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Entitled

SOLITON-BASED ALL-OPTICAL DATA PROCESSING

by

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Abstract

The growing demand for higher data processing speed and capacity motivates the replacement of the current electronic data processing by optical data processing in analogy with the successful replacement of electronic data communication by optical data communication. In a quest to achieve a comprehensive optical data processing we aim at using solitons in waveguide arrays to perform all-optical data processing operations. Solitons are special nonlinear waves appreciated for their ability to conserve their shape and velocity before and after scattering. They are observed naturally in diverse fields of science, namely, nonlinear physics, mathematics, hydrodynamics, biophysics, and quantum field theory etc. with potential applications in telecommunication systems, routers, switches, multiplexors, logic gates and computers.
The dissertation deals with solitons, and we target to design waveguide arrays that allow for useful data processing such as switching, routing, steering, logic gating, unidirectional flow, and ultimately computing. The dissertation is started by characterizing the discrete solitons dynamical behavior, including their interaction, and scattering off potentials, and then exploiting these properties to design the optical data processing devices. Theoretical method such as variational method, and numerical computation has been used to investigate the performance of the designed devices. Chapter 1 provides a brief overview about the topic and shows significance of the study. Chapter 2 is devoted to present a protocol for add binary numbers using discrete solitons in waveguide arrays where we show that the nonlinear interaction between discrete solitons in waveguide arrays can be exploited to design half and full adders. Chapter 3 deals with a protocol to achieve an essential feature of an optical transistor, namely the amplification of input signal with the use of discrete solitons in waveguide arrays. Chapter 4 studies a bound state of two discrete solitons in a two-dimensional waveguide array to investigate the effect of binding on the mobility of the two solitons. Chapter 5 deals with Skyrmion-like topological excitations for a two-dimensional spin-1/2 system mapped to a Manakov system. Chapter 6 is devoted to investigating the dynamics of two component bright-bright (BB) solitons through reflectionless double potential barrier and well in the framework of a Manakov system governed by the coupled nonlinear Schrödinger equations to achieve unidirectional flow. Chapter 7 provides a protocol for the quantum controlled-NOT gate which is based on two qubits operation by investigating the soliton scattering through a reflectionless potential well in an optical system. This protocol demonstrates the prospect of soliton scattering by a potential well for quantum information processing. Chapter 8 concludes the whole learned lessons and future directions of research.
We believe that this dissertation is an important contribution to the effort made towards the realization of optical devices in achieving the soliton based all-optical data processing.

Keywords: solitons, discrete solitons, optical solitons, waveguide arrays, all-optical data processing, all-optical devices.