Effect of Time-dependent Gain and Loss in a PT-Symmetric Optical Waveguide Array

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Quantum systems are typically treated as closed systems and hence described by hermitian Hamiltonian matrices. However, the discovery that a non-hermitian Hamiltonian can have real eigenvalues provided it is both parity (P) and time (T) symmetric has made it possible to study open systems with gain and loss. Such PT-symmetric Hamiltonians can then describe experimentally measurable quantities. Most work on PT-symmetry has been on time-independent Hamiltonians. In this research, I have investigated, analytically and numerically, the effect of periodic time-modulation of the potential term in the Hamiltonian to understand how PT-symmetric systems behave. For a wide range of periodic modulations, and for different tunneling terms, I find that time-modulation of the potential restores the PT-symmetric phase even when the parameters are such that the time-independent Hamiltonian would lead to PT-symmetry breaking. I also find conditions under which the PT-symmetry can be broken under time-modulation even though the PT-symmetry would be preserved for a time-independent Hamiltonian. I explore the origins of these behaviors through a study of the eigenvalues spectrum of the system and the behavior of the left and right eigenvectors. This research shows that even an infinitesimally small modulation frequency can break or restore PT-symmetry. The predictions of this work can be experimentally tested in an array of optically coupled waveguides in which only the nearest neighbor waveguides are coupled.

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