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Nonlinear and quantum effects in PT-symmetric optical structures

Andrey A. Sukhorukov^{1,*}, Sergey V. Suchkov^{1,2}, Diana A. Antonosyan¹, Alexander S. Solntsev¹, Igor V. Barashenkov³, Nora V. Alexeeva³, Sergey V. Dmitriev², and Yuri S. Kivshar¹

¹Nonlinear Physics Centre, Research School of Physics and Engineering, Australian National University, Canberra ACT 0200 Australia

²Institute for Metals Superplasticity Problems, Russian Academy of Science, Ufa 450001, Russia

³Department of Mathematics, University of Cape Town, Rondebosch 7701, South Africa

*corresponding author, E-mail: Andrey.Sukhorukov@anu.edu.au

Abstract

Recent interest to the study of parity-time (PT)- symmetric systems in physics stems from Bender's work [1], where it was shown that systems with non-Hermitian Hamiltonians can have an entirely real eigenvalue spectrum under parity-time symmetry constrain. The necessary condition for a Hamiltonian to be PT-symmetric is that its potential satisfies certain symmetry. In optics, a complex refractive index can play a role of that potential [2]. Thus, optical systems with regions of balanced gain and loss can have eigenmodes which conserve their power on average. Recently PT -symmetric structures have been realized experimentally [3].

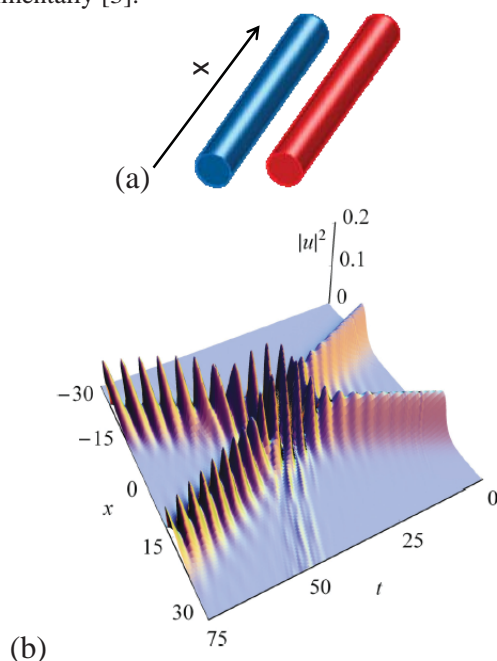


Figure 1: (a) Schematic representation of PT -symmetric coupled waveguides with gain (red, right) and loss (blue, left). (b) Example of soliton interaction leading to a breather formation.

In the present work we reveal novel regimes of

nonlinear wave interactions in a chain of optical PT -symmetric couplers with balanced gain and loss. The structure is governed by a system of discrete nonlinear Schrodinger equations with Kerr-type nonlinearity. We describe the interactions between different nonlinear modes: high-frequency and low-frequency solitons, soliton and breather, breather and breather [4]. We identify various scenarios of the interaction dynamics depending on model parameters and initial conditions.

We also study the beam propagation in an array of optical waveguides with an embedded defect created by a pair of waveguides with gain and loss, and find that the incident high-amplitude beam can excite the mode localized at the PT -symmetric defect [5]. By exciting the localized mode of a large amplitude, it is possible to perform phase-sensitive control of beam scattering and amplification or damping of the localized mode [6].

Additionally, we investigate the quantum process of photon generation through spontaneous nonlinear wave-mixing in coupled waveguides with loss. We identify the effect of losses on quantum walks, and the output correlations of the generated photons.

References

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