Optical Soliton Solutions to Gerdjikov-Ivanov Equation Without Four-Wave Mixing Terms in Birefringent Fibers by Extended Trial Function Scheme

Emad E. M. Mikael¹, Abdulmalik.A.Altwaty² and Bader R. K. Masry*¹

¹Department of Mathematics, Faculty of Science, University of Tobruk, Tobruk, Libya
²Department of Mathematics, Faculty of Science, University of Benghazi, AL KUFRA, Libya

Received: 21 January 2021/ Accepted: 31 January 2021
© Al-Mukhtar Journal of Sciences 2021
Doi: https://doi.org/10.54172/mjsc.v36i1.23

Abstract: Without four-wave mixing terms in birefringent fibers, the extended trial function scheme was used to obtain optical soliton solutions for the coupled system corresponding to the Gerdjikov-Ivanov equation. The procedure reveals singular soliton solutions, bright soliton solutions, and highly important solutions in terms of Jacobi’s elliptic function. And in the limiting case of the modulus of ellipticity, singular and singular-periodic soliton solutions, along with their respective existence criteria.

Keywords: Birefringent Fibers, The Coupled Gerdjikov-Ivanov Model Without Four-Wave Mixing Terms, Extended Trial Function Scheme, Optical Solutions.

INTRODUCTION

The Gerdjikov-Ivanov (GI) model without four-wave mixing terms (FWM) is one of the varieties of models that study the dynamics of optical soliton propagation for transmission technology, the transcontinental and transoceanic distances, optical fibers, data transmission, and the telecommunications industry. This model has been studied for polarization-preserving fibers along with strategic algorithms such as modified simple equation scheme, the csch method, the extended tanh – coth method, $\frac{g'}{g^2}$-expansion method, sine-cosine method, trial, and the extended trial equation method, trial equation integration architecture, extended Kudryashov’s method, and the exp$(-(\phi))$-expansion method (Arshed, 2018; Arshed et al., 2018; Biswas, Ekici, Sonmezoglu, Majid, et al., 2018; Biswas, Ekici, Sonmezoglu, Triki, et al., 2018; Biswas, Yildirim, Yasar, Triki, et al., 2018a, 2018b; Biswas, Yıldırım, et al., 2018; Ekici et al.,2017; Jawad et al.,2018; Kadkhoda, N.; Jafari, 2016; Yildirim, 2019d, 2019a, 2019b, 2019c) and the extended simplest equation method (Hassan & Altwaty, 2020). Although there are many advancements, the solitons were taken into account only along one model component. The extended trial function scheme has been applied to the coupled GI model without FWM given in two-component forms in birefringent fibers which gives rise to improving the model further. The strategy of the method reveals singular and bright soliton solutions. Furthermore, highly important solutions in terms of Jacobi’s elliptic function, and in the limiting case of the modulus of ellipticity, singular and singular-periodic soliton solutions have been gained and listed with their respective existence criteria.

GOVERNING MODEL

The (GI) equation (Arshed, 2018; Arshed et al., 2018; Biswas, Ekici, Sonmezoglu, Majid, et al., 2018; Biswas, Ekici, Sonmezoglu, Triki, et al., 2018; Biswas, Yildirim, Yasar, Triki, et al., 2018a, 2018b; Biswas, Yıldırım, et al., 2018; Ekici et al.,2017; Jawad et al.,2018; Kadkhoda, N.; Jafari, 2016; Yildirim, 2019d, 2019a, 2019b, 2019c) and the extended simplest equation method (Hassan & Altwaty, 2020). Although there are many advancements, the solitons were taken into account only along one model component. The extended trial function scheme has been applied to the coupled GI model without FWM given in two-component forms in birefringent fibers which gives rise to improving the model further. The strategy of the method reveals singular and bright soliton solutions. Furthermore, highly important solutions in terms of Jacobi’s elliptic function, and in the limiting case of the modulus of ellipticity, singular and singular-periodic soliton solutions have been gained and listed with their respective existence criteria.
Jawad et al., 2018; Yildirim, 2019d, 2019b, 2019c) is represented as

\( i \psi_t + a \psi_{xx} + b |\psi|^4 \psi + ic |\psi|^2 \psi_xt = 0 \) (1)

The first term is referred to as the temporal evolution of pulses when the existence of group velocity dispersion is supplied by the coefficient of \( a \) in this quite important governing model. The complex-valued function \( \psi(x, t) \) is referred to as the wave profile. The coefficient of \( b \) is named as the nonlinear term that signifies quintic nonlinearity. Once and for all the existence of a form of dispersive phenomenon is ensured with the coefficient of \( c \).

The GI model without FWM in birefringent fibers (Yildirim, 2019) is described by

\( i \psi_t + a_1 \psi_{xx} + (b_1 |\psi|^4 + c_1 |\psi|^2 |\phi|^2 + d_1 |\phi|^4) \psi + ic_1 |\psi|^2 \psi_xt + i(\beta_1 \psi^2 + \gamma_1 \phi^2) \phi_xt = 0, \)

\( i \phi_t + a_2 \phi_{xx} + (b_2 |\phi|^4 + c_2 |\phi|^2 |\psi|^2 + d_2 |\psi|^4) \phi + ic_2 |\phi|^2 \phi_xt + i(\beta_2 \phi^2 + \gamma_2 \psi^2) \psi_xt = 0. \) (2)

The coefficients of \( a_j \) correspond to group velocity dispersion when the coefficients of \( b_j \) stem from self-phase modulation in this coupled GI system. Once and for all, the coefficients of \( c_j \) as well as \( d_j \) correspond to cross-phase modulation, whilst the coefficients of \( \beta_j, \gamma_j \) account for other forms of dispersive phenomenon along with \( j = 1,2. \)

**MATHEMATICAL PRELIMINARIES**

The starting hypothesis for solving the considered coupled system is given by

\( \psi(x, t) = w_j(\xi(x,t)) e^{i\theta_j(x,t)}, \)

\( \phi(x,t) = w_j(\zeta(x,t)) e^{i\theta_j(x,t)}, \)

where \( w_j \) represent the amplitude component of the soliton and \( \theta_j \) for \( j = 1,2 \) is the phase component of the soliton that is described as

\( \xi(x,t) = k_3 x - vt, \)

\( \zeta(x,t) = -k_2 x + \mu t + k_3. \)

Here, \( v \) is the velocity of the soliton, \( k_3 \) is the frequency of the solitons in each of the two components while \( w \) is the soliton wave number and \( k_3 \) is the phase constant. By putting (4) and (5) into (2) we get:

\( -(a + a_1 k_3^2) w_j + a_1 k_3^2 w_j'' + b_1 w_j^4 + c_1 w_j^2 w_j'' + d_1 w_j^2 - k_2 \beta_1 w_j^3 - k_2 \gamma_1 w_j^2 w_j + i(-v - 2a_1 k_3 k_2 + k_3 \beta_1 w_j^2 + k_3 \gamma_1 w_j^2) w_j = 0, \)

\( -(a + a_2 k_3^2) w_j + a_2 k_3^2 w_j'' + b_2 w_j^2 + c_2 w_j^3 w_j'' + d_2 w_j^3 - k_2 \beta_2 w_j^3 - k_2 \gamma_2 w_j^2 w_j + i(-v - 2a_2 k_3 k_2 + k_3 \beta_2 w_j^2 + k_3 \gamma_2 w_j^2) w_j = 0. \) (7)

Equation (7) and (8) can be gathered as

\( -(a + a_1 k_3^2) w_j + a_1 k_3^2 w_j'' + b_1 w_j^4 + c_1 w_j^2 w_j'' + d_1 w_j^2 - k_2 \beta_1 w_j^3 - k_2 \gamma_1 w_j^2 w_j + i(-v - 2a_1 k_3 k_2 + k_3 \beta_1 w_j^2 + k_3 \gamma_1 w_j^2) w_j = 0, \)

\( -(a + a_2 k_3^2) w_j + a_2 k_3^2 w_j'' + b_2 w_j^2 + c_2 w_j^3 w_j'' + d_2 w_j^3 - k_2 \beta_2 w_j^3 - k_2 \gamma_2 w_j^2 w_j + i(-v - 2a_2 k_3 k_2 + k_3 \beta_2 w_j^2 + k_3 \gamma_2 w_j^2) w_j = 0. \) (8)

Equation (7) and (8) can be gathered as

\( -(a + a_1 k_3^2) w_j + a_1 k_3^2 w_j'' + b_1 w_j^4 + c_1 w_j^2 w_j'' + d_1 w_j^2 - k_2 \beta_1 w_j^3 - k_2 \gamma_1 w_j^2 w_j + i(-v - 2a_1 k_3 k_2 + k_3 \beta_1 w_j^2 + k_3 \gamma_1 w_j^2) w_j = 0, \)

\( -(a + a_2 k_3^2) w_j + a_2 k_3^2 w_j'' + b_2 w_j^2 + c_2 w_j^3 w_j'' + d_2 w_j^3 - k_2 \beta_2 w_j^3 - k_2 \gamma_2 w_j^2 w_j + i(-v - 2a_2 k_3 k_2 + k_3 \beta_2 w_j^2 + k_3 \gamma_2 w_j^2) w_j = 0. \) (9)

Equation (12) presents the velocity of the soliton solution, balancing \( w'' \) with \( w^5 \) in equation (11) gives \( N = \frac{1}{2}, \)

since \( N \) is not real, we set \( w_j = \sqrt{\theta_j} \).

Substituting into (11) and multiplying by \( 4\phi_j \sqrt{\theta_j} \) we get

\( a_{1,j} \theta_j^2 + a_{2,j} \theta_j \phi_j + a_{3,j} \phi_j^4 + a_{4,j} \phi_j^6 = 0, \)

(13)

where \( a_{1,j} = -4(a + a_1 k_3^2), a_{2,j} = 2a_1 k_3^2, a_{3,j} = -a_1 k_3^2, a_{4,j} = 4(b_j + c_j + d_j), a_{5,j} = -4k_2(\beta_j + \gamma_j). \)

Balancing \( \phi_j^6 \) with \( \phi_j^4 \) gives \( N = 1 \)

**EXTENDED TRIAL EQUATION SCHEME**

The traveling wave solution with extended trial function scheme is:

\( \phi_j = \sum_{u=0}^{\infty} A_{j,u} u^u, \quad j = 1,2, \) (14)

where

© 2021 Bader R. K. Masry et al. This open access article is distributed under a Creative Commons Attribution (CC-BY) 3.0 license.
ISSN: online 2617-2186 print 2617-2178

68
(\(u'\))^2 = \(\Gamma(u) = \frac{\partial \psi}{\partial u} = \sum_{i=0}^{\infty} A_i u^i\) \(\frac{\partial \psi}{\partial u}\) (15)

where \(\lambda_1, \chi_1, A_{i,j}\) are constants and \(\lambda_\tau, \chi_\rho\), \(A_{i,j}\) are non-zero. Equation (15) can be formulated as

\[
\pm (\zeta - \zeta_0) = \int \frac{du}{\sqrt{\psi(u)}} = \int \frac{\psi(u)}{\sqrt{\psi(u)}} du,
\]

(16)

The balancing principle applied to (13) implies

\[
\tau = \rho + 2N + 2,
\]

(17)

Since \(N = 1\) and setting \(\rho = 0\), we get \(\tau = 4\) consequently, from (14) we have

\[
\varphi_j = A_{0,j} + A_{1,j} u,
\]

(18)

\[
(\varphi_j')^2 = \frac{(A_{1,j})^2}{\epsilon} \sum_{i=0}^{\infty} A_i u^i
\]

(19)

\[
\varphi_j' = \frac{(A_{1,j})^2}{\epsilon} \sum_{i=0}^{\infty} A_i u^{-1}
\]

(20)

Substituting Eqs. (18) – (20) into Eq. (13), we obtain a system of algebraic equations. Solving the system, we get

\[
\lambda_4 \neq 0 \text{ and } \chi_0 \neq 0.
\]

Substituting into (15) and (16), we get

\[
\pm (\zeta - \zeta_0) = Q \int \frac{du}{\sqrt{\psi(u)}},
\]

(21)

where \(Q = \frac{\sqrt{\xi_0}}{\lambda_4}, \Gamma(u) = \sum_{i=0}^{\infty} \frac{A_i}{\lambda_4} u^i\)

Therefore the traveling wave solutions to Eq.(2) are

When \(\Gamma(u) = (u - \vartheta_1)^4\)

\[
\psi(x,t) = \sqrt{A_{0,1} + A_{1,1} \vartheta_1 \pm \frac{A_{1,1} Q}{k_\chi x - 2a_k k_\chi t - \zeta_0}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(22)

\[
\phi(x,t) = \sqrt{A_{0,2} + A_{1,2} \vartheta_1 \pm \frac{A_{1,2} Q}{k_\chi x - 2a_k k_\chi t - \zeta_0}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(23)

When \(\Gamma(u) = (u - \vartheta_1)^2(u - \vartheta_2), \text{ and } \vartheta_2 > \vartheta_1\)

\[
\psi(x,t) = \sqrt{A_{0,1} + A_{1,1} \vartheta_1 \pm \frac{A_{1,1} Q^2(\vartheta_1 - \vartheta_2)}{4Q^2 - ([\vartheta_1 - \vartheta_2](k_\chi x - 2a_k k_\chi t - \zeta_0))^2}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(24)

\[
\phi(x,t) = \sqrt{A_{0,2} + A_{1,2} \vartheta_1 \pm \frac{A_{1,2} Q^2(\vartheta_1 - \vartheta_2)}{4Q^2 - ([\vartheta_1 - \vartheta_2](k_\chi x - 2a_k k_\chi t - \zeta_0))^2}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(25)

When \((u - \vartheta_1)^2(u - \vartheta_2)^2\)

\[
\psi(x,t) = \sqrt{A_{0,1} + A_{1,1} \vartheta_1 + \frac{(-1)^{L+1}A_{1,1}(\vartheta_1 - \vartheta_2)}{e^{(\vartheta_1 - \vartheta_2)(k_\chi x - 2a_k k_\chi t - \zeta_0)} - 1}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(26)

\[
\phi(x,t) = \sqrt{A_{0,2} + A_{1,2} \vartheta_1 + \frac{(-1)^{L+1}A_{1,2}(\vartheta_1 - \vartheta_2)}{e^{(\vartheta_1 - \vartheta_2)(k_\chi x - 2a_k k_\chi t - \zeta_0)} - 1}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(27)

where \(L = 1,2\). When \((u - \vartheta_1)^2(u - \vartheta_2)(u - \vartheta_3), \text{ and } \vartheta_1 > \vartheta_2 > \vartheta_3\)

\[
\psi(x,t) = \sqrt{A_{0,1} + A_{1,1} \vartheta_1 \pm \frac{2A_{1,1}(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)}{R_1}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(28)

\[
\phi(x,t) = \sqrt{A_{0,2} + A_{1,2} \vartheta_1 \pm \frac{2A_{1,2}(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)}{R_1}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(29)

Where \(R_1 = 2\vartheta_1 - \vartheta_2 - \vartheta_3 + (\vartheta_3 - \vartheta_2) \times \cosh \left(\frac{1}{Q} \sqrt{(k_\chi \vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)}(k_\chi x - 2a_k k_\chi t - \zeta_0)\right)\).

When \((u - \vartheta_1)(u - \vartheta_2)(u - \vartheta_3)(u - \vartheta_4), \text{ and } \vartheta_1 > \vartheta_2 > \vartheta_3 > \vartheta_4\)

\[
\psi(x,t) = \sqrt{A_{0,1} + A_{1,1} \vartheta_1 \pm \frac{2A_{1,1}(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)(\vartheta_1 - \vartheta_4)}{R_2}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(30)

\[
\phi(x,t) = \sqrt{A_{0,2} + A_{1,2} \vartheta_1 \pm \frac{2A_{1,2}(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)(\vartheta_1 - \vartheta_4)}{R_2}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(31)

Where

\[
R_2 = \vartheta_1 - \vartheta_2 - \vartheta_3 + (\vartheta_3 - \vartheta_2) \times \cosh \left(\frac{1}{Q} \sqrt{(k_\chi \vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)}(k_\chi x - 2a_k k_\chi t - \zeta_0)\right) m
\]

\[
\epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(32)

\[
\phi(x,t) = \sqrt{\frac{\vartheta_1 - \vartheta_2}{\vartheta_1 - \vartheta_3}(\vartheta_1 - \vartheta_4)(k_\chi x - 2a_k k_\chi t - \zeta_0) m}
\]

\[
\epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(33)

\[
\psi(x,t) = \sqrt{\frac{(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)(\vartheta_1 - \vartheta_4)}{(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(34)

\[
\phi(x,t) = \sqrt{\frac{(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)(\vartheta_1 - \vartheta_4)}{(\vartheta_1 - \vartheta_2)(\vartheta_1 - \vartheta_3)}} \times \epsilon^{i(-k_\chi x + \mu t + k_\chi k_\chi)}
\]

(35)

Note that \(\vartheta_1, \vartheta_4\) are the roots of \(\Gamma(u) = 0\) and \(\vartheta_2, \vartheta_3\) are the solutions (22) – (31) are reduced to the following plane wave solutions:

© 2021 Bader R. K. Masry et al. This open access article is distributed under a Creative Commons Attribution (CC-BY) 3.0 license.

ISSN: online 2617-2186 print 2617-2178

69
singular soliton solutions:

$$\psi(x,t) = \frac{A_{1j}(\theta_0-\theta_1)}{\sqrt{2}} \left(1 + \coth(x)\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (36)

$$\phi(x,t) = \frac{A_{1j}(\theta_0-\theta_1)}{\sqrt{2}} \left(1 + \coth(x)\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (37)

and bright soliton solutions:

$$\psi(x,t) = \frac{D}{\sqrt{2} \sqrt{c_2 \coth(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}} \times e^{i(-k_2 x + \mu t + k_3)},$$ (38)

$$\phi(x,t) = \frac{D}{\sqrt{2} \sqrt{c_2 \coth(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}} \times e^{i(-k_2 x + \mu t + k_3)},$$ (39)

where $D = \frac{2A_{1j}(\theta_1-\theta_2)(\theta_1-\theta_3)}{(\theta_1-\theta_2)}, B = \frac{\sqrt{(\theta_1-\theta_2)(\theta_2-\theta_3)}}{q}, C = \frac{2\theta_1-\theta_2-\theta_3}{\theta_1-\theta_2}, j = 1, 2$.

The amplitude of the soliton is given by $D$ where the inverse width of the soliton is given by $B$. The solitons will exist for $A_{1j} < 0$. Furthermore, when $A_{0j} = -A_{1j}$ and $\zeta_0 = 0$, Jacobi’s elliptic function solutions (30), (31) are written as:

$$\psi(x,t) = \left(\frac{D_1}{c_1 + m^2(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (40)

$$\phi(x,t) = \left(\frac{D_1}{c_1 + m^2(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (41)

where $D_1 = \sqrt{\frac{A_{1j}(\theta_1-\theta_2)(\theta_2-\theta_3)}{(\theta_1-\theta_2)}}, B_L = \frac{(-1)^j(\theta_1-\theta_2)(\theta_2-\theta_3)}{2q}, c_1 = \frac{2\theta_1-\theta_2}{\theta_1-\theta_2}, \text{ and } L = 1, 2$.

**Remark-1:** When the modulus $m \rightarrow 1$, the singular optical soliton solutions are obtained as:

$$\psi(x,t) = \left(\frac{D_1}{c_1 + \tanh^2(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (42)

$$\phi(x,t) = \left(\frac{D_1}{c_1 + \tanh^2(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (43)

where $\theta_3 = \theta_4$.

**Remark-2:** When the modulus $m \rightarrow 0$, the singular-periodic solutions are obtained as:

$$\psi(x,t) = \left(\frac{D_1}{c_1 + \sin^2(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (44)

$$\phi(x,t) = \left(\frac{D_1}{c_1 + \sin^2(\theta_1 x - 2a_1 k_1 k_2 t - \zeta_0)}\right) \times e^{i(-k_2 x + \mu t + k_3)},$$ (45)

where $\theta_1 = \theta_3$.

**REFERENCES**

Arshed, S. (2018). Two reliable techniques for the soliton solutions of perturbed Gerdjikov–Ivanov equation. *Optik, 164*, 93–99.

Arshed, S., Biswas, A., Abdelaty, M., Zhou, Q., Moshokoa, S. P., & Belic, M. (2018). Optical soliton perturbation for Gerdjikov–Ivanov equation via two analytical techniques. *Chinese Journal of Physics, 56*(6), 2879–2886.

Biswas, A., Ekici, M., Sonmezoglu, A., Majid, F. B., Triki, H., Zhou, Q., … Belic, M. (2018). Optical soliton perturbation for Gerdjikov–Ivanov equation by extended trial equation method. *Optik, 158*, 747–752.

Biswas, A., Ekici, M., Sonmezoglu, A., Triki, H., Alshomrani, A. S., Zhou, Q., … Belic, M. (2018a). Optical soliton perturbation with full nonlinearity for Gerdjikov–Ivanov model by extended trial equation scheme. *Optik, 157*, 1241–1248.

Biswas, A., Yıldırım, Y., Yasar, E., Triki, H., Alshomrani, A. S., Ullah, M. Z., … Belic, M. (2018). Optical soliton perturbation with full nonlinearity for
Gerdjikov–Ivanov equation by trial equation method. *Optik*, 157, 1214–1218.

Biswas, A., Yıldırım, Y., Yaşar, E., Triki, H., Alshomrani, A. S., Ullah, M. Z., … Belic, M. (2018b). Optical soliton perturbation with Gerdjikov–Ivanov equation by modified simple equation method. *Optik*, 157, 1235–1240.

Biswas, A., Yıldırım, Y., Yaşar, E., Zhou, Q., Alshomrani, A. S., Moshokoa, S. P., & Belic, M. (2018). Solitons for perturbed Gerdjikov–Ivanov equation in optical fibers and PCF by extended Kudryashov’s method. *Optical and Quantum Electronics*, 50(3), 149.

Ekici, M., Zhou, Q., Sonmezoglu, A., Moshokoa, S. P., Ullah, M. Z., Biswas, A., & Belic, M. (2017). Optical solitons with DWDM technology and four-wave mixing. *Superlattices and Microstructures*, 107, 254-266.

Hassan, S. M., & Altwaty, A. A. (2020). Optical solitons of the extended Gerdjikov-Ivanov equation in DWDM system by extended simplest equation method. *Applied Mathematics and Information Sciences* 14, No. 5, 901-907

Jawad, A. J. M., Biswas, A., Abdelaty, M., Zhou, Q., Moshokoa, S. P., & Belic, M. (2018). Chirped singular and combo optical solitons for Gerdjikov–Ivanov equation using three integration forms. *Optik*, 172, 144–149.

Kadkhoda, N., & Jafari, H. (2016). Kudryashov method for exact solutions of isothermal magnetostatic atmospheres. *Iranian Journal of Numerical Analysis and Optimization*, 6(1), 43-53.

Yıldırım, Y. (2019a). Bright, dark and singular optical solitons to Kundu–Eckhaus equation having four-wave mixing in the context of birefringent fibers by using of modified simple equation methodology. *Optik*, 182, 110–118.

Yıldırım, Y. (2019b). Optical solitons of Gerdjikov–Ivanov equation in birefringent fibers with modified simple equation scheme. *Optik*, 182, 424–432.

Yıldırım, Y. (2019c). Optical solitons of Gerdjikov–Ivanov equation with four-wave mixing terms in birefringent fibers by modified simple equation methodology. *Optik*, 182, 745–754.

Yıldırım, Y. (2019d). Optical solitons to Gerdjikov–Ivanov equation in birefringent fibers with trial equation integration architecture. *Optik*, 182, 349–355.
الحلول البصرية اللامتقربة زمنيا لمعادلة جيردجيكوف ايفانوف بدون تداخل رباعي الموجات في الآليات ثنائية الانكسار باستخدام طريقة الدالة التجريبية الممتدة

عماد اغنية مكالي، عبد المالك عبد الواني، وبدر رمضان مصري

قسم الرياضيات، كلية العلوم، جامعة طبرق، طبرق - ليبيا

قسم الرياضيات، كلية العلوم، جامعة بنغازي، الكفرة - ليبيا

تاريخ الاستلام: 21 يناير 2021 / تاريخ القبول: 31 يناير 2021

@ مجله المختار للعلوم 2021

Doi: https://doi.org/10.54172/mjsc.v36i1.23:Doi

المستخلص: بدون تداخل رباعي الموجات، طريقة الدالة التجريبية الممتدة استخدمت للحصول على حلول بصرية لا متغيرة زمنيا للنظام المزدوج المقابل لمعادلة جيردجيكوف ايفانوف. الإجراء يكشف حلول بصرية مفردة، حلول بصرية ساطعة، وحلول في غاية الأهمية في صيغة دالة جاكوبى الإهليلجية، وفي نهاية الدالة الإهليلجية تحصل على حلول بصرية مفردة، وحلول بصرية مفردة

دورية جنبا إلى جنب مع معايير وجودها.

الكلمات المفتاحية: ألياف ثنائية الانكسار، نموذج جيردجيكوف ايفانوف المزدوج بدون تداخل رباعي الموجات، طريقة الدالة التجريبية الممتدة، حلول بصرية.