INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

One of the most fruitful strategies in optics research is to investigate the implications of concepts and mathematics used in seemingly very different fields of physics such as quantum field theory and high energy physics. One such recent concept widely explored in the context of optics is the so-called Parity-time (PT) symmetry. PT Symmetry can be realized in an optical system with judicious manipulation of optical loss and gain. In fact, this may result in achieving new classes of synthetic structures with altogether new physical behavior and novel functionality. PT-symmetry is no longer a theoretical concept only; it has been demonstrated experimentally numerous times in optical and other physical systems. This thesis work explores the idea of parity-time-symmetry in different types of optical structures and systems in the context of nonlinear optics. These include quadrimer waveguides, nonlinear Bragg structure, ring-resonator system, nonlocal Schrödinger system and negative-index metamaterials. Our studies on parity-time symmetric quadrimer waveguide explore the effects of the nonlinearity and the dispersions on the PT-phase transition of the system. In another nonlinear quadrimer configuration, with a different coupling scheme, we have addressed the issue of parity-time symmetry from attractor perspective. Next, we report analytical traveling solitary wave solutions for the forward and the backward waves in a nonlinear PT-symmetric Bragg grating structure. We predict the existence of bright solitary wave solution below the PT-threshold for forward wave and dark solitary wave solution above the PT-threshold for backward wave. In a definite parametric regime, the existence of optical rogue waves (ORWs) has been elucidated. In another work, in the recently discovered nonlocal nonlinear Schrödinger system with parity-time symmetric nonlinearity we have studied the Peregrine Soliton (PS) dynamics. Due to prototypical analogy between the Peregrine solitons and the rogue waves, we numerically confirm that an initial PS excitation could yield Peregrine rogue wave (PRW) in the broken PT-phase. In the single ring resonator system, we find that simple alterations in the parity-time (PT) symmetric synthetic coupler structures could result in a dynamically controllable algorithm for the chaotic dynamics inherent in the system. We have also shown the dependence of the period doubling point upon the input amplitude, emphasizing on the dynamical aspects. Finally, a theoretical study has been performed in order to explore the parity-time (PT)-symmetry in optical negative-index material with parametric amplifier settings. In this study we have exploited the notion of parity-time (PT)-symmetry in order to address the issue of optical loss. It has been found that the strength of the signal can be significantly enhanced if the system is operated beyond the PT-threshold point. It is shown that the aforementioned behavior is robust against small deviation from the exact phase-matching condition or the PT-symmetry.