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Dispersive solitary wave solutions of new coupled Konno-Oono, Higgs field and Maccari equations and their applications

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ABSTRACT

In this research we apply generalized Exp-Function method to obtain exact, solitary and new soliton wave solutions of new coupled Konno-Oono equation, Higgs field equation and Maccari equation via generalized Exp-Function method which are very substantial models in define a current-fed string interacting with an external magnetic field in three-dimensional Euclidean space, introduces quantum field (or the Higgs field) to illustrate the generation mechanism of mass for gauge bosons and described the motion of the isolated waves, localized in a small part of space, in many fields such as hydrodynamic, plasma physics, nonlinear optics and others. generalized Exp-Function method is very sturdy, fabulous, felicitous and effective method to get exact, solitary and new soliton wave solution of nonlinear partial differential equations (PDEs.). We present a contrasting between the results of this modern method and another method and show that how the results that obtained by this method is much closed to cover many different methods in this field and not just that but also get a new solitary and soliton wave solutions which give a wide range of solutions that help all researchers who apply these models in our life.

1. Introduction

From the beginning of the universe, there exist many of phenomenal phenomena in different fields in the life for example (Mathematical Physics, Biology, Chemistry, fluid mechanics, hydrodynamics, optics, and plasma physics and so on, but because of ignorance of the causes of these phenomena and do not know even how to occur or how to make use of them. Humanity has been lagging behind in scientific progress. This is the Dark Age continued until the emergence of partial differential equations (PDEs.) which can represent many of these phenomena. However all of these but still the problem persists as we cannot understand what is the physical meaning of these phenomena. In 1965 when Zabusky & Kruskal introduced the mean of soliton and showed how possible that every natural phenomena in different fields which help us to know a lot of information about the physical meaning of these phenomena. From this day, the scientific race began between all scientists and researchers to discover suitable methods to solve these phenomena to be able to apply in our life for example the $\left(\frac{G'}{G}\right)$ – expansion method, Novel $\left(\frac{G'}{G}\right)$ – expansion method, modified $\left(\frac{G'}{G}\right)$ – expansion method, the $\left(\frac{G'}{G},\frac{1}{G}\right)$ – expansion method, the $e^{-\phi(\xi)}$ – expansion method, extended $e^{-\phi(\xi)}$ – expansion method, the extended tanh-function method, the Kudryashov, modified Kudryashov methods, The improved $\tan\left(\frac{\phi}{2}\right)$ – expansion method, modified simple equation method and so on (Seadawy, 2014, 2017; Arshad et al., 2016; Liu et al., 2001; Naher et al., 2012; Seadawy et al., 2017a,b,c,d; Yang et al., 2016, 2017a,b; Lu et al., 2017a,b; Ebaid, 2007; Pava, 2007; El-Wakil and Abdou, 2007; Wazwaz, 2004; Khater, 2015; Gao et al., 2017; Lee and Sakthivel, 2013, 2014; Chun and Sakthivel, 2010; Zhou et al., 2003; Seadawy and Mostafa, 2017). Generalized Exp-Function method is considered the latest method in this area as it just discovered from just one year and also it contain the results of some methods so that, these methods can be considered as special case of Generalized Exp-Function method.

In this research, we treat with three important models in three different fields to get traveling wave solutions of these models by

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using Generalized Exp-Function method and for further information and steps of Generalized Exp-Function method; you can see Khater et al. (2017). These equations called new coupled Konno-Oono equation, Higgs field equation, and Maccari equation. In the following order, we give an introduction for each one of them. Firstly: new coupled Konno-Oono equation which defines a current-fed string interacting with an external magnetic field in three-dimensional Euclidean space (Konno and Oono, 1994; Konno and Kakuhata, 1995; Souleymanou et al., 2012). In 1990, Konno and Oono (1994) presented more general version of coupled integrable dispersionless system defined as

$$\begin{cases} q_{xt} - 2\alpha q r_x - 2\beta q s_x + \gamma(rs)_x = 0, \\ r_{xt} - \alpha r r_x - 2\beta(2qq_x + r_x s) - 2\gamma q_x r = 0, \\ s_{xt} - 2\beta s s_x + 2\alpha(2qq_x + rs_x) - 2\gamma s q_x = 0, \end{cases} \tag{1.1}$$

where (α, β, γ) are arbitrary constants. This system appears geometrically as the parallel transport of each point of the curve along the direction of time where the connection is magnetic-valued (Khalique, 2012). When special values of some coefficients is taken in Eq. (1.1a), this system converted into new Konno-Oono equation system which is a coupled integrable dispersionless equations as following:

$$\begin{cases} v_t + 2uu_x = 0, \\ u_{xt} - 2vu = 0, \end{cases} \tag{1.2}$$

where $(u\&v)$ are functions in (x, t). This new Konno-Oono equation system attract attention some scientist from all over the world. They have investigated this model in terms of new and different properties by using some mathematical approaches.

Secondly: A complex couple Higgs field equation which introduces quantum field (or the Higgs field) to illustrate the generation mechanism of mass for gauge bosons (Hon and Fan, 2009; Hase and Satsuma, 1988). The general form of the complex couple Higgs field equation be in the following from

$$\begin{cases} u_{tt} - u_{xx} - \alpha_1 u + \beta_1 |u|^2 u - 2uv = 0, \\ v_{tt} + v_{xx} - \beta_1 (|u|^2)_{xx} = 0, \end{cases} \tag{1.3}$$

where $\beta_1 \& \alpha_1$ are arbitrary constant.

Thirdly: The $(2+1)$-dimensional nonlinear complex coupled Maccari equations are the second complex coupled equations that will be discussed. The complex coupled Maccari equations is a nonlinear evolution equation described the motion of the isolated waves, localized in a small part of space, in many fields such as hydrodynamic, plasma physics, nonlinear optics and others (Rostamy et al., 2011; Zhao, 2008; Arshad et al., 2017; Jabbari et al., 2011; Bekir, 2009). Complex coupled Maccari equation derived from the Kadomtsev–Petviashvili equation (the best known two-dimensional generalizations of the KdV equation) and can be written in the form

$$\begin{cases} iu_t + u_{xx} + uv = 0, \\ v_t + v_y + (|u|^2)_x = 0. \end{cases} \tag{1.4}$$

This equation is called integrable $(2+1)$-dimensional nonlinear Maccari system (Maccari, 1996).

The remnant of this paper is systematized as follows: In Section 2, we apply generalized Exp-Function method to get the exact solutions of (NLPDEs.) pointed out above. In Section 3, we illustrate our solutions and what is the difference between our results and that obtained by using different methods and also what is the new in this paper which makes our paper is suitable for publication. In Section 4, conclusions are given.

2. Application

In this section, we apply generalized Exp-Function method for these three models (new coupled Konno-Oono equation, Higgs field equation and Maccari equation) and also we show the exact traveling wave solutions and solitary wave solutions of each one of these models.

2.1. New coupled Konno-Oono equation

By using traveling wave transformation $u(x,t) = u(\xi)\&v(x,t) = v(\xi)$ where $\xi = k(x - ct)$ on Eq. (1.2), we obtain:

$$\begin{cases} -ckv' + 2kuu' = 0, \\ -ck^2 u'' - 2uv = 0. \end{cases} \tag{2.1.1}$$

Integrating first equation in the system (2.1.1) and submit the result into second equation in the same system, we obtain

$$\rho u'' + 2u^3 + 2\delta u = 0, \tag{2.1.2}$$

where $(\delta \& \rho = c^2 k^2)$ are a constant of integration. Balance the highest order derivatives and nonlinear terms appearing in Eq. (2.1.2) $\Rightarrow (u'' \& u^3) \Rightarrow (N = 1)$. So that, by using Generalized Exp-Function method, we get the exact solution of Eq. (2.1.2) be in the following form:

$$u(\xi) = a_0 + a_1 a^{f(\xi)}. \tag{2.1.3}$$

Substituting (2.1.3) and its derivative into Eq. (2.1.2) and collecting all term with the same power of $[a^{if(\xi)}$ where $i = 0, 1, 2, 3]$, we get the system of algebraic equations by solving it, we obtain:

$$\rho = \frac{-a_1^2}{\sigma^2}, \quad \delta = \frac{a_1^2(-\beta^2 + 4\alpha\sigma)}{4\sigma^2}, \quad a_0 = \frac{a_1 \beta}{2\sigma}, \quad a_1 = a_1.$$

So that, the exact traveling wave solution will be in the form:

$$u(\xi) = \frac{a_1 \beta}{2\sigma} + a_1 a^{f(\xi)}. \tag{2.1.4}$$

Thus, the solitary traveling wave solutions:

When $(\beta^2 - \alpha\sigma < 0 \& \sigma \neq 0)$

$$u(\xi) = \frac{a_1 \beta}{2\sigma} + a_1 \left[\frac{-\beta}{\sigma} + \frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{\sigma} tan \left(\frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{2} \xi \right) \right], \tag{2.1.5}$$

or

$$u(\xi) = \frac{a_1 \beta}{2\sigma} + a_1 \left[\frac{-\beta}{\sigma} + \frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{\sigma} cot \left(\frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{2} \xi \right) \right]. \tag{2.1.6}$$

When $(\beta^2 - \alpha\sigma > 0 \& \sigma \neq 0)$

$$u(\xi) = \frac{a_1 \beta}{2\sigma} + a_1 \left[\frac{-\beta}{\sigma} - \frac{\sqrt{(\beta^2 - \alpha\sigma)}}{\sigma} tanh \left(\frac{\sqrt{(\beta^2 - \alpha\sigma)}}{2} \xi \right) \right], \tag{2.1.7}$$

or

$$u(\xi) = \frac{a_1 \beta}{2\sigma} + a_1 \left[\frac{-\beta}{\sigma} - \frac{\sqrt{(\beta^2 - \alpha\sigma)}}{\sigma} coth \left(\frac{\sqrt{(\beta^2 - \alpha\sigma)}}{2} \xi \right) \right]. \tag{2.1.8}$$

When $(\beta^2 - \alpha^2 > 0 \& \sigma \neq 0 \& \sigma = -\alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{\beta^2+\alpha^2}}{\alpha} tanh\left(\frac{\sqrt{\beta^2+\alpha^2}}{2}\xi\right)\right], \quad (2.1.9)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{\beta^2+\alpha^2}}{\alpha} coth\left(\frac{\sqrt{\beta^2+\alpha^2}}{2}\xi\right)\right]. \quad (2.1.10)$$

When $(\beta^2 - \alpha^2 < 0 \& \sigma \neq 0 \& \sigma = -\alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2+\alpha^2)}}{\alpha} tan\left(\frac{\sqrt{-(\beta^2+\alpha^2)}}{2}\xi\right)\right], \quad (2.1.11)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2+\alpha^2)}}{\alpha} cot\left(\frac{\sqrt{-(\beta^2+\alpha^2)}}{2}\xi\right)\right]. \quad (2.1.12)$$

When $(\beta^2 - \alpha^2 < 0 \& \sigma \neq 0 \& \sigma = \alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2-\alpha^2)}}{\alpha} tan\left(\frac{\sqrt{-(\beta^2-\alpha^2)}}{2}\xi\right)\right], \quad (2.1.13)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2-\alpha^2)}}{\alpha} cot\left(\frac{\sqrt{-(\beta^2-\alpha^2)}}{2}\xi\right)\right]. \quad (2.1.14)$$

When $(\beta^2 - \alpha^2 > 0 \& \sigma \neq 0 \& \sigma = \alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{(\beta^2-\alpha^2)}}{\alpha} tanh\left(\frac{\sqrt{(\beta^2-\alpha^2)}}{2}\xi\right)\right], \quad (2.1.15)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{(\beta^2-\alpha^2)}}{\alpha} coth\left(\frac{\sqrt{(\beta^2-\alpha^2)}}{2}\xi\right)\right]. \quad (2.1.16)$$

When $(\alpha\sigma < 0 \& \sigma \neq 0 \& \beta = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\sqrt{\frac{-\alpha}{\sigma}} tanh\left(\frac{\sqrt{-\alpha\sigma}}{2}\xi\right)\right]. \quad (2.1.17)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\sqrt{\frac{-\alpha}{\sigma}} coth\left(\frac{\sqrt{-\alpha\sigma}}{2}\xi\right)\right]. \quad (2.1.18)$$

When $(\beta = 0 \& \alpha = -\sigma)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-(1+e^{2\alpha\xi}) \pm \sqrt{2(e^{4\alpha\xi}+1)}}{e^{2\alpha\xi}-1}\right], \quad (2.1.19)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-(1+e^{2\alpha\xi}) \pm \sqrt{e^{4\alpha\xi}+6e^{2\alpha\xi}+1}}{e^{2\alpha\xi}}\right]. \quad (2.1.20)$$

When $(\alpha = \sigma = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-(1+e^{2\beta\xi}) \pm \sqrt{2(e^{4\beta\xi}+1)}}{e^{2\beta\xi}-1}\right], \quad (2.1.21)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-(1+e^{2\beta\xi}) \pm \sqrt{e^{4\beta\xi}+6e^{2\beta\xi}+1}}{e^{2\beta\xi}}\right]. \quad (2.1.22)$$

When $(\beta^2 = \alpha\sigma)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + \frac{-\alpha a_1(\beta\xi+2)}{\beta^2\xi}. \quad (2.1.23)$$

When $(\beta = k \& \alpha = 2k \& \sigma = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1[e^{k\xi}-1]. \quad (2.1.24)$$

When $(\beta = k \& \sigma = 2k \& \alpha = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + \frac{a_1 e^{k\xi}}{1-e^{k\xi}}. \quad (2.1.25)$$

When $(2\beta = \alpha + \sigma)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{1-\alpha e^{0.5(\alpha-\sigma)\xi}}{1-\sigma e^{0.5(\alpha-\sigma)\xi}}\right], \quad (2.1.26)$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\alpha e^{0.5(\alpha-\sigma)\xi}+1}{-\sigma e^{0.5(\alpha-\sigma)\xi}-1}\right]. \quad (2.1.27)$$

When $(-2\beta = \alpha + \sigma)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{e^{0.5(\alpha-\sigma)\xi}+\alpha}{e^{0.5(\alpha-\sigma)\xi}+\sigma}\right]. \quad (2.1.28)$$

When $(\alpha = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + \frac{\beta a_1 e^{\beta\xi}}{1+0.5\sigma e^{\beta\xi}}. \quad (2.1.29)$$

When $(\beta = \alpha = \sigma \neq 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} - \frac{a_1(\alpha\xi+2)}{\alpha\xi}. \quad (2.1.30)$$

When $(\beta = \sigma = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + 0.5\alpha a_1\xi. \quad (2.1.31)$$

When $(\beta = \alpha = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} - \frac{2a_1}{\sigma\xi}. \quad (2.1.32)$$

When $(\beta = 0 \& \alpha = \sigma)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1 tan(\frac{\alpha\xi+C}{2}). \quad (2.1.33)$$

When $(\sigma = 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1[e^{\beta\xi} - \frac{\alpha}{2\beta}]. \quad (2.1.34)$$

Where k, C are arbitrary constant.

2.2. Higgs field equation

Using the traveling wave transformation $[u(x,t) = e^{i\theta}U(\xi), v(x,t) = V(\xi)]$ where $[\xi = x + ct \& \theta = px + rt]$, on Eq. (1.3), we obtain:

$$\begin{cases} (c^2-1)U'' + (p^2 - r^2 - \alpha_1)U + \beta_1 U^3 - 2UV = 0, \\ (c^2+1)U' - 2\beta_1 (U')^2 - 2\beta_1 UU'' = 0. \end{cases} \tag{2.2.1}$$

Integrate the second equation of the system twice with zero constant of integration and submit the result in first equation in the system, we get

$$AU'' + BU + CU^2 = 0, \tag{2.2.2}$$

where $[A = (c^4 - 1)\&B = (p^2 - r^2 - \alpha_1)\&C = \beta_1(c^2 - 1)]$. Balance the highest order derivatives and nonlinear terms appearing in Eq. (2.2.2) $\Rightarrow (U''\&U^3) \Rightarrow (N = 1)$. So that, by using Generalized Exp-Function method, we get the exact solution of Eq. (2.2.2). That solutionis the same solution of Eq. (2.1.2) and is in the form (2.1.3). Substituting (2.1.3) and its derivative into Eq. (2.2.2) and collecting all term with the same power of $[a^{if(\xi)}$ where $i = 0, 1, 2, 3]$, we get the system of algebraic equations by solving it, we obtain:

$$B = \frac{-2A\sigma(-a_0^2\sigma + \alpha a_1^2)}{a_1^2}, \quad C = \frac{-2A\sigma^2}{a_1^2},$$

$$\beta = \frac{2\sigma a_0}{a_1}, \quad a_0 = a_0, \quad a_1 = a_1.$$

So that, the exact traveling wave solution will be in the form:

$$u(\xi) = a_0 + a_1 a^{f(\xi)}. \tag{2.2.3}$$

Thus, the solitary traveling wave solutions:

When $(\beta^2 - \alpha\sigma < 0\&\sigma\neq 0)$

$$u(\xi) = a_0 + a_1\left[\frac{-\beta}{\sigma} + \frac{\sqrt{-(\beta^2-\alpha\sigma)}}{\sigma} tan\left(\frac{\sqrt{-(\beta^2-\alpha\sigma)}}{2}\xi\right)\right], \tag{2.2.4}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{-\beta}{\sigma} + \frac{\sqrt{-(\beta^2-\alpha\sigma)}}{\sigma} cot\left(\frac{\sqrt{-(\beta^2-\alpha\sigma)}}{2}\xi\right)\right]. \tag{2.2.5}$$

When $(\beta^2 - \alpha\sigma > 0\&\sigma\neq 0)$

$$u(\xi) = a_0 + a_1\left[\frac{-\beta}{\sigma} - \frac{\sqrt{(\beta^2-\alpha\sigma)}}{\sigma} tanh\left(\frac{\sqrt{(\beta^2-\alpha\sigma)}}{2}\xi\right)\right], \tag{2.2.5}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{-\beta}{\sigma} - \frac{\sqrt{(\beta^2-\alpha\sigma)}}{\sigma} coth\left(\frac{\sqrt{(\beta^2-\alpha\sigma)}}{2}\xi\right)\right]. \tag{2.2.6}$$

When $(\beta^2 - \alpha^2 > 0\&\sigma\neq 0\&\sigma = -\alpha)$

$$u(\xi) = a_0 + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{\beta^2+\alpha^2}}{\alpha} tanh\left(\frac{\sqrt{\beta^2+\alpha^2}}{2}\xi\right)\right], \tag{2.2.7}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{\beta^2+\alpha^2}}{\alpha} coth\left(\frac{\sqrt{\beta^2+\alpha^2}}{2}\xi\right)\right]. \tag{2.2.8}$$

When $(\beta^2 - \alpha^2 < 0\&\sigma\neq 0\&\sigma = -\alpha)$

$$u(\xi) = a_0 + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2+\alpha^2)}}{\alpha} tan\left(\frac{\sqrt{-(\beta^2+\alpha^2)}}{2}\xi\right)\right], \tag{2.2.9}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2+\alpha^2)}}{\alpha} cot\left(\frac{\sqrt{-(\beta^2+\alpha^2)}}{2}\xi\right)\right]. \tag{2.2.10}$$

When $(\beta^2 - \alpha^2 < 0\&\sigma\neq 0\&\sigma = \alpha)$

$$u(\xi) = a_0 + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2-\alpha^2)}}{\alpha} tan\left(\frac{\sqrt{-(\beta^2-\alpha^2)}}{2}\xi\right)\right], \tag{2.2.11}$$

or

$$u(\xi) = a_0 + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2-\alpha^2)}}{\alpha} cot\left(\frac{\sqrt{-(\beta^2-\alpha^2)}}{2}\xi\right)\right]. \tag{2.2.12}$$

When $(\beta^2 - \alpha^2 > 0\&\sigma\neq 0\&\sigma = \alpha)$

$$u(\xi) = a_0 + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{(\beta^2-\alpha^2)}}{\alpha} tanh\left(\frac{\sqrt{(\beta^2-\alpha^2)}}{2}\xi\right)\right], \tag{2.2.13}$$

or

$$u(\xi) = a_0 + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{(\beta^2-\alpha^2)}}{\alpha} coth\left(\frac{\sqrt{(\beta^2-\alpha^2)}}{2}\xi\right)\right]. \tag{2.2.14}$$

When $(\alpha\sigma < 0\&\sigma\neq 0\&\beta = 0)$

$$u(\xi) = a_0 + a_1\left[\sqrt{\frac{-\alpha}{\sigma}} tanh\left(\frac{\sqrt{-\alpha\sigma}}{2}\xi\right)\right], \tag{2.2.15}$$

or

$$u(\xi) = a_0 + a_1\left[\sqrt{\frac{-\alpha}{\sigma}} coth\left(\frac{\sqrt{-\alpha\sigma}}{2}\xi\right)\right]. \tag{2.2.16}$$

When $(\beta = 0\&\alpha = -\sigma)$

$$u(\xi) = a_0 + a_1\left[\frac{-(1+e^{2\alpha\xi}) \pm \sqrt{2(e^{4\alpha\xi}+1)}}{e^{2\alpha\xi}-1}\right], \tag{2.2.17}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{-(1+e^{2\alpha\xi}) \pm \sqrt{e^{4\alpha\xi}+6e^{2\alpha\xi}+1}}{e^{2\alpha\xi}}\right]. \tag{2.2.18}$$

When $(\alpha = \sigma = 0)$

$$u(\xi) = a_0 + a_1\left[\frac{-(1+e^{2\beta\xi}) \pm \sqrt{2(e^{4\beta\xi}+1)}}{e^{2\beta\xi}-1}\right], \tag{2.2.19}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{-(1+e^{2\beta\xi}) \pm \sqrt{e^{4\beta\xi}+6e^{2\beta\xi}+1}}{e^{2\beta\xi}}\right]. \tag{2.2.20}$$

When $(\beta^2 = \alpha\sigma)$

$$u(\xi) = a_0 - \frac{\alpha a_1(\beta\xi+2)}{\beta^2\xi}. \tag{2.2.21}$$

When $(\beta = k\&\alpha = 2k\&\sigma = 0)$

$$u(\xi) = a_0 + a_1[e^{k\xi} - 1]. \tag{2.2.22}$$

When $(\beta = k\&\sigma = 2k\&\alpha = 0)$

$$u(\xi) = a_0 + \frac{a_1 e^{k\xi}}{1-e^{k\xi}}. \tag{2.2.23}$$

When $(2\beta = \alpha + \sigma)$

$$u(\xi) = a_0 + a_1\left[\frac{1 - \alpha e^{0.5(\alpha-\sigma)\xi}}{1 - \sigma e^{0.5(\alpha-\sigma)\xi}}\right], \tag{2.2.24}$$

or

$$u(\xi) = a_0 + a_1\left[\frac{\alpha e^{0.5(\alpha-\sigma)\xi} + 1}{-\sigma e^{0.5(\alpha-\sigma)\xi} - 1}\right]. \tag{2.2.25}$$

When $(-2\beta = \alpha + \sigma)$

$$u(\xi) = a_0 + a_1\left[\frac{e^{0.5(\alpha-\sigma)\xi} + \alpha}{e^{0.5(\alpha-\sigma)\xi} + \sigma}\right]. \tag{2.2.26}$$

When $(\alpha = 0)$

$$u(\xi) = a_0 + \frac{\beta a_1 e^{\beta\xi}}{1 + 0.5\sigma e^{\beta\xi}}. \tag{2.2.27}$$

When $(\beta = \alpha = \sigma \neq 0)$

$$u(\xi) = a_0 - \frac{a_1(\alpha\xi + 2)}{\alpha\xi}. \tag{2.2.28}$$

When $(\beta = \sigma = 0)$

$$u(\xi) = a_0 + 0.5a_1\alpha\xi. \tag{2.2.29}$$

When $(\beta = \alpha = 0)$

$$u(\xi) = a_0 - \frac{2a_1}{\sigma\xi}. \tag{2.2.30}$$

When $(\beta = 0 \& \alpha = \sigma)$

$$u(\xi) = a_0 + a_1 tan\left(\frac{\alpha\xi + C}{2}\right). \tag{2.2.31}$$

When $(\sigma = 0)$

$$u(\xi) = a_0 + a_1\left[e^{\beta\xi} - \frac{\alpha}{2\beta}\right]. \tag{2.2.32}$$

Where k, C are arbitrary constant.

2.3. Maccari equation

Using the traveling wave transformation $[u(x,t) = e^{i\theta}U(\xi) \& v(x,y,t) = V(\xi)]$ where $[\xi = x + y + ct \& \theta = pxqy + rt]$ on Eq. (1.4), we obtain:

$$\begin{cases} c(p^2 + r)U - U'' - UV = 0, \\ (c+1)V' + 2UV' = 0. \end{cases} \tag{2.3.1}$$

Integrate second equation of the system (2.3.1) with zero constant of integration and submit the result into thefirst equation of the same system, we obtain:

$$lU - MU'' + U^3 = 0, \tag{2.3.2}$$

where $[l = (1 - 2p)(p^2 + r) \& M = (1 - 2p)]$. Balance the highest order derivatives and nonlinear terms appearing in Eq. (2.3.2) $\Rightarrow (U'' \& U^3) \Rightarrow (N = 1)$. So that, by using Generalized Exp-Function method, we get the exact solution of Eq. (2.2.2). That solutionis the same solution of Eq. (2.1.2) and is in the form (2.1.3). Substituting (2.1.3) and its derivative into Eq. (2.3.2) and collecting all term with the same power of $[a^{if(\xi)} where i = 0, 1, 2, 3]$, we get the system of algebraic equations by solving it, we obtain:

$$l = \frac{a_1^2(-\beta^2 + 4\alpha\sigma)}{4\sigma^2}, \quad M = \frac{a_1^2}{2\sigma^2}, \quad a_0 = \frac{a_1\beta}{2\sigma}, \quad a_1 = a_1.$$

So that, the exact traveling wave solution will be in the form:

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1 a^{f(\xi)}. \tag{2.3.3}$$

Thus, the solitary traveling wave solutions:
When $(\beta^2 - \alpha\sigma < 0 \& \sigma \neq 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-\beta}{\sigma} + \frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{\sigma} tan(\frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{2}\xi)\right], \tag{2.3.4}$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-\beta}{\sigma} + \frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{\sigma} cot\left(\frac{\sqrt{-(\beta^2 - \alpha\sigma)}}{2}\xi\right)\right]. \tag{2.3.5}$$

When $(\beta^2 - \alpha\sigma > 0 \& \sigma \neq 0)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-\beta}{\sigma} - \frac{\sqrt{(\beta^2 - \alpha\sigma)}}{\sigma} tanh\left(\frac{\sqrt{(\beta^2 - \alpha\sigma)}}{2}\xi\right)\right], \tag{2.3.6}$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{-\beta}{\sigma} - \frac{\sqrt{(\beta^2 - \alpha\sigma)}}{\sigma} coth\left(\frac{\sqrt{(\beta^2 - \alpha\sigma)}}{2}\xi\right)\right]. \tag{2.3.7}$$

When $(\beta^2 - \alpha^2 > 0 \& \sigma \neq 0 \& \sigma = -\alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{\beta^2 + \alpha^2}}{\alpha} tanh\left(\frac{\sqrt{\beta^2 + \alpha^2}}{2}\xi\right)\right], \tag{2.3.8}$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{\beta^2 + \alpha^2}}{\alpha} coth\left(\frac{\sqrt{\beta^2 + \alpha^2}}{2}\xi\right)\right]. \tag{2.3.8}$$

When $(\beta^2 - \alpha^2 < 0 \& \sigma \neq 0 \& \sigma = -\alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2 + \alpha^2)}}{\alpha} tan\left(\frac{\sqrt{-(\beta^2 + \alpha^2)}}{2}\xi\right)\right], \tag{2.3.9}$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2 + \alpha^2)}}{\alpha} cot\left(\frac{\sqrt{-(\beta^2 + \alpha^2)}}{2}\xi\right)\right]. \tag{2.3.10}$$

When $(\beta^2 - \alpha^2 < 0 \& \sigma \neq 0 \& \sigma = \alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2 - \alpha^2)}}{\alpha} tan\left(\frac{\sqrt{-(\beta^2 - \alpha^2)}}{2}\xi]\right)\right], \tag{2.3.11}$$

or

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{-(\beta^2 - \alpha^2)}}{\alpha} cot\left(\frac{\sqrt{-(\beta^2 - \alpha^2)}}{2}\xi\right)\right]. \tag{2.3.12}$$

When $(\beta^2 - \alpha^2 > 0 \& \sigma \neq 0 \& \sigma = \alpha)$

$$u(\xi) = \frac{a_1\beta}{2\sigma} + a_1\left[-\frac{\beta}{\alpha} + \frac{\sqrt{(\beta^2 - \alpha^2)}}{\alpha} tanh\left(\frac{\sqrt{(\beta^2 - \alpha^2)}}{2}\xi\right)\right], \tag{2.3.13}$$

or

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[-\frac{\beta}{\alpha}+\frac{\sqrt{(\beta^2-\alpha^2)}}{\alpha}coth\left(\frac{\sqrt{(\beta^2-\alpha^2)}}{2}\xi\right)\right]. \quad (2.3.14)$$

When $(\alpha\sigma<0\&\sigma\neq0\&\beta=0)$

$$u(\xi)=a_1\left[\sqrt{\frac{-\alpha}{\sigma}}tanh\left(\frac{\sqrt{-\alpha\sigma}}{2}\xi\right)\right], \quad (2.3.15)$$

or

$$u(\xi)=a_1\left[\sqrt{\frac{-\alpha}{\sigma}}coth\left(\frac{\sqrt{-\alpha\sigma}}{2}\xi\right)\right]. \quad (2.3.16)$$

When $(\beta=0\&\alpha=-\sigma)$

$$u(\xi)=a_1\left[\frac{-(1+e^{2\alpha\xi})\pm\sqrt{2(e^{4\alpha\xi}+1)}}{e^{2\alpha\xi}-1}\right], \quad (2.3.17)$$

or

$$u(\xi)=a_1\left[\frac{-(1+e^{2\alpha\xi})\pm\sqrt{e^{4\alpha\xi}+6e^{2\alpha\xi}+1}}{e^{2\alpha\xi}}\right]. \quad (2.3.18)$$

When $(\alpha=\sigma=0)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[\frac{-(1+e^{2\beta\xi})\pm\sqrt{2(e^{4\beta\xi}+1)}}{e^{2\beta\xi}-1}\right], \quad (2.3.19)$$

or

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[\frac{-(1+e^{2\beta\xi})\pm\sqrt{e^{4\beta\xi}+6e^{2\beta\xi}+1}}{e^{2\beta\xi}}\right]. \quad (2.3.20)$$

When $(\beta^2=\alpha\sigma)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}-\frac{\alpha a_1(\beta\xi+2)}{\beta^2\xi}. \quad (2.3.21)$$

When $(\beta=k\&\alpha=2k\&\sigma=0)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1[e^{k\xi}-1]. \quad (2.3.22)$$

When $(\beta=k\&\sigma=2k\&\alpha=0)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+\frac{a_1e^{k\xi}}{1-e^{k\xi}}. \quad (2.3.23)$$

When $(2\beta=\alpha+\sigma)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[\frac{1-\alpha e^{0.5(\alpha-\sigma)\xi}}{1-\sigma e^{0.5(\alpha-\sigma)\xi}}\right], \quad (2.3.24)$$

or

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[\frac{\alpha e^{0.5(\alpha-\sigma)\xi}+1}{-\sigma e^{0.5(\alpha-\sigma)\xi}-1}\right]. \quad (2.3.25)$$

When $(-2\beta=\alpha+\sigma)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[\frac{e^{0.5(\alpha-\sigma)\xi}+\alpha}{e^{0.5(\alpha-\sigma)\xi}+\sigma}\right]. \quad (2.3.26)$$

When $(\alpha=0)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+\frac{a_1\beta e^{\beta\xi}}{1+0.5\sigma e^{\beta\xi}}. \quad (2.3.27)$$

When $(\beta=\alpha=\sigma\neq0)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}-\frac{a_1(\alpha\xi+2)}{\alpha\xi}. \quad (2.3.28)$$

When $(\beta=\sigma=0)$

$$u(\xi)=0.5\alpha a_1\xi. \quad (2.3.29)$$

When $(\beta=\alpha=0)$

$$u(\xi)=-\frac{2a_1}{\sigma\xi}. \quad (2.3.30)$$

When $(\beta=0\&\alpha=\sigma)$

$$u(\xi)=a_1tan\left(\frac{\alpha\xi+C}{2}\right). \quad (2.3.31)$$

When $(\sigma=0)$

$$u(\xi)=\frac{a_1\beta}{2\sigma}+a_1\left[e^{\beta\xi}-\frac{\alpha}{2\beta}\right]. \quad (2.3.32)$$

Where k,C are arbitrary constant.

3. Discuss the results

In this section, we will discuss our results and make a comparison between our results and that obtained by using a different method in the following steps:

3.1. Firstly: new coupled Konno-Oono equation (Choi et al., 2016):

You can see when you make a comparison between our results and that obtained by GülnurYel, Haci Mehmet Baskonus, HasanBulutwho used the sine-Gordon expansion method that our results are completely new about that obtained in this research. So that, our results will provide researchers with a wide range of the possibilities and capacities to use this wonderful model in the life.

3.2. Secondly: Higgs field equation (Yel et al., 2017)

You can see when you make a comparison between our results and that obtained by M.A. Abdelkawy, A.H. Bhrawy, E. Zerrad and A. Biswas who used tanh method that our solutions (2.2.15) and (2.2.16) are equivalent with them solutions (17) and (18) when the parameters take this values $[a_0=0,C=(1-c^2)\beta_1\sigma,\beta=0]$, our solution (2.2.30) is equivalent with them solution (19) when the parameters take this value $[a_0=0,\beta=0,a_1=\pm i\sqrt{\frac{(1+c^2)}{2\beta_1}}]$ and our solution (2.2.31) is equivalent with them solution (20) when the parameters take this value $[a_0=0,\beta=0,a_1=\pm i\sqrt{\frac{2(1-c^2)(r^2(1-c^2)+\alpha_1)}{2\beta_1(c^2-1)}}]$. So that, it very clear that our method (Generalized Exp-Function method) covered all solutions that given by *using tanh method.*

3.3. Thirdly: Maccari equation (Yel et al., 2017)

You can see when you make a comparison between our results and that obtained by M.A. Abdelkawy, A.H. Bhrawy, E. Zerrad and A. Biswas who used tanh method that our solutions (2.3.15) and (2.3.16) are equivalent with them solutions (46) when the parameters take this values $[a_0=0,\beta=0,a_1=\pm i\sqrt{1+(p^2+r)(1-2p)}]$, our solution (2.3.30) is equivalent with them solution (47) when the parameters take this value $[a_0=0,\beta=0,a_1=-\frac{\sigma\sqrt{2-4p}}{2}]$ and our solution (2.3.31) is equivalent with them solution (48) when the parameters take this value $[a_0=0,\beta=0,a_1=\pm i\sqrt{1+(p^2+r)(1-2p)}]$. So that, it very clear that our method (Generalized Exp-Function method) covered all solutions that given by *using tanh method.*

4. Conclusion

In this paper, we succeed in applying Generalized Exp-Function method and obtaining traveling wave solution and new solitary traveling wave solutions for each of the following models (new coupled Konno-Oono equation, Higgs field equation and Maccari equation). We believe that our results of these models will be useful for young researchers who are going to study the exact solutions of nonlinear partial differential equations (NLPDEs.). We also hope that our results will be interesting for some referees. According to above discussion and all solutions that obtained by using Generalized Exp-Function method, we can notice that: Generalized Exp-Function method is very simple, direct, effective and powerful method to apply it for many nonlinear evolution equations.

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