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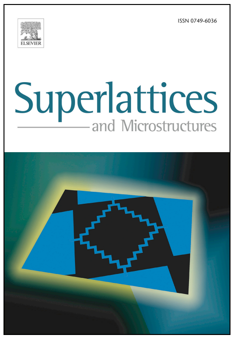

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Ebru Cavlak Aslan, Fairouz Tchier, Mustafa Inc

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On optical solitons of the Schrödinger-Hirota equation with power law nonlinearity in optical fibers

[1]Ebru Cavlak Aslan, [2]Fairouz Tchier, [1]Mustafa Inc
[1]Fırat University, Science Faculty, Department of Mathematics, 23119 Elazığ/Türkiye
[2]Department of Mathematics, King Saud University, P.O. Box 22452, Riyadh 11495, Saudi Arabia
ebrucavlak@hotmail.com, ftchier@ksu.edu.sa, minc@firat.edu.tr

In this study, we acquire optical soliton solutions of the Schrödinger-Hirota equation (SHE) in optical fiber. The integration algorithm employed in this work is the Jacobi elliptic function (JEF). We acquire new type JEF solutions, bright and dark optical solitons that are valuable in the field of optoelectronics. Constraint conditions are presented for the obtained solitons. The results show that this method is a powerful and efficient mathematical tool for solving problems in optical fibers. The remarkable features of such solitons are demonstrated by several interesting figures.

Keywords: *Soliton, JEF, Optical soliton, SHE*

1. Introduction

Solitons are the solutions of nonlinear dispersive partial differential equations defined by phsical systems. The soliton in nonlinear optic has begun to attract attetion in recent years. Optical soliton structure is an important subject in many fields of physics as optics, plasma and fluids. The dynamics of the optical solitons is the described with nonlinear Schrödinger equation (NLSE). The NLSE has many solutions such as bright, dark soliton and so on [1-19]. In this work, we consider the Schrödinger-Hirota equation (SHE) that are governs of dispersive optical solitons and the governing equation is studied with Jacobi elliptic functions. We have also given figures that drawn by optical soliton solutions.

2. Mathematical Analysis

The NSHE is given by

$$iq_t + \frac{1}{2}q + |q|^2 q + i\lambda q_{xxx} = 0. \tag{1}$$

In this paper, the SHE with power-law nonlinearity is given by [20]

$$iq_t + aq_{xx} + b|q|^{2n}q + ic(q_{xxx} + d|q|^{2n}q_x) = 0. \tag{2}$$

where, a, b, c and d are all real valued constants and $q(x,t)$ is the wave profile. Also, the exponent n represents the power law nonlinearity parameter as

$$0 < n < 2. \tag{3}$$

The starting hypothesis is given by [2]

$$q(\mathrm{x,t}) = \mathbb{P}(x,t)e^{i\phi}. \tag{4}$$

We have

$$\phi(x,t) = -kx + wt + \theta \tag{5}$$

where k and w are frequency and wave number of soliton, respectively and θ is the phase constant [1].

If we substitute (4) into (2) and equating the real and imaginary part, we get

$$-w\mathbb{P} + a\frac{\partial^2\mathbb{P}}{\partial x^2} - ak^2\mathbb{P} + b\mathbb{P}^{2n+1} + 3ck\frac{\partial^2\mathbb{P}}{\partial x^2} - k^3c\mathbb{P} + cdk\mathbb{P}^{2n+1} = 0 \tag{6}$$

and

$$\frac{\partial\mathbb{P}}{\partial t} - 2ka\frac{\partial\mathbb{P}}{\partial x} + c\frac{\partial^3\mathbb{P}}{\partial x^3} - 3ck^2\frac{\partial^2\mathbb{P}}{\partial x^2} + cd\mathbb{P}^{2n}\frac{\partial\mathbb{P}}{\partial x} = 0 \tag{7}$$

respectively.

In Eqs. (6) and (7), $\mathbb{P}(x,t)$ will be investigated in two cases of Power law nonlinearities.

Case 1 (Dark Soliton)

The form of the dark soliton solution is given as:

$$\mathbb{P}(x,t) = Asn^{\mathbb{P}}(\zeta, l) \tag{8}$$

with

$$\zeta = B(x - vt)\ . \tag{9}$$

In Eqs. (8) and (9), A and B are the amplitude and the inverse width of soliton, respectively. l is the modulus of the Jacobi elliptic function. If we substitute (8) into (3), we obtain