# Unexpected configurations for the optical solitons propagation in lossy fiber system with dispersion terms effect

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## ABSTRACT

In this work, we will design unexpected configurations for the optical soliton propagation in lossy fiber system in presence the dispersion term solitons via two distinct and impressive techniques. The first one is the (G'/G)-expansion method, while the second is solitary wave ansatze method. The two methods are implemented in same vein and parallel. The obtained perceptions are new and weren't achieved before. The comparison between our achieved visions and that achieved by other authors who used different schemas has been documented.

**Keywords:** The lossy fiber system under dispersion terms influence**,** the (G'/G)-expansion method, the solitary wave ansatze method, the optical soliton solutions.

## 1-Introduction

The optical soliton propagation phenomenon is one of the famous optical fiber phenomenon that have impressive effect in telecommunication processes. There are many models are proposed to describe different kinds of propagation all are derived from the will known Schrödinger equation with its various forms. The famous one of these various form is the propagation of optical soliton in lossy fiber system in presence the dispersion term. The suggested model is famous one of the variable-coefficient nonlinear Schrödinger equation that describes the optical soliton propagation in dispersion management fiber systems. In the achieved solutions the coefficients of the third order dispersion term, the group velocity dispersion terms which achieved new improved results for the interference solitons as well as the other parameters whose effect on the nature of the optical soliton propagation have been exploring. It is important to upgrade this phenomenon to develop all visible and audio telecommunications means.

The propagation of light in optical fiber which is one of important phenomena's in telecommunication processes appearing for the first time in 1973 by [1]. This phenomena caused revolution in modern telecommunications process because when a light ray incident upon an optical fiber it will split into two rays or a lot which have slightly various paths under the polarization property. Recently, some studies have been established to discuss this phenomenon theoretically and experimentally via distinct published articles [2-22] through which the scientists have been shored that when the dispersion effect and nonlinear effect of the medium reach a stable equilibrium, the pulse can maintain its shape and velocity in the form of solitons during the transmission process [23-25]. The optical fiber transmission system is the ideal effective carriers one which possesses high rate, large channel capacity and no limitation of transmission distance, hence ensure the high quality to long-distance communications. The dispersion fiber management system by the variable coefficient NLSE [26] which surrender to the self-steepness effect, simulated Raman scattering, fiber loss, group velocity dispersion, and third-order dispersion.

We will extract the new configurations of the propagation of optical solitons in lossy fiber system for the first time using two distinct and impressive techniques. The first one is the (G'/G)-expansion method [27-30] which successes to design new impressive representations for the propagation optical soliton in lossy fiber system in presence the dispersion term solitons, while the second one is the famous solitary wave ansatze method [31-35] which successes to detect other new impressive representations to the optical soliton propagation in lossy fiber system. The two suggested techniques have been examined previously for many other nonlinear problems and achieved good results. The achieved solitons will help in improve amplifiers device, audio and optical telecommunications. We will demonstrate comparisons between our achieved results and that achieved previously by other authors who used different techniques to solve this system. According to [27] the suggested model can be written as,

$$u_x+\frac{i\beta_2(x)}{2}u_{tt}-i\gamma(x)u^2u+\frac{\alpha}{2}u-\frac{\beta_3(x)}{6}u_{ttt}-i\gamma_r\left|u^2\right|_t u+\gamma_s(\left|u^2\right|u)_t-\mu(x)u=0 \quad (1)$$

where $u=u(x,t)$ is a complex function measured small changes formal of the complex valued electric field at position x and time t in the fiber, while the coefficients $\beta_2(x),\gamma(x)$ and $\beta_3(x)$ are respectively denoted to group velocity , kerr-nonlinearity and third-order dispersion. Moreover, $\alpha,\mu(x)$ are denotes to loss and periodic amplification of the signal and $\gamma_r,\gamma_s$ are the coefficients of self-steepness and simulated Raman scattering.

To solve this model let us firstly assume

$$u(x,t)=V(\zeta)e^{i\varphi(x,t)},\zeta=x-pt,\varphi=q-kx+wt+\theta \quad (2)$$

Hence,

$$u_x=V'e^{i\varphi}-kVe^{i\varphi} \quad (3)$$

$$u_t=-pV'e^{i\varphi}+wVe^{i\varphi} \quad (4)$$

$$u_{tt}=p^2V''e^{i\varphi}-2pwV'e^{i\varphi}+w^2Ve^{i\varphi} \quad (5)$$

$$\left|u^2\right|=V^2 \quad (6)$$

Via inserting the relations (2-6) into Eq. (1) the following real and imaginary parts must be emerged

$$\mathrm{Re}\Rightarrow\frac{p^3\beta_3(x)}{6}V'''-\frac{\beta_3(x)}{6}(p^2w+2pw)V''+\left(1+\frac{w^2\beta_3(x)}{6}(p+w+2)\right)V'-3\gamma_s pV^2V'+\left(\frac{\alpha}{2}-k-\mu+w\gamma_s\right)V=0. \quad (7)$$

$$\mathrm{Im}\Rightarrow\frac{p^2\beta_2(x)}{2}V''-pw\beta_2(x)V'+\frac{w^2\beta_2(x)}{2}V-\gamma_sV^3+2p\gamma_rV^2V'=0. \quad (8)$$

## 2. Quick view -of the (G'/G)-expansion method

Any nonlinear evolution equation can be written in the form:

$$\psi(R,R_x,R_t,R_{xx},R_{tt},......)=0, \quad (9)$$

where $\psi$ is a function of R, its highest order partial derivatives and the nonlinear terms. When Eq. (9) surrenders to the transformation $R(x,t)=R(\zeta),\zeta=x-pt$ it will be converted to the following ODE:

$$S(V, V', V'', \ldots \qquad ) = 0, \tag{10}$$

where $S$ in terms of $V(\zeta)$ and total derivatives with respect to $\zeta$

The constructed solution according to this method is:

$$V(\zeta) = A_0 + \sum_{k=1}^{N} A_k \left[\frac{G'}{G}\right]^k, A_N \neq 0. \tag{11}$$

Where the positive integer $N$ in *E*q. (11) can be located by balancing the highest order derivative term and the nonlinear term, while $G(\zeta)$ satisfies the second order differential equation $G'' + \mu G' + \lambda G = 0$.

This equation admits three forms of solutions depending on the cases $\mu^2 - 4\lambda \succ 0$, $\mu^2 - 4\lambda \prec 0$ *and* $\mu^2 - 4\lambda = 0$

**Case 1:** When $\mu^2 - 4\lambda \succ 0$, the solution is;

$$\left(\frac{G'}{G}\right) = \frac{\sqrt{\mu^2 - 4\lambda}}{2}\left(\frac{l_1 \,\mathrm{Sinh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta + l_2 \,\mathrm{Cosh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta}{l_1 \,\mathrm{Cosh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta + l_2 \,\mathrm{Sinh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta}\right) - \frac{\mu}{2} \tag{12}$$

**Case 2:** When $\mu^2 - 4\lambda \prec 0$, the solution is;

$$\left(\frac{G'}{G}\right) = \frac{\sqrt{\mu^2 - 4\lambda}}{2}\left(\frac{-l_1 \,\mathrm{Sin}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta + l_2 \,\mathrm{Cos}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta}{l_1 \,\mathrm{Cos}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta + l_2 \,\mathrm{Sin}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta}\right) - \frac{\mu}{2} \tag{13}$$

**Case 3:** When $\mu^2 - 4\lambda = 0$, the solution is;

$$\left(\frac{G'}{G}\right) = \left(\frac{l_2}{l_1 + l_2\zeta}\right) - \frac{\mu}{2}. \tag{14}$$

Where $l_1, l_2$ are constants

Firstly, we will implement the $(\frac{G'}{G})$-expansion for the real part Eq. (7) which is

$$\frac{p^3\beta_3(x)}{6}V''' - \frac{\beta_3(x)}{6}(p^2w + 2pw)V'' + \left(1 + \frac{w^2\beta_3(x)}{6}(p + w + 2)\right)V' - 3\gamma_s pV^2V' + \left(\frac{\alpha}{2} - k - \mu + w\gamma_s\right)V = 0. \tag{15}$$

By balancing $V''', V^2V'$ in Eq. (15) leads to $N = 1$, hence the solution according to the suggested method is $V(\zeta) = A_0 + A_1(\frac{G'}{G})$

Via inserting $V(\zeta)$, its derivatives into Eq.(15),collecting and equating the coefficients of various powers of $(\frac{G'}{G})^k$ to zero we get a system of algebraic equations by solving it we obtain the following results

$$(1) A_0 = i\left(\frac{\sqrt{3\beta_3}(2+p)w - 3\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{18p\sqrt{\gamma_s}}\right),$$
$$\lambda = \frac{-\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{p^2\sqrt{3\beta_3}}, A_1 = \frac{ip\sqrt{\beta_3}}{\sqrt{3\gamma_s}}, \mu = -k + w\gamma_s + \frac{\alpha}{2} \quad (16)$$

$$(2) A_0 = -i\left(\frac{\sqrt{3\beta_3}(2+p)w - 3\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{18p\sqrt{\gamma_s}}\right),$$
$$\lambda = \frac{-\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{p^2\sqrt{3\beta_3}}, A_1 = \frac{-ip\sqrt{\beta_3}}{\sqrt{3\gamma_s}}, \mu = -k + w\gamma_s + \frac{\alpha}{2} \quad (17)$$

$$(3) A_0 = -i\left(\frac{\sqrt{3\beta_3}(2+p)w - 3\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{18p\sqrt{\gamma_s}}\right),$$
$$\lambda = \frac{\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{p^2\sqrt{3\beta_3}}, A_1 = \frac{-ip\sqrt{\beta_3}}{\sqrt{3\gamma_s}}, \mu = -k + w\gamma_s + \frac{\alpha}{2} \quad (18)$$

$$(4) A_0 = i\left(\frac{\sqrt{3\beta_3}(2+p)w - 3\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{18p\sqrt{\gamma_s}}\right),$$
$$\lambda = \frac{\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{p^2\sqrt{3\beta_3}}, A_1 = \frac{ip\sqrt{\beta_3}}{\sqrt{3\gamma_s}}, \mu = -k + w\gamma_s + \frac{\alpha}{2} \quad (19)$$

For simplicity and similarity we will locate only one of these four results say the first one which is

$$A_0 = i\left(\frac{\sqrt{3\beta_3}(2+p)w - 3\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{18p\sqrt{\gamma_s}}\right),$$
$$\lambda = \frac{-\sqrt{36p+\beta_3(-12kp^4-4w^2+5p^2w^2+6pw^3+6\alpha p^4+12p^4w\gamma_s}}{p^2\sqrt{3\beta_3}}, A_1 = \frac{ip\sqrt{\beta_3}}{\sqrt{3\gamma_s}}, \mu = -k + w\gamma_s + \frac{\alpha}{2}$$

This result can be simplified to be

$$p = w = a_2 = k = 1, A_0 = -0.95i, A_1 = i, \gamma_s = \pm 1, \beta_3 = \pm 3, \lambda = -2.9, \mu = 0.5 \quad (20)$$

This result will generate other four sub-results, we will plot only one say,

$$p = w = a_2 = k = 1, A_0 = -0.95i, A_1 = i, \gamma_s = 1, \beta_3 = 3, \lambda = -2.9, \mu = 0.5 \quad (21)$$

From the point of view of the proposed method and the values of $\mu, \lambda$ the solution is

$$V(\zeta) = A_0 + A_1\left(\frac{G'}{G}\right)$$

Where $$\left(\frac{G'}{G}\right) = \frac{\sqrt{\mu^2-4\lambda}}{2}\left(\frac{l_1 \operatorname{Sinh}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta + l_2 \operatorname{Cosh}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta}{l_1 \operatorname{Cosh}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta + l_2 \operatorname{Sinh}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta}\right) - \frac{\mu}{2}$$

$$(\frac{G'}{G}) = i\left\{1.7\left(\frac{\mathrm{Sinh}1.7\zeta + 2\,\mathrm{Cosh}1.7\zeta}{\mathrm{Cosh}1.7\zeta + 2\,\mathrm{Sinh}1.7\zeta}\right) - 0.25\right\} \tag{22}$$

$$V(\zeta) = -0.95i + i\left\{1.7\left(\frac{\mathrm{Sinh}1.7\zeta + 2\,\mathrm{Cosh}1.7\zeta}{\mathrm{Cosh}1.7\zeta + 2\,\mathrm{Sinh}1.7\zeta}\right) - 0.25\right\} \tag{23}$$

$$V(\zeta) = i\left\{1.7\left(\frac{\mathrm{Sinh}1.7\zeta + 2\,\mathrm{Cosh}1.7\zeta}{\mathrm{Cosh}1.7\zeta + 2\,\mathrm{Sinh}1.7\zeta}\right) - 1.2\right\} \tag{24}$$

$$u(x,t) = i\left\{1.7\left(\frac{\mathrm{Sinh}1.7\zeta + 2\,\mathrm{Cosh}1.7\zeta}{\mathrm{Cosh}1.7\zeta + 2\,\mathrm{Sinh}1.7\zeta}\right) - 1.2\right\} e^{i(1.1-x+t)} \tag{25}$$

$$\mathrm{Re}\,u(x,t) = -\left\{1.7\left(\frac{\mathrm{Sinh}1.7\zeta + 2\,\mathrm{Cosh}1.7\zeta}{\mathrm{Cosh}1.7\zeta + 2\,\mathrm{Sinh}1.7\zeta}\right) - 1.2\right\} \mathrm{Sin}(1.1 - x + t) \tag{26}$$

$$\mathrm{Im}\,u(x,t) = \left\{1.7\left(\frac{\mathrm{Sinh}1.7\zeta + 2\,\mathrm{Cosh}1.7\zeta}{\mathrm{Cosh}1.7\zeta + 2\,\mathrm{Sinh}1.7\zeta}\right) - 1.2\right\} \mathrm{Cos}(1.1 - x + t) \tag{27}$$

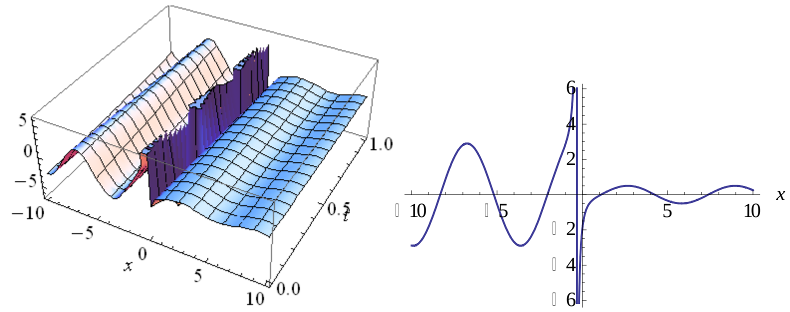


**Fig.1:** The soliton of the Re. part Eq.(26) in 2D and 3D with value:
$p = w = \alpha = k = 1, A_0 = -0.95i, A_1 = i, \gamma_s = 1, \beta_3 = 3, \lambda = -2.9, \mu = 0.5, l_1 = 1, l_2 = 2, \theta = 0.1$

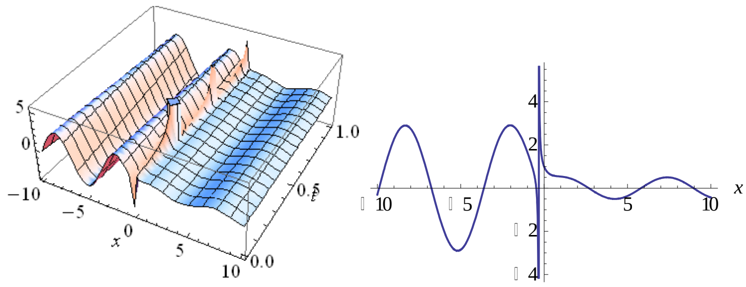


**Fig.2:** The soliton of the Im. part Eq.(27) in 2D and 3D with value:
$p = w = \alpha = k = 1, A_0 = -0.95i, A_1 = i, \gamma_s = 1, \beta_3 = 3, \lambda = -2.9, \mu = 0.5, l_1 = 1, l_2 = 2, \theta = 0.1$

Via the same method we can plot the other cases.
Secondly, we will implement the (G′/G)-expansion for the imaginary part Eq. (8)

$$\frac{p^2\beta_2(x)}{2}V'' - pw\beta_2(x)V' + \frac{w^2\beta_2(x)}{2}V - \gamma_s V^3 + 2p\gamma_r V^2 V' = 0 \tag{28}$$

The above equation contains two nonlinear terms which are $V^3, V^2V'$, when we implement the balance between $V''$ and the first one which is $V^3$ it lead to $N = 1$. Although the balance is one, unfortunately the two families of this method don't achieve any solutions. In other trail, when we implement the balance rule between $V''$ and the second one which is $V^2V'$ it leads to $N=\frac{1}{2}$, this pushes us to take the transformation $R=V^2$ which will transform this equation into the following form

$$\frac{p^2\beta_2(x)}{4}RR''-\frac{p^2\beta_2(x)}{8}R'^2-pw\beta_2(x)RR'+\frac{w^2\beta_2(x)}{2}R^2-\gamma_s R^3+p\gamma_r R^2R'=0\,. \qquad (29)$$

In this equation which also contains two nonlinear terms which are $R^3, R^2R'$, when we implement the balance between $RR''$ and any one of them lead to $N=1$, hence the solution according to the suggested method is $R(\zeta)=A_0+A_1(\frac{G'}{G})$.

Via inserting $R(\zeta)$, its derivatives into Eq. (15), collecting and equating the coefficients of various powers of $(\frac{G'}{G})^k$ to zero we get a system of algebraic equations by solving it we obtain the following results

$$(1)\mu=\frac{8(3+\sqrt{7})w^2}{p^2},\lambda=\frac{2(2+\sqrt{7})w}{p},A_0=\frac{(3+\sqrt{7})w^2\beta_2}{\gamma_s},A_1=\frac{(2+\sqrt{7})pw\beta_2}{4\gamma_s} \qquad (30)$$

$$(2)\mu=-\frac{8(-3+\sqrt{7})w^2}{p^2},\lambda=-\frac{2(-2+\sqrt{7})w}{p},A_0=-\frac{(-3+\sqrt{7})w^2\beta_2}{\gamma_s},A_1=-\frac{(-2+\sqrt{7})pw\beta_2}{4\gamma_s} \qquad (31)$$

$$(3)\mu=\frac{8A_0\gamma_s(w^2\beta_2-2A_0\gamma_s)[(-5+\sqrt{7})w^2\beta_2+(11-4\sqrt{7})A_0\gamma_s]}{9p^2w^2\beta_2^2[(3+\sqrt{7})w^2\beta_2-A_0\gamma_s]}$$
$$,\lambda=-\frac{2(-2+\sqrt{7})(w^2\beta_2-4A_0\gamma_s)}{4pw\beta_2},A_1=\frac{(2+\sqrt{7})pw\beta_2}{4\gamma_s} \qquad (32)$$

$$(4)\mu=\frac{8A_0\gamma_s(w^2\beta_2-2A_0\gamma_s)[(5+\sqrt{7})w^2\beta_2-(11-4\sqrt{7})A_0\gamma_s]}{9p^2w^2\beta_2^2[(3+\sqrt{7})w^2\beta_2-A_0\gamma_s]}$$
$$,\lambda=\frac{2(2+\sqrt{7})(w^2\beta_2-4A_0\gamma_s)}{4pw\beta_2},A_1=-\frac{(-2+\sqrt{7})pw\beta_2}{4\gamma_s} \qquad (33)$$

$$(5)\mu=\frac{8(11+5\sqrt{7})w^2}{9p^2},\lambda=\frac{2(2+\sqrt{7})w}{p},A_0=\frac{(3+\sqrt{7})w^2\beta_2}{\gamma_s},A_1=\frac{(2+\sqrt{7})pw\beta_2}{4\gamma_s} \qquad (34)$$

$$(6)\mu=\frac{8(11-5\sqrt{7})w^2}{9p^2},\lambda=-\frac{2(-2+\sqrt{7})w}{p},A_0=-\frac{(-3+\sqrt{7})w^2\beta_2}{\gamma_s},A_1=-\frac{(-2+\sqrt{7})pw\beta_2}{4\gamma_s} \qquad (35)$$

$$(7)\lambda=\frac{2w}{p},A_0=0,A_1=\frac{pw\beta_2}{4\gamma_s} \qquad (36)$$

$$(8)\lambda=\frac{2w}{p},\mu=0,A_0=0,A_1=\frac{pw\beta_2}{4\gamma_s} \qquad (37)$$

$$(9)\lambda=\frac{8(pw\beta_2-A_1\gamma_s)}{3p^2\beta_2},\mu=0,A_0=0 \qquad (38)$$

$$(10)\mu=\frac{39p^4w^4\beta_2^4+152p^3w^3\beta_2^3A_1\gamma_s+384p^2w^2\beta_2^2A_1^2\gamma_s^2+384pw\beta_2A_1^3\gamma_s^3+256A_1^4\gamma_s^4}{3p^4\beta_2^2(pw\beta_2-4A_1\gamma_s)^2}$$
$$,\lambda=\frac{-6w(pw\beta_2+4A_1\gamma_s)}{p(pw\beta_2-4A_1\gamma_s)},A_0=\frac{-A_1[13p^2w^2\beta_2^2+16pwA_1\beta_2\gamma_s)+16A_1^2\gamma_s^2]}{3p^2\beta_2(pw\beta_2-4A_1\gamma_s)} \qquad (39)$$

For simplicity and similarity we will choose only two different results of them say the first, the ninth and draw them.

(1)The first result is, $\mu=\frac{8(3+\sqrt{7})w^2}{p^2},\lambda=\frac{2(2+\sqrt{7})w}{p},A_0=\frac{(3+\sqrt{7})w^2\beta_2}{\gamma_s},A_1=\frac{(2+\sqrt{7})pw\beta_2}{4\gamma_s}$

This result can be simplified to be

$$k=p=w=\gamma_s=1,\beta_2=0.3,A_1=0.4,A_0=1.9,\mu=45.2,\lambda=9.2,\theta=0.1 \qquad (40)$$

From the point of view of the proposed method and the values of $\mu,\lambda$ the solution is

$$V(\zeta)=A_0+A_1(\frac{G'}{G})$$

Where $$(\frac{G'}{G})=\frac{\sqrt{\mu^2-4\lambda}}{2}\left(\frac{l_1\,\mathrm{Sinh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta+l_2\,\mathrm{Cosh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta}{l_1\,\mathrm{Cosh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta+l_2\,\mathrm{Sinh}(\frac{\sqrt{\mu^2-4\lambda}}{2})\zeta}\right)-\frac{\mu}{2}$$

$$(\frac{G'}{G})=22.4\left(\frac{\mathrm{Sinh}\,22.4\zeta+2\,\mathrm{Cosh}\,22.4\zeta}{\mathrm{Cosh}\,22.4\zeta+2\,\mathrm{Sinh}\,22.4\zeta}\right)-22.6 \qquad (41)$$

$$V(\zeta)=\left\{8.96\left(\frac{\mathrm{Sinh}\,22.4\zeta+2\,\mathrm{Cosh}\,22.4\zeta}{\mathrm{Cosh}\,22.4\zeta+2\,\mathrm{Sinh}\,22.4\zeta}\right)-7.1\right\} \qquad (42)$$

$$u(x,t)=\left\{8.96\left(\frac{\mathrm{Sinh}\,22.4\zeta+2\,\mathrm{Cosh}\,22.4\zeta}{\mathrm{Cosh}\,22.4\zeta+2\,\mathrm{Sinh}\,22.4\zeta}\right)-7.1\right\}e^{i(1.1-x+t)} \qquad (43)$$

$$\mathrm{Re}\,u(x,t)=\left\{8.96\left(\frac{\mathrm{Sinh}\,22.4\zeta+2\,\mathrm{Cosh}\,22.4\zeta}{\mathrm{Cosh}\,22.4\zeta+2\,\mathrm{Sinh}\,22.4\zeta}\right)-7.1\right\}\mathrm{Cos}(1.1-x+t) \qquad (44)$$

$$\mathrm{Im}\,u(x,t)=\left\{8.96\left(\frac{\mathrm{Sinh}\,22.4\zeta+2\,\mathrm{Cosh}\,22.4\zeta}{\mathrm{Cosh}\,22.4\zeta+2\,\mathrm{Sinh}\,22.4\zeta}\right)-7.1\right\}\mathrm{Sin}(1.1-x+t) \qquad (45)$$

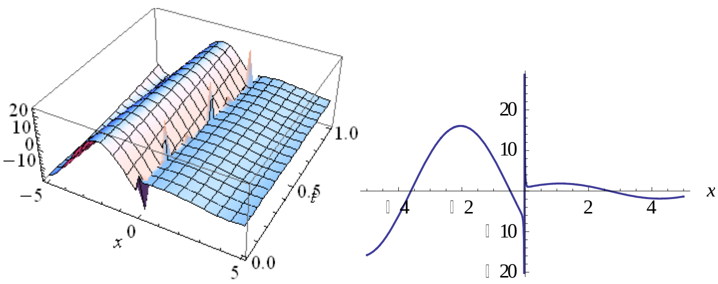


**Fig.3:** The soliton of the Re. part Eq.(44) in 2D and 3D with value:
$k=p=w=\gamma_s=1,A_1=1.2,A_0=5.6,\mu=45.2,\lambda=9.2,l_1=1,l_2=2,\theta=0.1$

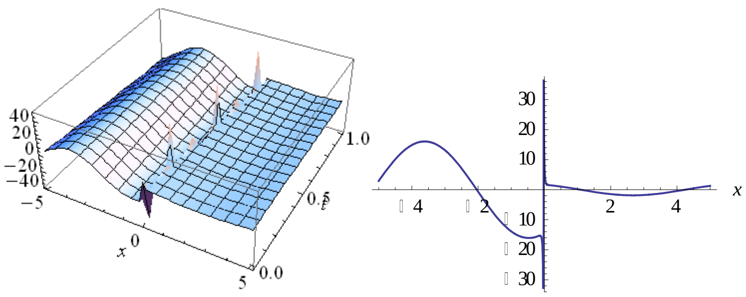

**Fig.4:** The soliton of the Im. part Eq.(45) in 2D and 3D with value:
$k=p=w=\gamma_s=1, A_1=1.2, A_0=5.6, \mu=45.2, \lambda=9.2, l_1=1, l_2=2, \theta=0.1$

(2)The ninth results which is $\lambda=\frac{8(pw\beta_2-A_1\gamma_s)}{3p^2\beta_2}, \mu=0, A_0=0$

This result can be simplified to be

$$k=p=w=\gamma_s=1, \beta_2=0.3, A_1=-1, A_0=0, \mu=0, \lambda=42.7, \theta=0.1 \tag{46}$$

From the point of view of the proposed method and the values of $\mu,\lambda$ the solution is

$$V(\zeta)=A_0+A_1\left(\frac{G'}{G}\right)$$

Where $\left(\frac{G'}{G}\right)=\frac{\sqrt{\mu^2-4\lambda}}{2}\left(\frac{-l_1\,\mathrm{Sin}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta+l_2\,\mathrm{Cos}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta}{l_1\,\mathrm{Cos}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta+l_2\,\mathrm{Sin}\left(\frac{\sqrt{\mu^2-4\lambda}}{2}\right)\zeta}\right)-\frac{\mu}{2}$

$$\left(\frac{G'}{G}\right)=3.3i\left(\frac{-\mathrm{Sin}\,3.3i\zeta+2\,\mathrm{Cos}\,3.3i\zeta}{\mathrm{Cos}\,3.3\zeta+2\,\mathrm{Sin}\,3.3i\zeta}\right) \tag{47}$$

$$V(\zeta)=-3.3i\left(\frac{-\mathrm{Sin}\,3.3i\zeta+2\,\mathrm{Cos}\,3.3i\zeta}{\mathrm{Cos}\,3.3\zeta+2\,\mathrm{Sin}\,3.3i\zeta}\right) \tag{48}$$

$$u(x,t)=\left\{-3.3i\left(\frac{-\mathrm{Tanh}\,3.3\zeta+2}{1+2\,\mathrm{Tanh}\,3.3\zeta}\right)\right\}e^{i(1.1-x+t)} \tag{49}$$

$$\mathrm{Re}\,u(x,t)=3.3\left(\frac{-\mathrm{Tanh}\,3.3(x-t)+2}{1+2\,\mathrm{Tanh}\,3.3(x-t)}\right)\mathrm{Sin}(1.1-x+t) \tag{50}$$

$$\mathrm{Im}\,u(x,t)=-3.3\left(\frac{-\mathrm{Tanh}\,3.3(x-t)+2}{1+2\,\mathrm{Tanh}\,3.3(x-t)}\right)\mathrm{Cos}(1.1-x+t) \tag{51}$$

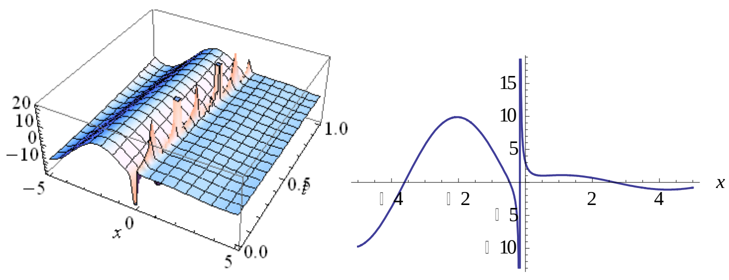

**Fig.5:** The soliton of the Re. part Eq.(50) in 2D and 3D with value:
$k=p=w=\gamma_s=1, \beta_2=0.3, A_1=-1, A_0=0, \mu=0, \lambda=42.7, \theta=0.1$

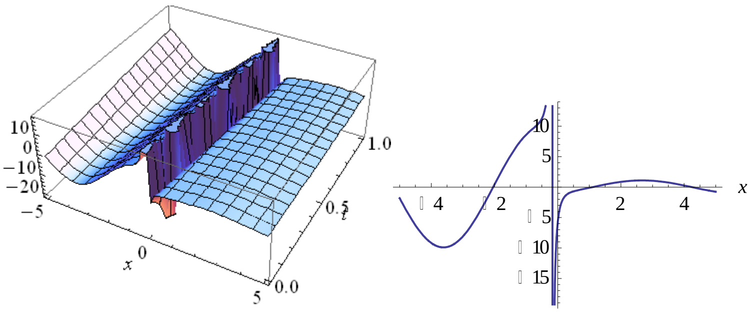


**Fig.6:** The soliton of the Im. part Eq.(51) in 2D and 3D with value:
$k = p = w = \gamma_s = 1, \beta_2 = 0.3, A_1 = -1, A_0 = 0, \mu = 0, \lambda = 42.7, \theta = 0.1$

## 4. The SWAM formalism

The SWAM [31-35] can be introduced as follows:

$$u(x,t) = \psi(x,t)e^{iR(x,t)} \tag{52}$$

Such that $\psi(x,t)$ is the portion argument, while $R(x,t)$ is the phase portion of soliton and we can easily obtain the following relations:

$$u_t = (\psi_t + i\psi R_t)e^{iR}$$
$$u_x = (\psi_x + i\psi R_x)e^{iR}$$
$$u_{xx} = (\psi_{xx} + 2i\psi_x R_x + i\psi R_{xx} - \psi R_x^2)e^{iR}$$
$$u_{xxx} = (\psi_{xxx} + 3i\psi_{xx}R_x - i\psi R_x^3 - 3\psi_x R_x^2 + i\psi R_{xxx} + 3i\psi_x R_{xx} - 3\psi R_x R_{xx})e^{iR} \tag{53}$$

The suggested model Eq. (1) in the framework of the relations mentioned in Eq. (53) will be converted into the following real and imaginary equations respectively

$$\psi_x + (\frac{\alpha}{2} - \mu)\psi - \frac{\beta_3}{6}(\psi_{ttt}) + 3\gamma_s \psi^2 \psi_t - (\frac{\beta_2}{2}R_t + 3R_t^2)\psi_t = 0 \tag{54}$$

$$(k + \frac{\alpha}{2} - \frac{\beta_2}{2}R_t^2 - R_t^3)\psi + \frac{\beta_2}{2}\psi_{tt} + (\gamma_s R_t - \gamma)\psi^3 - \frac{\beta_3}{2}\psi_{tt}R_t - 2\gamma_r \psi^2 \psi_t = 0 \tag{55}$$

**The bright soliton solutions**

$$\psi(x,t) = A_1 \operatorname{sech}^{R_1} t_1,\ where\, t_1 = B_1(x - w_1 t)\, and\, R_1(x,t) = kx - \Omega t$$
$$\psi_t = A_1 B_1 w_1 R_1 \operatorname{sech}^{R_1} t_1 \tanh t_1$$
$$\psi_x = -A_1 B_1 R_1 \operatorname{sech}^{R_1} t_1 \tanh t_1$$
$$\psi_{xx} = -A_1 B_1^2 R_1(1 + R_1)\operatorname{sech}^{R_1+2} t_1 + A_1 B_1^2 R_1^2 \operatorname{sech}^{R_1} t_1$$
$$\psi_{tt} = -A_1 B_1^2 w_1^2 R_1(1 + R_1)\operatorname{sech}^{R_1+2} t_1 + A_1 B_1^2 w_1^2 R_1^2 \operatorname{sech}^{R_1} t_1$$
$$\psi_{xxx} = A_1 B_1^3 R_1(R_1 + 1)(R_1 + 2)\operatorname{sech}^{R_1+2} t_1 \tanh t_1 - A_1 B_1^3 R_1^3 \operatorname{sech}^{R_1} t_1 \tanh t_1$$
$$\psi_{ttt} = -A_1 B_1^3 w_1^3 R_1(R_1 + 1)(R_1 + 2)\operatorname{sech}^{R_1+2} t_1 \tanh t_1 + A_1 B_1^3 w_1^3 R_1^3 \operatorname{sech}^{R_1} t_1 \tanh t_1 \tag{56}$$

Via substituting the relations (56) into the real and imaginary parts equations (54), (55) at the same time we get,

$$
\begin{aligned}
&-A_1B_1R_1\operatorname{sech}^{R_1}t_1\tanh t_1+\left(\frac{\alpha}{2}-\mu\right)A_1\operatorname{sech}^{R_1}t_1\\
&+\frac{\beta_3}{6}A_1B_1^3w_1^3R_1(R_1+1)(R_1+2)\operatorname{sech}^{R_1+2}t_1\tanh t_1-\frac{\beta_3}{6}A_1B_1^3w_1^3R_1^3\operatorname{sech}^{R_1}t_1\tanh t_1\\
&+3B_1w_1R_1\gamma_sA_1^3\operatorname{sech}^{3R_1}t_1\tanh t_1+\left(\Omega\frac{\beta_2}{2}-3\Omega^2\right)A_1B_1w_1R_1\operatorname{sech}^{R_1}t_1\tanh t_1=0
\end{aligned}
\tag{57}
$$

$$
\begin{aligned}
&\left((k+\frac{\alpha}{2}-\frac{\beta_2}{2}\Omega^2-\Omega^3+B_1^2w_1^2R_1^2[\frac{\beta_2}{2}+\frac{\beta_3}{2}\Omega]\right)A_1\operatorname{sech}^{R_1}t_1\\
&-A_1B_1^2w_1^2R_1(1+R_1)\left(\frac{\beta_2}{2}+\frac{\beta_3}{2}\Omega\right)\operatorname{sech}^{R_1+2}t_1\\
&+(\gamma_s\Omega-\gamma)A_1^3\operatorname{sech}^{3R_1}t_1-2B_1w_1R_1\gamma_rA_1^3\operatorname{sech}^{3R_1}t_1\tanh t_1=0
\end{aligned}
\tag{58}
$$

Equations (57), (58) implies the following results,

$$R_1=1, A_1=\pm 0.6i, B_1=\pm 1.87, kx-\Omega t=1, \Omega=1.7, \beta_2=\beta_3=\gamma_s=k=\alpha=w_1=1 \tag{59}$$

This solution will generate 4-solutions according to the probability of exchange the signs of different parameters, for simplicity we will plot only one of these four solutions which is

$$R_1=1, A_1=0.6i, B_1=1.87, kx-\Omega t=1, \Omega=1.7, \beta_2=\beta_3=\gamma_s=k=\alpha=w_1=1 \tag{60}$$

The bright solution is

$$
\begin{aligned}
u(x,t)&=A_1\left(\operatorname{sech}^{R_1}B_1(x-w_1t)\right)e^{i(kx-\Omega t)}\\
u(x,t)&=0.6i\left(\operatorname{sech}[1.9x-1.9t]\right)e^{i(x-1,7t)}\\
u(x,t)&=0.6i\left(\operatorname{sech}[1.9x-1.9t]\right)\times\left(\cos(x-1.7t)+i\sin(x-1.7t)\right)
\end{aligned}
\tag{61}
$$

$$\operatorname{Re}u(x,t)=-0.6\left(\operatorname{sech}[1.9x-1.9t]\right)\times\sin(x-1.7t) \tag{62}$$

$$\operatorname{Im}u(x,t)=0.6\left(\operatorname{sech}[1.9x-1.9t]\right)\times\cos(x-1.7t) \tag{63}$$

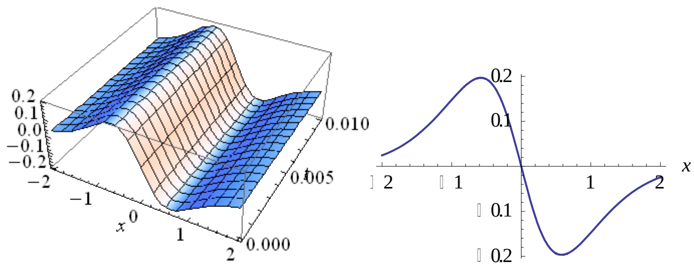

**Fig.7** The bright soliton of the Re. part Eq.(62) in 2D and 3D with values:

$$R_1=1, A_1=0.6i, B_1=1.87, kx-\Omega t=1, \Omega=1.7, \mu=0.5, \beta_2=\beta_3=\gamma_s=k=\alpha=w_1=1$$

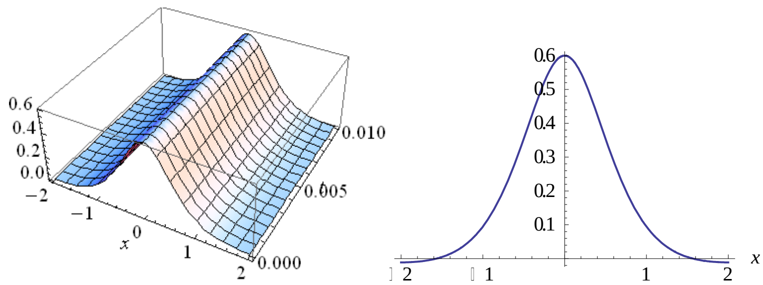

**Fig.8** The bright soliton of the Im. part Eq.(63) in 2D and 3D with values:

$$R_1=1, A_1=0.6i, B_1=1.87, kx-\Omega t=1, \Omega=1.7, \mu=0.5, \beta_2=\beta_3=\gamma_s=k=\alpha=w_1=1$$

By the same manner we can easily drawing the other three solutions.

**The dark soliton solutions**

$$\psi(x,t) = A_2 \tanh^{R_2} t_2,\ where\ t_2 = B_2(x - w_2 t)\ and\ R_2(x,t) = kx - \Omega t$$
$$\psi_t = -A_2 B_2 R_2 w_2 [\tanh^{R_2-1} t_2 - \tanh^{R_2+1} t_2]$$
$$\psi_x = A_2 B_2 R_2 [\tanh^{R_2-1} t_2 - \tanh^{R_2+1} t_2]$$
$$\psi_{xx} = A_2 R_2 (R_2 - 1) B_2^2 \tanh^{R_2-2} t_2 - 2A_2 R_2^2 B_2^2 \tanh^{R_2} t_2 + 2A_2 R_2 (R_2+1) B_2^2 \tanh^{R_2+2} t_2$$
$$\psi_{tt} = A_2 R_2 B_2^2 w_2^2 [(R_2-1)\tanh^{R_2-2} t_2 - 2R_2 \tanh^{R_2} t_2 + (R_2+1)\tanh^{R_2+2} t_2]$$
$$\begin{aligned}\psi_{xxx} &= A_2 R_2 B_2^3 [(R_2-1)(R_2-2)\tanh^{R_2-3} t_2 - ((R_2-1)(R_2-2) + 2R_2^2)\tanh^{R_2-1} t_2 \\ &\quad + ((R_2+1)(R_2+2) + 2R_2^2)\tanh^{R_2+1} t_2 - (R_2+1)(R_2+2)\tanh^{R_2+3} t_2]\end{aligned}$$
$$\begin{aligned}\psi_{ttt} &= -A_2 R_2 B_2^3 w_2^3 [(R_2-1)(R_2-2)\tanh^{R_2-3} t_2 - ((R_2-1)(R_2-2) + 2R_2^2)\tanh^{R_2-1} t_2 \\ &\quad + ((R_2+1)(R_2+2) + 2R_2^2)\tanh^{R_2+1} t_2 - (R_2+1)(R_2+2)\tanh^{R_2+3} t_2]\end{aligned} \tag{64}$$

Via inserting the relations (64) into the real and imaginary parts equations (54), (55) at the same time we obtain,

$$\begin{aligned}&\left(A_2 B_2 R_2 + \frac{\beta_3}{6}((R_2-1)(R_2-2) + 2R_2^2) - (\frac{\Omega\beta_2}{2} - 3\Omega^2) A_2 B_2 R_2 w_2\right)\tanh^{R_2-1} t_2 \\ &+ \left(\frac{\beta_3}{6}((R_2+1)(R_2+2) + 2R_2^2) - A_2 B_2 R_2 + (\frac{\Omega\beta_2}{2} - 3\Omega^2) A_2 B_2 R_2 w_2\right)\tanh^{R_2+1} t_2 \\ &+ (\frac{\alpha}{2} - \mu) A_2 \tanh^{R_2} t_2 + \frac{\beta_3}{6} A_2 R_2 B_2^3 w_2^3 [(R_2-1)(R_2-2)\tanh^{R_2-3} t_2 \\ &+ \frac{\beta_3}{6}(R_2+1)(R_2+2)\tanh^{R_2+3} t_2 - 3\gamma_s A_2^3 B_2 R_2 w_2 \tanh^{3R_2-1} t_2 + 3\gamma_s A_2^3 B_2 R_2 w_2 \tanh^{3R_2+1} t_2 = 0\end{aligned} \tag{65}$$

$$\begin{aligned}&\left(k + \frac{\alpha}{2} - \frac{\beta_2}{2}\Omega^2 - \Omega^3 - \beta_2 R_2^2 B_2^2 w_2^2 - \Omega\beta_3 R_2^2 B_2^2 w_2^2\right) A_2 \tanh^{R_2} t_2 \\ &+ \left(\frac{\beta_2 A_2 R_2 B_2^2 w_2^2}{2} + \frac{\Omega\beta_3 A_2 R_2 B_2^2 w_2^2}{2}\right)(R_2-1)\tanh^{R_2-2} t_2 \\ &+ \left(\frac{\beta_2 A_2 R_2 B_2^2 w_2^2}{2} + \frac{\Omega\beta_3 A_2 R_2 B_2^2 w_2^2}{2}\right)(R_2+1)\tanh^{R_2+2} t_2 \\ &+ (\gamma_s \Omega - \gamma) A_2^3 \tanh^{3R_2} t_2 + 2\gamma_r A_2^3 B_2 R_2 w_2 \left(\tanh^{3R_2-1} t_2 - \tanh^{3R_2+1} t_2\right) = 0\end{aligned} \tag{66}$$

Via equating the highest order of $\tanh^i t_2$ implies $R_2 = 1$ hence we get the following values:

$$\mu = 0.5, \gamma_r = 0, A_2^2 = -0.5, \Omega = 0.5 \pm 0.5i, \beta_3 = 0, k = B_2 = \alpha = \beta_2 = w_2 = 1 \tag{67}$$

The solution in the framework of these values is

$$u(x,t) = \pm 0.7i \tanh(x-t) \times e^{i(x-0.5t)} \times e^{\pm 0.5t} \tag{68}$$

This solution will generate 4-solutions; for simplicity we will take only one of them say,

$$u(x,t) = 0.7i \tanh(x-t) \times e^{i(x-0.5t)} \times e^{0.5t} \tag{69}$$
$$\operatorname{Re} u(x,t) = -0.7 e^{0.5t} \times \tanh(x-t) \times \sin(x-0.5t) \tag{70}$$
$$\operatorname{Im} u(x,t) = 0.7 e^{0.5t} \times \tanh(x-t) \times \cos(x-0.5t) \tag{71}$$

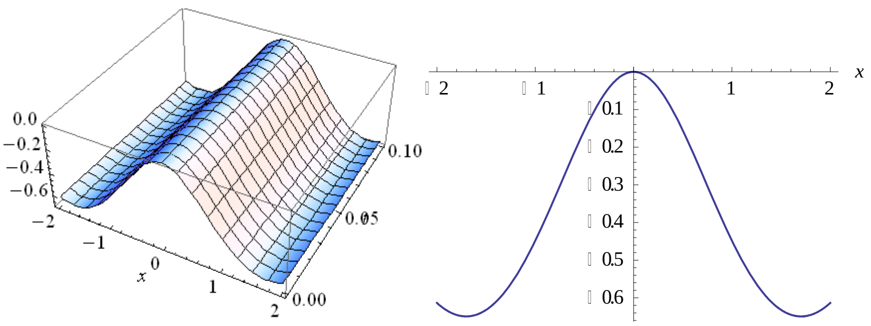


**Fig.9:** The dark soliton of the Re. part Eq.(70) in 2D and 3D with values:

$$\mu = 0.5, \gamma_r = 0, A_2 = 0.7i, \Omega = 0.5 + 0.5i, \beta_3 = 0, k = B_2 = \alpha = \beta_2 = w_2 = 1$$

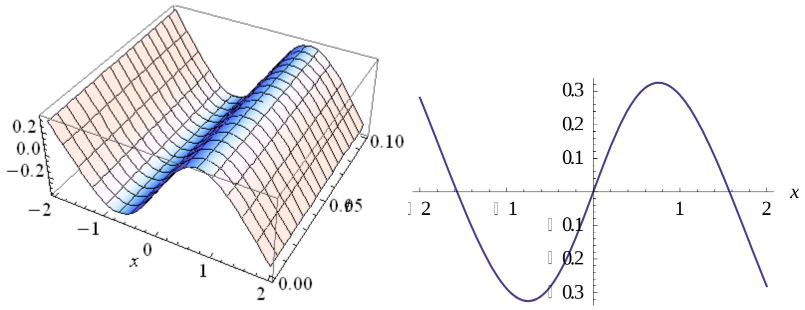


**Fig.10:** The dark soliton of the Im. part Eq.(71) in 2D and 3D with values:

$$\mu = 0.5, \gamma_r = 0, A_2 = 0.7i, \Omega = 0.5 + 0.5i, \beta_3 = 0, k = B_2 = \alpha = \beta_2 = w_2 = 1$$

By the same manner we can easily drawing the other three solutions.

## 5-Conclusion

In this paper, new configuration designs of solitons arising in lossy fiber system under influence dispersion terms via two distinct methods have been documented. The two suggested methods are previously examined for many other nonlinear partial differential equations and achieved good results. The first one has profile name the (G'/G)-expansion method, while the second one has profile name the SWAM. The two schemes are implemented in the same time and parallel. The (G'/G)-expansion has been used successfully to detect new solitons configurations for some achieved solutions that emerged from the real and imaginary part of the suggested model figures (1-6). Moreover, the SWAM also applied effectively to demonstrate other new configurations of the solitons propagation in this model figures (7-10). In all achieved solutions the coefficients of the third order dispersion term, the group velocity dispersion term as well as the other parameters are not only detected but also its explore their effects on nature of the optical soliton propagation are established. Some of the achieved solitons via these two various methods isomorphic with that achieved previously by [36] who used different techniques to investigate this model while the majority “which weren’t achieved before” are considered to be novelty solitons of this model. Hence, new distinct configurations perceptions of solitons of this model have been documented and will add future visions not only for this model but also for all related phenomena.

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