

Superradiance, Chaos, and Thermalization in Atom-Photon Systems

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The Dicke model describes a system of N two-level atoms collectively coupled to a quantized field with a single bosonic mode. It provides a framework for understanding the phenomenon of superradiance in light-matter systems and is also a valuable tool for studying nonequilibrium dynamics.

The model has two classical degrees of freedom and exhibits both regular and chaotic dynamics, depending on the Hamiltonian parameters and the energy region under consideration. This framework makes it possible to explore the relationship between instability, classical chaos, and thermalization [1,2]. Chaos is dominant in the high energy region of the superradiant phase [4]. The presence of classically unstable periodic orbits is associated with quantum scarring, which constrains the delocalization of eigenstates and gives rise to dynamical revivals [3].

A striking contrast arises when atoms interact with photon pairs. In this case, there exists a critical coupling at which the energy spectrum collapses, and the superradiant phase survives only as a finite-size effect [4]. Moreover, chaotic behavior becomes particularly relevant at high energies in the normal phase [5].

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