

OPEN QUANTUM SYSTEMS DRIVEN BY CHIRPED PULSE: QUANTIZED VS. SEMICLASSICAL FIELD & THE VALIDITY OF RWA

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Population transfer via chirped rapid adiabatic passage is studied using open quantum and semiclassical models, with and without the rotating-wave approximation. A time-dependent variational approach based on the multiple-Davydov D_2 trial state is employed to simulate the quantum models with an arbitrary finite mean photon number. We examine the accuracy of both the semiclassical field description and the rotating-wave approximation. Robust population transfer is identified over a wide parameter regime controlled by the laser spectral chirp and is found to be insensitive to the spin-phonon coupling strength, Gaussian pulse area, and energy gap of the two-level system.

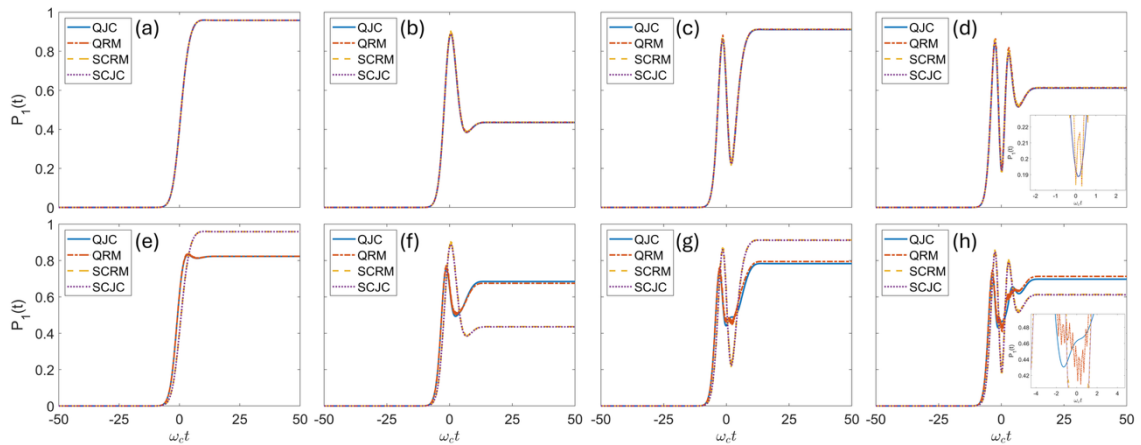


Figure 1. Time evolution of population transfer $P_1(t)$ of the quantum JC model (blue), quantum Rabi model (orange), semiclassical Rabi model (yellow) and semiclassical JC model (purple) with different initial mean photon number $|\alpha|^2$ for various pulse area: (a) $|\alpha|^2 = 10^4$, $\Theta = \pi$; (b) $|\alpha|^2 = 10^4$, $\Theta = 2\pi$; (c) $|\alpha|^2 = 10^4$, $\Theta = 3\pi$; (d) $|\alpha|^2 = 10^4$, $\Theta = 4\pi$; (e) $|\alpha|^2 = 1$, $\Theta = \pi$; (f) $|\alpha|^2 = 1$, $\Theta = 2\pi$; (g) $|\alpha|^2 = 1$, $\Theta = 3\pi$; and (h) $|\alpha|^2 = 1$, $\Theta = 4\pi$. The spin-phonon coupling A is set to be $0.22\omega_c^{-2}$, the spectral chirp $\varphi'' = -7\omega_c^2$ and the energy gap at resonant excitation ($\epsilon = \omega_0$) is set at $10\omega_c$.

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