Harnessing quantum emitter rings for efficient energy transport and trapping

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Efficient transport and harvesting of excitation energy under low light conditions is an important process in nature and quantum technologies alike. Here we formulate a quantum optics perspective to excitation energy transport in configurations of two-level quantum emitters with a particular emphasis on efficiency and robustness against disorder. We study a periodic geometry of emitter rings with subwavelength spacing, where collective electronic states emerge due to near-field dipole-dipole interactions. The system gives rise to collective subradiant states that are particularly suited to excitation transport and are protected from energy disorder and radiative decoherence. Comparing ring geometries with other configurations shows that that the former are more efficient in absorbing, transporting, and trapping incident light. Because our findings are agnostic as to the specific choice of quantum emitters, they indicate general design principles for quantum technologies with superior photon transport properties and may elucidate potential mechanisms resulting in the highly efficient energy transport efficiencies in natural light-harvesting systems.

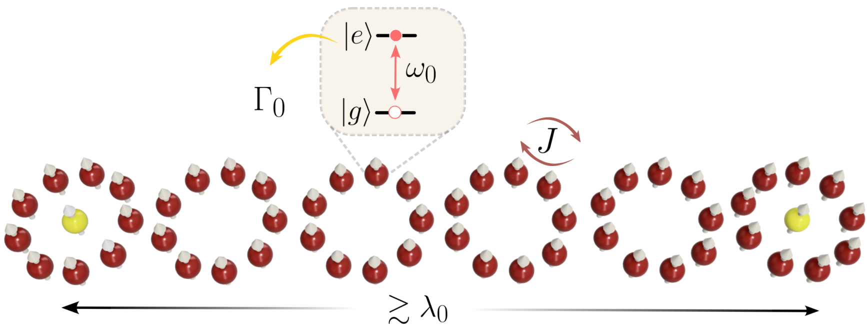

Fig. 1: Lattices of nanoscopic quantum emitter rings. Each ring is composed of two-level quantum emitters with resonance frequency ω_0 and separation $d < \lambda_0$, where $\lambda_0 = \omega_0/c$ is the wavelength of light.

References

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