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Soliton solutions of Schrodinger¨ Equation with Quadratic Cubic non linearity and its Stability

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ABSTRACT: The resonant nonlinear Schrödinger equation (NLSE) having quadratic-cubic nonlinearity for describing pulse phenomena and studied in nonlinear optics. We achieved optical soliton and solitary wave solutions of resonant NLSE with quadratic-cubic nonlinearity by employing extended simple equation method, which have key applications in engineering and applied physics. The stability of model is examined by employing the modulation instability analysis, which shows that the obtained exact solutions are stable. We also given the movement of some achieved solutions graphically, which facilitates to recognize the physical phenomena's of this nonlinear model.

keywords: Improved Simple equation method, nonlinear schrödinger equation with quadratic-cubic nonlinearity, Soli-tons, periodic solutions, Solitary wave.

1 Introduction

In several branch of engineering and applied science, nonlinear phenomena exist naturally. Several non-linear evolution equations (NLEEs) have been derived to explain these real nonlinear situations. The nonlinear Schrödinger equations in NLEEs have been considered as the models to illustrate some non-linear phenomenon in different areas such as condensed matter physics, fluids, fluid dynamics, quantum mechanics, plasmas, optics, biophysics and particle physics [1–7]. The studies of the analytical solutions in different form for example solitons, solitary wave and so on to different types of nonlinear Schrödinger equations have become a very significant practice by various scholars [8]. The solutions of NLSEs play a very important role in solving the problems of real-life. Soliton for the different NLSEs have been searched to investigation the non-linear phenomenas, where the solitons might be whichever dark or bright on the information of the governing NLSEs [9–12], and dark one is a mark with a characteristic phase step crossways it, while the amplitude of bright soliton is peak [13].

In the previous many decades, the non-linear dynamics of optical solitons are structured by the famous NLSE [14] which has been investigated widely. Ahead of 1997, researchers have been focused almost on the optical solitons in restricted non-linear media having refractive index (RI) at a specific position is only associated to intensity of the beam at same position. The nonlinear nonlocal model was projected by the authors in [15] that permits the RI of a object at a specific point to be associated to the intensity of beam at every other points of objects in the year of 1997. Consequently, the nonlocal solitons attained much concentration, and numerous new solitons are established, such as gray solitons [16], Gaussian and higher-order Gaussian solitons [15], vector Laguerre–Gaussian solitons [17], multipole and dipole solitons [18], surface solitons [19] and so on [20, 21]. The solitons in different reveal various distinctive properties, such as shift of large phase [22], self-induced mode transformation [23], attraction between dark solitons [24], long-range interaction [25]. These days various engineering methods have been build to investigate the non-linearity of the non-linear media [26].

The constructing of analytical solutions in the form of solitons and solitary wave of non-linear Schrödinger equations have been examined generally and intensely in various features as it was developed. Many powerful and efficient techniques have been developed to attain solu-tions in the form of soltion and solitary wave for example semi-inverse variational principle [27], modified direct alge-braic method [28], Kudryashov method [20], F-Expansion method [6], Elliptic function method [30], simple equa-tion scheme [31],Darboux transformation [32], similarity transformations method [33], expansion method [34], exp-function method [35], (G_0 =G)-expansion scheme [36] and many more [37–42]. The researchers in [43] investigated the dynamical manners of the NLSE.

In many branches of physics, modulation instability (MI) is fundamental procedure [5, 6, 28], which arises as a outcome of the collaboration between diffraction in the spatial domain or dispersion in the time domain and nonlinearity.

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The acumen in the media of non-Kerr has verified to be an immensely exciting study field in MI, for scrutinize promulgation of an optical pulse in NLSE of higher order [44]. The significant cause behind is that the modulation instability may be supposed as, to the ancestor of soliton construction.

In the current article, the exact solitons and solitary wave solutions in different form of resonant NLSE, for quadratic-cubic nonlinearity are constructed by the described extended simple equation scheme. The achieved analytical solutions are novel and more generalized. The stability of achieved solutions are discuss by utilizing modulation instability anal-ysis.

The rest of this article is structured as follows: The theoretical model is illustrated in Section 2. The key steps of modified F-expansion scheme are presented in Section 3. In Section 4, the appliance of the described scheme is pre-sented. In Section 5, the MI analysis is used to discuss the stability of model. The results and discussion of achieved exact solutions are discussed in Section 6. In Last section, the conclusion is revealed.

2 Theoretical Model

The observing resonant non-linear Schrödinger equation with Quardatic Cubic (QC) nonlinearity is written in its dimensionless form as

$$iq_t + a_1 q_{xx} + a_2 \frac{(|q|)_{xx}}{|q|} q + a_3|q|q + a_4|q|^2 q = i|q|^{2m} q_x + i q_x + i (|q|^{2m} q)_x + i (|q|^{2m})_x q + \frac{(|q|)_{xx}}{|q|^2} q = 0; \quad (1)$$

where the function $q(x; t)$ is dependent that shows the complex valued wave profile with $i = \sqrt{-1}$. The dependent variables x and t are the variables of temporal and spatial correspondingly. Furthermore the parameter a_1 and a_2 are the group velocity dispersion and Boham potential for chiral solitions with quatum hall cause respectivly. The terms a_3 and a_4 are QC non-linear together. The is signifies inter-model dispersion, also accounts for self-steepening having short pulses while and are associated to non-linear dis-persion. Lastly provides the relativistic effect in Plasmas. The parameter m is the full nonlinearity.

3 Description of Method

In this part, we will describe the algorithm of modified F-expantion method for finding the exact solutions of NLEEs. In generally, assume NLESE having independent variable x and t as

$$F(q; q_t; q_x; q_{xx}; q_{xxx}; ::::::::) = 0; \quad (2)$$

where the function $q(x; t)$ is unknown and polynomial function is F having some specified functions or variables, which have linear and non-linear of highest order derivative terms of $q(x; t)$ and be able to reduce into a polynomial function via using transformation in which the independent variables can be combine into a complex variable. The main steps of this technique are as:

Step 1: Considering travelling wave transformation to alter independent variables into single variable as

$$q(t; x) = V(\ ); \quad = x + t \quad (3)$$

where and are wave length and frequency. through utilizing transformation (3), the equation (2) is shrink into ODE as

$$P(V; V^{0}; V^{00}; V^{000}; :::::) = 0; \quad (4)$$

where prime(0) shows derivative of V with respect to and P is polynomial of V ( ).

Step 2: Consider the solution of equation (4) in the following form as:

$$V(\ ) = \sum_{i=-N}^{N} b_i (\ (\ ))^{i}; \quad (5)$$

where the real constants are b_i and n. ( ) gratifies the giving below ansatz equation

$$^{0}(\ ) = c_0 + c_1 (\ ) + c_2 {}^{2}(\ ) + c_3 {}^{3}(\ ); \quad (6)$$

where the arbitrary constants are $c_0; c_1; c_2$ and c_3.

Step 3: The possitive integer N is generally obtained via utilizing the homogeneous balancing principle on equation (4), and the coefficients $b_{-N}; b_{-N+1}; ::::; b_0; b_1; ::::; b_N$; ; are parameters can be obtained.

Step 4: putting equation (5) and equation (6) into equation (4) and putting the coefficients of dissimilar powers of $^{i}(\ )$ to zero, gives way a system of algebraic equations. Mathematica software is utilized to solve this system of equations, then the solution of parameters can be obtained.

Step 5: substituting the parameters value achieving in previous step into equation (5) then solutions of equation (4) can be attained.

4 Application of description method to resonant NLSE with quardatic-cubic nonlinearity

As the equation (1) is complex, so we suppose the solution in the form traveling wave of equation (1) as

$$q(x; t) = V(\ )e^{i}; \quad = kx + t + ; \quad (7)$$

where the amplitude component of the wave profiles is V ( ), phase factor is and k; ; symbolize the solitons frequency, the phase constant, the wave number respectively. Putting equation (7) into equation (1) and splitting into parts, give way as

$$(a_1{}^{2} + a_2{}^{2}\ {}^{2})V^{00} + (k + a_1k^2 + k^2)V + a_3V^2 + a_4V^3 + (k + k)V^{1+2m} = 0: \quad (8)$$

$$(\ +\ + 2m\ + 2m\ )V^{2m}\ 2a_1k + 2k = 0: \quad (9)$$

Substitute equation (9) into equation (8), we have

$$a_1{}^2 + a_2{}^2 \quad {}^2 \; V^{00} + V \; a_1k^2 + k + k^2$$
$$\frac{2a_1k + 2k \;\; +}{}$$
$$+ (k + k) \quad + \; + 2m \; + 2m$$
$$+ a_3V^2 + a_4V^3 = 0: \qquad (10)$$

Utilizing homogeneous balancing principle on equation (10) and consider the solution of equation (10) is in the form as

$$V(\,) = \frac{b_{2}}{{}^2(\,)} + \frac{b_{1}}{(\,)} + b_0 + b_1 (\,) + b_2 {}^2(\,): \quad (11)$$

Substituting equation (11) together with equation (6) into equation (10) and taking the coefficients of dis-similar powers of $_i(\,)$ to zero, we attained a algebraic system of Equations in parameters b_2; b_1; b_0; b_1; b_2; c_0; c_1; c_2; c_3; k; ; !; ; m and . Mathematica 9.0.1 is utilized to solve this algebraic system. The following cases of solutions are achieved as

Case 1: $c_0 = c_3 = 0$,

$$= 2a_3 \sqrt{9a_4}\; a_1k^2(3 + 3 + 2\,m + 2m\,) + k(3k\,(\,+\,) + 2m(\,+\,)(\,+k\,))\;(\,+ + 2\,m + 2m\,))$$
$$2a_3^2(\,+ \quad + 2\,m + 2m\,) \quad = (27a_4k(\,+\,)\; \overline{a_4c_1{}^2\,(\;\; a_1 \quad 2)}\;;\; = \frac{p\;\; 2a_3}{\frac{p}{2a_3c_2}};$$
$$b_{2} = b_{1} = 0;\; b_0 = \frac{2a_3}{3a_4};\; b_1 = \frac{p\;2a_3c_2}{3a_4c_1};\; b_2 = 0: \qquad (12)$$

$$= p\;\overline{2}\,a_3\;2a_3^2\,(\;+\;+ 2\,m + 2m\,)\;\; 9a_4\;\; a_1k^2 \quad (3 + 3 + 2\,m + 2m\,) + k(3k\,(\;+\;) + 2m(\;+\;)(\,+k\,))\;\;(\;+\;+ 2\,m + 2m\,)))) = (27a_4k(\,+\,)\;\overline{a_4c_1{}^2\,(\;\; a_1 \quad a_2)}\;;\; = \frac{p\;\overline{2a_3}}{2\;p\;\overline{3\,2}};$$
$$b_{2} = b_{1} = b_2 = 0;\; b_0 = 0;\; b_1 = \frac{2\,a\,c}{3a_4c_1}: \qquad (13)$$

The following soliton solutions of equation (1) are obtained from solution (12) as

$$q_{11}(x;t) = \frac{(2a_3)}{3a_4 \;\; c_2e^{c_1(d+\,)}\; 1}\; e^{i(kx+\;t+\,)};\; c_1 \quad > 0: \quad (14)$$

$$q_{12}(x;t) = \frac{2a_3}{3a_4\; c_2e^{c_1(d+\,)} + 1}\; e^{i(kx+\;t+\,)};\; c_1 \quad < 0 \quad (15)$$

More soliton solutions of equation (1) are obtained from solution (13) as

$$q_{13}(x;t) = \frac{2a_3c_2e^{c_1(d+\,)}}{3a_4\; c_2e^{c_1(d+\,)}\; 1}\; e^{i(kx+\;t+\,)};\; c_1 \quad > 0: \quad (16)$$

$$q_{14}(x;t) = \frac{2a_3c_2e^{c_1(d+\,)}}{3a_4\; c_2e^{c_1(d+\,)} + 1}\; e^{i(kx+\;t+\,)};\; c_1 \quad < 0: \quad (17)$$

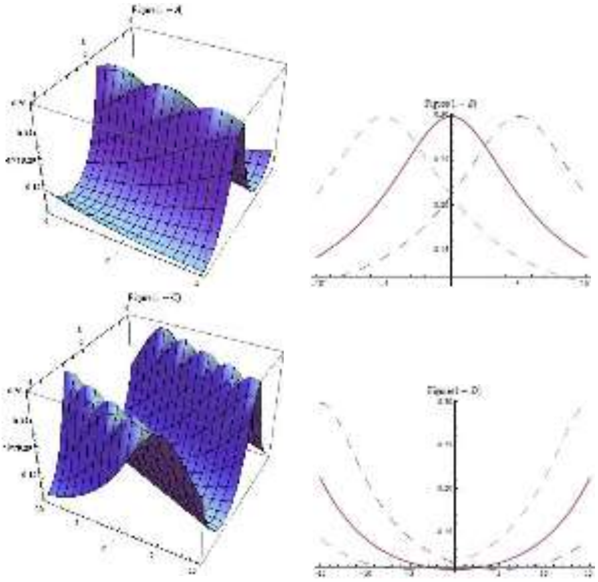

Figure 1: *Solitons are drawn in different forms of Case 1 solutions.*

Case 2: $c_1 = c_3 = 0$,

$$= \;a_3\;\; 9a_4\;\; a_1k^2(3 \; + 3 \; + 2\,m + 2m\,)$$
$$+k(3k\,(\;+\;) + 2m(\;+\;)(\;+k\,)) \quad (\;+ +2\,m + 2m\,))\;\; 2a_3^2(\;+\;+ 2\,m +2m\,))) = 27\,p\;\overline{2a_4k(\;+\;)}\;\overline{a_4c_0c_2\,(a_1 + a_2\;\;)};$$
$$b_{2} = b_{1} = 0;\; b_0 = \frac{a_3\;\, p\;\overline{c_0}}{3a_4};\; b_1 = \frac{ia_3\; p\;\overline{c_2}}{3a_4\;\, p\;\overline{c_0}};\; b_2 = 0;\; = \frac{a_3}{3\;\; 2a_4c_0c_2\,(a_1 + a_2\;\;\;)}: \qquad (18)$$

$$b_{2} = b_{1} = 0;\; b_0 = \frac{a_3\,p\;\overline{c_0}}{3a_4};\; b_1 = \frac{ia_3\; p\,\overline{c_2}}{3a_4\;\, p\;\overline{c_0}};\; b_2 = 0;\; = \frac{a_3}{p\;\overline{3\,2}\;\; p\;\overline{a_4c_0c_2\,(\,a_1\;\;2 +\,)}};$$
$$+\,) + 2m(\;+\;)(\;+k\,))\;\;{}^2(3\; + 3\; + 2\,m + 2m\,) + k(3k\,(\;+\;+ 2\,m + 2m\,))$$
$$2a_3^2(\;+\;+ 2\,m + 2m\,) \;=\; 27\,p\;\overline{2}a_4k(\,+\,)\;p\;\overline{a_4c_0c_2\,(\;a_1\quad 2 + \;)}\;: \qquad (19)$$

The following solitary wave solutions of Eq.(1) are obtained from solution (18) as:

$$q_{21}(x;t) = \frac{a_3\;\; 1 + i\tan\;\; p\,\overline{c_0c_2}\,(d + \;)}{3a}\; e^{i(kx+\;t+\,)};\quad \overline{c\;c}\;{}_{0\;\,2} > 0: \qquad (20)$$

$$q_{22}(x;t) = \frac{3\;\; 3a_4}{ia\quad \tan\;\; p\,\overline{c\,c}_{0\,2}\,(d + \;)\qquad i}\; e^{i(kx+\;t+\,)}:\quad c_0c_2 \;< 0: \qquad (21)$$

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More solutins in the form of solitary wave solutions are constructed of equation (1) from solution (19) as

$$q_{23}(x;t) = \frac{ia \quad \tan \quad \overline{c}\, p\, \overline{c}\,(d+\ ) \quad +i}{3 \quad p \quad {}^{0}3a_4{}^{2}} \quad e^{(i(kx+\ t+\ }; \qquad c_0c_2 > 0: \qquad (22)$$

$$q_{24}(x;t) = \frac{3 \quad p \quad {}^{0}3a_4{}^{2}}{ia \quad \tan \quad {}_{c}\ p\, c\ (d+\ ) \quad +i} \quad e^{(i(kx+\ t+\ }; \qquad c_0c_2 < 0: \qquad (23)$$

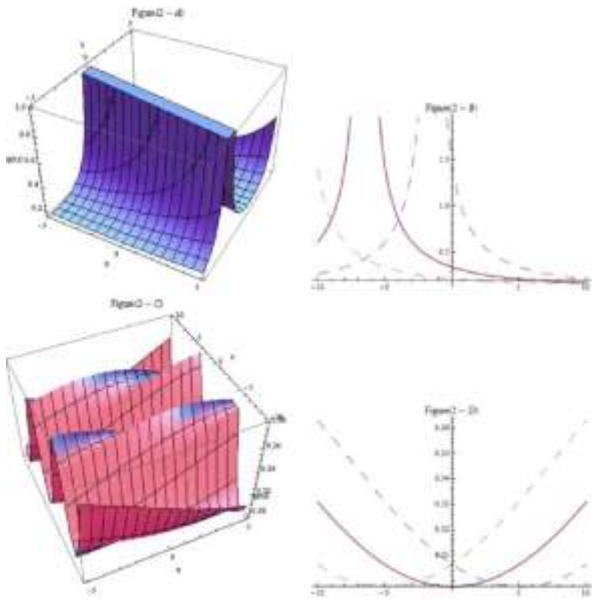

Figure 2: *Solitary wave and soliton in various forms are plotted of Case 2 solutions.*

Case 3: $c_3 = 0$,

$$b_2 = b_1 = 0;\ b_0 = \frac{3c_1 \ p\ \overline{2a_4}\, p\ \overline{a_1 \quad a_2 +\qquad + 2a_3}}{6a_4};$$

$$b_1 = \frac{p\ \overline{2c_2}\ \ \overline{a_1 \quad a_2}}{p\ \overline{a_4}};\ c_0 = \frac{9a_4{}^2 c_1{}^2 (\quad a_1 \quad a_2) \quad 2a_3{}^2}{36a_4{}^2 c_2 (\quad a_1 \quad a_2)};$$

$$b_2 = 0;\ \ {}_{+2m+2} = \ 2a_3{}^2(\ +\ +2\ m+2m\ )\ \ 9a_4\ \ a_1k^2 \qquad (3\ +3$$
$$m\ )+k(3k\ (\ +\ )+2m(\ +\ )(\ +k\ ))$$
$$(\ +\ +2\ m+2m\ )))) = (9a_4k(\ +\ ))\ : \qquad (24)$$

$$b_2 = b_1 = 0;\ b_0 = \frac{3p\ \overline{2a_4}\, c_1 \ p\ \overline{a_1 \quad a_2 \qquad 2a_3}}{6a_4};$$

$$b_1 = \frac{p\ \overline{2c_2}\ \ \overline{a_1 \quad a_2}}{p\ \overline{a_4}};\ c_0 = \frac{9a_4{}^2 c_1{}^2 (\quad a_1 \quad a_2) \quad 2a_3{}^2}{36a_4{}^2 c_2 (\quad a_1 \quad a_2)};$$

$$b_2 = 0;\ \ {}_{+2m+2} = \ 2a_3{}^2(\ +\ +2\ m+2m\ )\ \ 9a_4\ \ a_1k^2 \qquad (3\ +3$$
$$m\ )+k(3k\ (\ +\ )+2m(\ +\ )(\ +k\ ))$$
$$(\ +\ +2\ m+2m\ )))) = (9a_4k(\ +\ ))\ : \qquad (25)$$

We achieve the following exact solution of equation (1) from solutions (24) and (25) as

$$q_{31}(\ ) = \frac{3\ p\ \overline{2a_4(\quad a_1 \quad a_2)}}{p\ \overline{c \quad c^2}} \quad q\ \overline{4c_0c_2 \quad c_1{}^2}\ \tan\left(\frac{(d+\ )^{!}}{2c_1}\right) \frac{!}{2a_3} = (6a_4)\ e^{!};$$

$$4c_0c_2 > c_1^2: \qquad (26)$$

$$q_{32}(\ ) = 0\ \ B\ \frac{\rho\ \overline{4c_0c_2 \quad c_1{}^2}\ p\ \ a_1 \quad a_2 \tan \quad \overline{p\,4c_0c_2 \quad c^2}\,(d+\ )}{p\ \overline{2}\ \rho\ \overline{a_4}}$$

$$@ \quad \frac{e^{i(kx+\ t+\ )}}{a_3};\ 4c_0c_2 > c_1^2: \qquad (27)$$

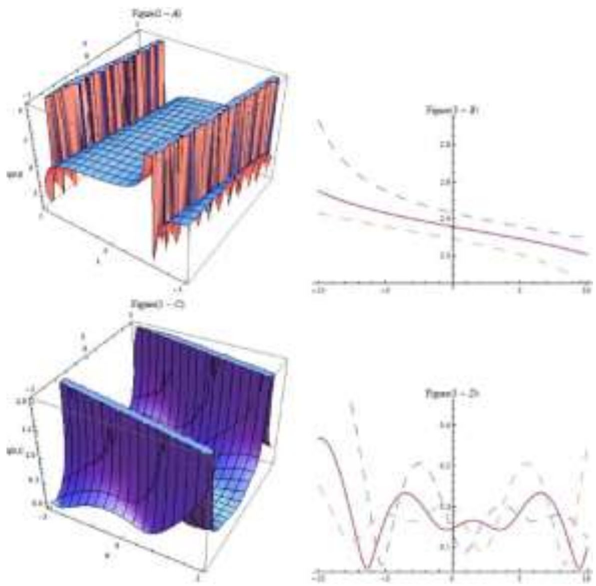

Figure 3: *Different shapes of solitary wave solutions are drawn of Case 3.*

Case 4: $c_0 = c_2 = 0$,

$$b_2 = b_1 = 0;\ b_0 = \frac{2a_3}{3a_4};\ b_1 = 0;$$

$$b_2 = \frac{2a_3c_3}{3a_4c_1};\ = \frac{ia_3}{3\ \rho\ \overline{2a_4c_1{}^2\ (a_1+a_2\qquad)}};$$

$$=\ ia_3\ \ 9a_4\ \ a_1k^2(3\ +3\ +2\ m+2m\ )$$
$$+k(3k\ (\ +\ )+2m(\ +\ )(\qquad +k\ )) \qquad (\ +$$
$$+2\ m+2m\ ))\ \ 2a\ \ \frac{3^2(\ +}{{}_2+2\ m+2m\ )}$$

$$=\ 27\ p\ \ 2a_4k(\ +\ )^{q}\ a_4c_1(\ a_1 \quad a_2+\ )\ : \qquad (28)$$

$$b_2 = b_1 = 0;\ b_0 = \frac{2a_3c_3n_2}{3a_4c_1};\ b_1 = 0;$$

$$b_2 = \frac{2a_3c_3}{3a_4c_1};\ = \frac{ia_3}{3p\ 2a_4c_1^2\ (a_1 + \ 2\ )};$$

$$= \ ia_3\ \ 9a_4\ \ a_1k^2(3\ \ +3\ \ +2\ m + 2m\ )$$
$$+k(3k\ (\ +\ ) + 2m(\ +\ )(\ +k\ ))\ (\ +\ +2\ m + 2m\ ))$$
$$2a_3^2(\ +\ +2\ m + 2m\ )$$

$$= 27\ \ p\ 2a_4k(\ +\ )\ q\ \overline{a_4c_1^2\ (\ a_1\ \ 2 + \ )}: \quad (29)$$

The following solutions in the form of solitary wave are constructed from solution (28) of equation (1) as

$$q_{41}(\ ) = \frac{2a_3\ \ c_1(c_3e^{2c_1}\ \ 1)\ \ 1}{3a_4}e^{'};\ c_1 > 0: \quad (30)$$

$$q_{42}(\ ) = \frac{2a_3\ \ \frac{2(p\ \ c\ \ +1)c}{c_1(e^{2c_1}\ \ c_3)}\ \ 1}{3a_4}\ e^{'};\ c_1 < 0: \quad (31)$$

In the similar way, more exact solutions of equation (1) are also obtained from solution (29) as

$$q_{43}(x;t) = \frac{2a_3c_3e^{2c_1}\ ^{3=2}}{3a_4c_1\ \ 3a_4c_1c_3e}\ e^{i(kx+\ t+\ )} \quad (32)$$

$$q_{44}(x;t) = \frac{2a_3c_3e^{2(p\ \ c_1\ \ +1)c_1}}{3a_4c_1\ (e^{2c_1}\ \ c_3)}\ e^{i(kx+\ t+\ )}: \quad (33)$$

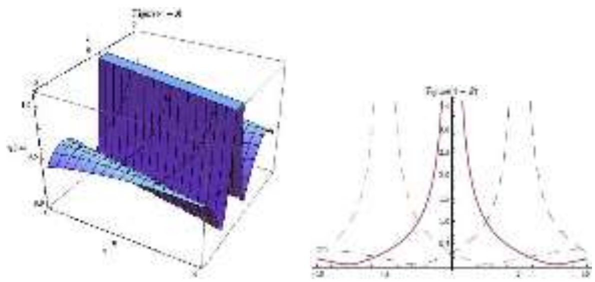

Figure 4: *Solitary wave solution in different forms is drawn of Case 4 solution.*

5 Modulation Instability

Several higher order nonlinear models demonstrating an instability that guides to investigate the steady state mod-ulation as a result of the interrelation among the nonlinear and dispersive effects. To attain the MI of model (1) through utilizing the standard linear stability analysis [5–7, 28] to study how weak and time-dependent perturbations create on the promulgation distance. The solution in study state form of NLSE as

$$q(x;t) = \ \ P_1^2\ +\ (x;t)\ \ e^{'(t)};\ \ (t) = P\ \ t; \quad (34)$$

where optical power P is normalized. The perturba-tion (x; t) is investigate by using linear stability analysis.

Putting equation (34) into equation (1) and linearizing, yield

$$4i\frac{@}{@t}\ 4i\ \ \frac{@}{@x} + 4a_1\frac{@^2}{@x^2}\ \ \ + 4P\ ((2a_4)\ \ + a_4\ \ ) = 0; \quad (35)$$

where represents complex conjugate. Assume the solution of equation (35) in the form as

$$(x;t) = \ _1e^{i(\ x\ \ !t)} + \ _2e^{\ i(\ x\ \ !t)}; \quad (36)$$

where the normalized wave number and frequency of pertur-bation are and !. The dispersion relation (DR) ! = !( ) of a constant coefficient linear equation decides how time oscillations $e^{i\ x}$ are associated to spatial oscillations $e^{i!t}$ of wave number . Putting equation (36) in equation (35), we obtained the following DR as

$$! = \ \ p\ \overline{(a_1\ ^2\ \ 3a_4P + \ P\ )\ (a_1\ ^2\ \ a_4P + \ P\ )} \quad (37)$$

The relation (37) discloses the steady state stability depends on the self phase modulation, wave number ! and stimulated Raman scattering. If the expres-sion $a_1\ ^2\ \ 3a_4P + \ P\ \ \ a_1\ ^2\ \ a_4P + \ P\ \ \ 0$, its mean that the ! is real for all , then the steady state is stable against small perturbations. Otherwise the steady state becomes unstable if the expression $a_1\ ^2\ \ 3a_4\ P + \ P\ \ \ a_1\ ^2\ \ a_4P + \ P\ ) < 0$. One $^2\ 3a_4P + \ P\ \ \ ^2$ this circumstance, the growth rate of MI gain spectrum could be articulated as

$$h(\ ) = 2Im(\ )$$
$$= 2\ p\ \overline{(a_1\ ^2\ \ 3a_4P + \ P\ )\ (a_1\ ^2\ \ a_4P + \ P\ )}: \quad (38)$$

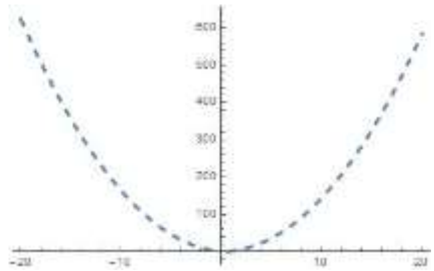

Figure 5: *The graph of dispersion relation* ! = !( ).

6 Results and Discussion

The achieved exact solutions via the proposed scheme are dissimilar from the constructed solutions of different re-searchers through existing techniques due to the supposed equation (6) of the proposed scheme is different from the existing schemes. Various special form of solutions such as trigonometric, hyperbolic trigonometric and rational func-tions are achieved of equation (6) by grants special values to parameters. The researchers in [45] employed semi-inverse variational principle to obtain resonant soliton solutions of equation (1). So, our achieved analytical solutions are novel and have not constructed in literature.

The Figure 1 illustrates exact Solitons in diﬀerent forms are pinched of Case 1. The figure(1-A) and (1-C) demon-strate the bright soliton and periodic aoliton of solutions
(14) and (15) respectively, and the figure(1-B) and figure(1-D) evaluate of same solutions in one-dimension at same values of parameters.

The Figure 2 indicates Solitary wave and solitions in diﬀer-ent forms are plotted drawn. The figure(2-A) and figure(2-C) illustrates the solitary wave and soliton of solutions (20) and (21) respectively, and the Figure(2-B) and Figure(2-D) evaluate of the same solutions in one-dimension at same values of parameters.

The Figure 3 indicates exact Solitary waves in diﬀerent shapes are drawn. The figure(3-A) and figure(3-C) illus-trates the periodic solitary waves of solutions (26) and (27) respectively, and the Figure(3-B) and Figure(3-D) evaluate of the same solutions in one-dimension at same values of parameter.

The Figure 4 evaluate Solitary wave in various shapes are plotted. The Figures(4-A) show solitary wave of solu-tion (31) and the Figure(4-B) signify same solution in one-dimension at same values of parameter. The DR ! = !( ) between frequency ! and wave number of perturbation is presented in Figure 5.

7 Conclusion

We have been eﬀectively utilized the modified ex-tended simple equation technique to get optical soliton and solitary wave solution to the resonant NLSE with quadratic-cubic nonlinearity that have key application in engineering, physics and applied Mathematics. The stability of model is inspected by employing the MI analysis, which shows that the achieved exact solutions are stable. we have also shown the some obtained solutions graphically, which facili-tates to recognize the physical phenomena of this nonlinear model. All the achieved results are novel and does not exist in literature also. The power of current method shows it can be applied in future to solve many problems arises in engineering and applied physics.

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