Photon interaction via one-dimensional arrays of atoms coupled to waveguides

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As the interaction between photons in free space is completely negligible any applications of photon-interaction rely on indirect interaction via non-linear coupling to matter [1]. We present a concise analytical description of photons coupled to a one-dimensional array of two-level atoms in the two- or three-level configuration [2][3], see Fig. 1. The description incorporates input, scattering of the polaritons that emerge as a coupled state inside the medium, and the ejection of the photons from the array. We discuss the emergence of (in-)elastic scattering regulated by the level structure of the emitter, the degree of chirality of the coupling and the detuning of the photons. We show how the developed theory can be expanded to an effective field theory to study many-body dynamics [2]. Finally, we demonstrate that certain setups can function as a passive phase gate for photons with success probabilities and fidelities above 99 percent for a single digit number of emitters [3].

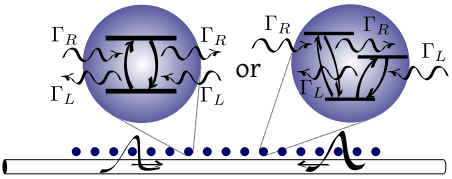

Fig. 1: We consider equidistant two level (or three level) systems that are (chirally) coupled to a one-dimensional waveguide. Photons absorbed and re-emitted scatter (in-)elastically with each other due to the non-linear nature of the system.

References

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