The stationary states of a nonlinear coupler in a $\mathcal{PT}$ symmetric periodic potential

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A class of non-Hermitian Hamiltonians possess entirely real eigenvalue spectra provided they respect the parity-time symmetry as demonstrated by Bender et.al in 1998 [1]. A Hamiltonian is said to be $\mathcal{PT}$ symmetric, if the potential energy V(x) satisfies the condition $V(x) = V(-x)^*$. The complex nature of the dielectric permittivity and the refractive index paved the way to achieve experimentally the $\mathcal{PT}$ symmetry in optics [2]. These inventions motivated researchers to study the $\mathcal{PT}$ symmetric systems extensively in nonlinear optics, Bose-Einstein Condensates, plasma physics, meta-materials and atom interferometry. The $\mathcal{PT}$ symmetric couplers have potential applications in all-optical signal processing, beam splitters and optical switchers. These systems have been studied in various contexts such as ”Phase transition in multimode nonlinear parity-time-symmetric waveguide couplers” [3], ”Parity-time symmetric coupled systems with varying loss/gain coefficient” [4], ”Soliton beam dynamics in parity-time symmetric nonlinear coupler” [5], ”Optical solitons in $\mathcal{PT}$ symmetric nonlinear couplers with gain and loss” [6] etc. A coupler consists of two neihbouring channels very close to each other along the entire length. The coupler is said to be $\mathcal{PT}$ symmetric if the gain of one channel is balanced by the loss of the other.

In this work, we have analyzed a nonlinear coupler in a $\mathcal{PT}$ symmetric periodic potential with Kerr type nonlinearity. The stationary states of the system has been analysed. The propagation constants have real values in the $\mathcal{PT}$ symmetric regime and complex in the broken $\mathcal{PT}$ symmetric regime as it is evident from figure 1a and 1b. As the strength of the gain/loss term increases the imaginary part of the propagation constant also increases as plotted in figure 1c. We found that the coupling length and the gain/loss coefficient together determine the $\mathcal{PT}$ symmetric phase transition point. When the strength of the gain/loss term increases, the critical coupling length decreases as shown in figure 1d. The system possess harmonic solution in the $\mathcal{PT}$ symmetric regime.

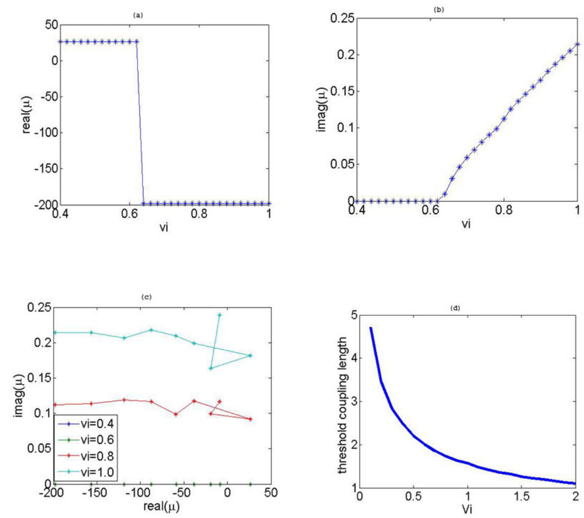

Figure 1: a) V_i versus Real(μ), b) V_i versus Imag(μ), c) Real(μ) versus Imag(μ) and d) V_i versus the coupling length.

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