Polychromatic discrete solitons in nonlinear photonic lattices

A.-A. Sukhorukov*, Kristian Motzek, Ivan L. Garanovich, Yuri S. Kivshar

Nonlinear Physics Centre and Centre for Ultra-high bandwidth Devices for Optical Systems (CUDOS), Research School of Physical Sciences and Engineering, Australian National University, Canberra ACT 0200, Australia
* Electronic Address: ans124@rsphysse.anu.edu.au

Propagation of optical beams and pulses in periodic photonic structures can demonstrate many of the key phenomena encountered in various physical systems with intrinsic discreteness [1, 2]. Fabricated waveguide arrays [3] and nonlinear photonic lattices [4] can support discrete solitons, which nontrivial localization and mobility properties have been a topic of intensive theoretical and experimental research. The fundamental properties of discrete solitons in different physical contexts are governed by an interplay of nonlinearity and wave coupling between the neighboring lattice sites. The unique feature of photonic structures is the possibility to continuously tune the linear coupling strength by varying the wavelength [5].

We reveal, for the first time to our knowledge, *novel physical effects associated with reshaping of polychromatic beams in discrete photonic lattices.* We show that the dispersion of coupling coefficient may result in *different dynamical regimes in the same lattice* with negative nonlinearity, where the beam can either become localized and form a *polychromatic discrete soliton* [6] or exhibit enhanced diffraction depending on the input frequency spectrum. Such highly nontrivial dynamics of polychromatic light beams has no analogues in the physics of white-light solitons in bulk media or lattices with positive nonlinear response [7]. We also predict the formation of novel *polychromatic discrete surface solitons*, which localization is defined through a nontrivial interplay of wave transport effects in adjacent lattices.

We also demonstrate that the effective coupling strength can be engineered in a broad frequency range by introducing special longitudinal modulation of coupled waveguides. In particular, we predict the existence of *white-color discrete breathers that remain localized even in the linear regime* despite a nontrivial dynamics inside the periodic photonic structure. We also demonstrate wavelength-selective control of normal and anomalous diffraction creating new opportunities for manipulation of white-light beams in nonlinear lattices. These effects may find applications for shaping and switching of beams with supercontinuum spectra generated in photonic-crystal fibers.

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