Dynamics in nonlinear non-Hermitian systems

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Real physics systems often exhibit gain or loss due to the interactions with the environment, and their Hamiltonians are usually described by non-Hermitian matrices in quantum mechanics. One of the most important characteristics of non-Hermitian systems is the presence of exceptional points, which are singularities where multiple eigenvectors merge into one. In contrast to Hermitian physics, a linear non-Hermitian system could display non-adiabatic state transfer and chirality behaviors when moving near or around exceptional points [1]. Futhermore, recent research suggests that higher order exceptional points could be realized in nonlinear non-Hermitian systems [2,3]. In this study, we systematically investigate a non-Hermitian system consisting of two resonant modes with nonlinear gain, loss and coupling terms. We thoroughly solve for the stable steady state solution under different types of nonlinear effects. Based on these solutions, we conduct numerical simulations to study the dynamical properties along different parameter trajectories. We find that the non-adiabatic state transfer depends on the continuity of the stable steady state solution, and it could occur even when the trajectory of parameters does not enclose any nonlinear exceptional points.

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