Chirped optical solitons in fiber Bragg gratings with dispersive reflectivity

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Abstract. The present work investigates the chirped optical solitons in a medium of fiber Bragg gratings (BGs) with dispersive reflectivity. BGs is considered here with polynomial law of nonlinear refractive index. The model of coupled nonlinear Schrödinger equations is analyzed and reduced to an integrable form under specific conditions. The results are obtained with the aid of soliton ansatz technique. Different structures of wave solutions including W-shaped, bright, dark, kink and anti-kink solitons are retrieved and their behaviors are presented so as to enhance the applications of fiber BGs.

Introduction

The data transmission through optical fiber for intercontinental distances is based on soliton propagation that arises due to delicate balance between chromatic dispersion (CD) and fiber nonlinearity. However, the CD may have low count that leads to limit the transmission distances. Thus, Bragg gratings (BGs) is found to be one of the effective techniques to tackle this problem by introducing induced dispersion to compensate for low CD and subsequently ensure the existence of soliton transmission. In literatures, many studies have been carried out using the technology of fiber BGs to investigate chirped and chirp-free optical solitons with different forms of nonlinearity, see [1–4]. The current study mainly discusses the dimensionless form of the coupled nonlinear Schrödinger equations in fiber BGs having polynomial law of nonlinearity given by [4]

$$\begin{aligned} &iq_t + a_1 r_{xx} + (b_1|q|^2 + c_1|r|^2)q + (d_1|q|^4 + f_1|q|^2|r|^2 + g_1|r|^4)q \\ &+(l_1|q|^6 + m_1|q|^4|r|^2 + n_1|q|^2|r|^4 + p_1|r|^6)q + ih_1 q_x + k_1 r = 0, \end{aligned} \tag{1}$$

$$\begin{aligned} &ir_t + a_2 q_{xx} + (b_2|r|^2 + c_2|q|^2)r + (d_2|r|^4 + f_2|r|^2|q|^2 + g_2|q|^4)r \\ &+(l_2|r|^6 + m_2|r|^4|q|^2 + n_2|r|^2|q|^4 + p_2|q|^6)r + ih_2 r_x + k_2 q = 0, \end{aligned} \tag{2}$$

where the functions $q(x,t)$ and $r(x,t)$ stand for forward and backward propagating waves, respectively, whereas a_j for $j = 1, 2$ represent the coefficients of dispersive reflectivity. In the coupled equations above, b_j indicate the coefficients of self-phase modulation (SPM) and c_j denote the cross-phase modulation (XPM) for cubic nonlinearity portion. For quintic nonlinear part, d_1 are the coefficients of SPM while f_j and g_j are the coefficients of XPM. Regarding septic nonlinearity, l_j are the coefficients of SPM while m_j, n_j and p_j are the coefficients of XPM. Finally, h_j accounts for inter-modal dispersion and k_j define detuning parameters. All of the coefficients are real valued constants and $i = \sqrt{-1}$.

The objective of the present study is to investigate chirped optical solitons in fiber BGs. The system of equations (1) and (2) is handled with the help of traveling wave transformation and then some specific conditions are assumed to ensure an integrable form for the coupled system. The generated traveling wave reduction is effectively solved by means of soliton ansatz method which yields various forms of chirped optical solitons.

Results and discussion

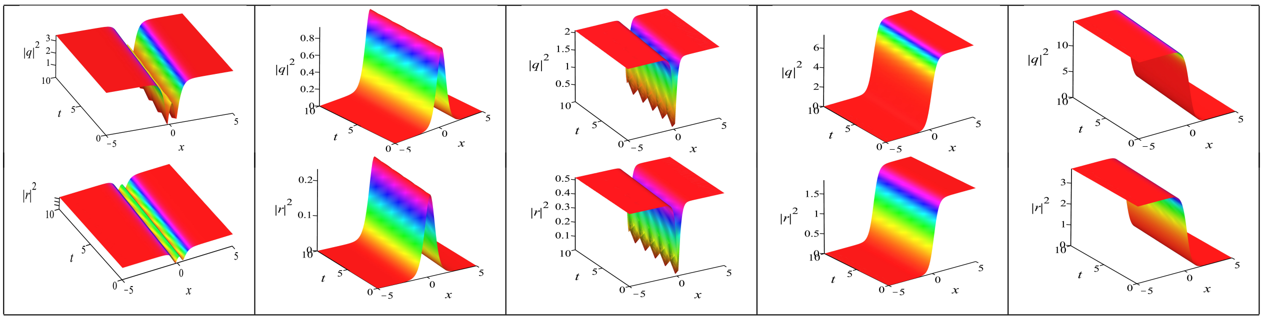

Figure 1: The profile of W-shaped, bright, dark, kink and anti-kink solitons.

The derived wave solutions for the model of the coupled NLSE (1) and (2) discribe distinct chirped solitons having nonlinear phase functions in terms of the reciprocal of amplitude function which are entirely different from the previous studies in the literature. The obtained optical solitons include several forms such as W-shaped, bright, dark, kink and anti-kink solitons. These new results obtained here are expected to contribute in improving the experimental studies and engineering applications related to fiber BGs.

References

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