RWA (dashed lines) as compared to full-interaction (solid lines) formalisms. The red curve is the difference of these scaled decay rates in both formalisms. (a) Detuning dependence of two-atom collective decay rates at a fixed distance with $k_0R = 1/2$. (b) Super- and subradiant decay rates at a finite frequency detuning $\delta = \gamma$, as a function of interatomic separation. In both panels, the maximal error due to making the RWA is indicated by a vertical dashed line. (Figure reproduced from Ref. [2]).

In the second part we present results on solid-state quantum emitters in photonic nanostructures. These emitters are open quantum systems in a double sense, as they typically couple both to the electromagnetic field and to phonons. In state of the art experiments it has become possible to engineer collective light emission despite the presence of phonons [3]. We present and compare two methods to calculate superradiant spectra that take both Markovian and non-Markovian effects of phonons into account [4].

References

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