Long-lived quantum coherences in a V-type system strongly driven by a thermal environment

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Abstract:

The three-level V-system is a prototype model of quantum coherent dynamics in multilevel systems, including photosynthetic light-harvesting complexes and photovoltaic devices. The symmetric V-system weakly driven by incoherent light undergoes coherent dynamics under certain conditions [1,2]. Here we explore the coherent dynamics of a three-level V-system interacting with a thermal bath in the limit where thermal excitation is fast compared to the spontaneous decay rate. The two-photon quantum coherences between the excited levels of the symmetric V-system show an oscillatory behavior in the underdamped regime (Δ/γ≈(n̄)) and reach a long-lived quasi-stationary state in the overdamped regime (Δ/γ<̄(n)) for the large photon occupation numbers (n̄≫1). The lifetime of the long-lived coherent state scales as τ_c~ n̄^(-2) for p_c, where p_c is a critical value of the transition dipole alignment factor (p_c = 1 - ε with ε > 0 over a wide range of excited-level splitting Δ and radiative decay rates γ). For p < p_c the lifetime of the coherences decreases sharply and becomes comparable to the radiative lifetime of the excited levels, in contrast with the situation in the weak pumping limit.

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