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Mini Review

Innovation in Engineering Field and Basic Sciences in the Analytical Solution of Nonlinear Partial Differential Equations (PDE) by new Approaches AYM

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Abstract

In this paper, for the first time, we exposure analytical methods for solving complicated nonlinear differential equations in engineering fields and basic sciences, where these new methods can easily and flexibly analyze complex engineering problems. Some complicated highly nonlinear differential equations (including ODEs and PDEs) in different fields. In this article, we present an innovative method called Akbari-Yasna Method(AYM). In this article, we want to solve equations like the following in the fields of engineering and basic sciences:

This virgin method can be successfully applied in various engineering fields such as petroleum industry (solid, fluid, mass and heat transfer, dynamic, quantum physic, chemical reactors, electronics, applied sciences, economics, and etc.). Besides, the methodology behind these techniques is completely understandable, easy to use, and users with common knowledge of mathematics will be capable of solving the most complicated equations at low calculation cost.

Keywords: New Approach; Akbari-Yasna-Method (AYM); Nonlinear Partial Differential Equation (PDE); Innovation in Engineering Mathematics Fields

$$\frac{\partial u(x,t)}{\partial t} = \alpha \frac{\partial^p}{\partial x^p}\left(u^p(x,t) \frac{\partial^p u^p(x,t)}{\partial x^p} \right)$$

Introduction

In the study, our aims introduce accuracy, capabilities and power for solving complicated non-linear differential (PDE) in the engineering field and basic sciences. AYM method can be successfully applied in various engineering fields and all application areas, and also in the basic sciences (physics), economics and so on. It is worth noting that these methods are convergent at any form of differential equations, including any number of initial and boundary condi-

tions. During the solution procedure, it is not required to convert or simplify the exponential, trigonometric and logarithmic terms, which enables the user to obtain a highly precise solution. As all experts know most of engineering actual systems behavior in practical are nonlinear process and analytical scrutiny these nonlinear problems are difficult or sometimes impossible. Our purpose is to enhance the ability of solving the mentioned nonlinear differential equations (PDE) in all areas with three methods of simple and innovative approach which entitled "AYM". He's Amplitude Frequency Formulation method [1-4] which was first presented by Ji-Huan He gives convergent successive approximations of the exact solution and Homotopy perturbation technique HPM [5].It is necessary to mention that the above methods do not have this ability to gain the solution of the presented problem in high precision and accuracy so nonlinear differential equations such as the presented problem in this case study should be solved by utilizing new approaches like AGM method [6-13] that created by Mohammadreza Akbari (in 2014). In recent years, analytical methods in solving nonlinear differential equations have been presented and created by Mohammadreza Akbari, these methods are called and AKLM [14] (Akbari Kalantari Leila Method)and ASM [15,16] (Akbari Sara's Method) and AYM [17,19] (Akbari Yasna's Method) and IAM [20] (Integral Akbari Method).These example somehow can be considered as complicated cases to deal with for all of the existed analytical methods especially in the design slides engineering , which means old methods cannot resolve them precisely or even solve them in a real domain.

Mathematical formulation of the problem

We consider a few complicated examples in nonlinear differential equations (Pde and Ode) to represent engineering field and basic science problems as follows:

Analytical solution of nonlinear partial differential equations by AYM method (Akbari Yasna Method)

We consider a nonlinear partial differential equation as a nonlinear phenomenon in the engineering field and basic sciences as follows:

$$\frac{\partial u}{\partial t} = \alpha \frac{\partial^p}{\partial x^p}\left(u^p \frac{\partial^p}{\partial x^p}\left(u^p\right)\right) \tag{1}$$

$$u = u(x, t) \tag{2}$$

The boundary and initial conditions are:

$$u(0, t) = u1\ ,\ u(L, t) = u2\ ,\ u(x, 0) = uo \tag{3}$$

AYM solution process (Akbari Yasna Method)

The following values have been used for the physical parameters of this problem as:

$$\alpha = 0.1\ ,\ L = 1\ ,\ uo = 1 \tag{4}$$

The output answers the Eq. (1) according to boundaries and initial conditions Eqs. (3) and physical values Eqs.(4) by AYM method is obtained as follows.

$$A = \frac{2uo}{n\pi}\left(1 - (-1)^n\right) \tag{5}$$

i) For p=1, AYM answer as:

$$u(x, t) = A \sum_{n=1}^{\infty} \sin\left(\frac{n\pi x}{L}\right) e^{-Lm(t)}$$
$$Lm(t) = \text{LambertW}\left(-\frac{2A\alpha n\pi}{3L^2}\left((-1)^n - 1\right)t\right) \tag{6}$$

The graphs of the solution of the differential equation by AYM according to the physical values Eqs.(4)and Eq.(5) for p=1 as follows: (Figure 1)

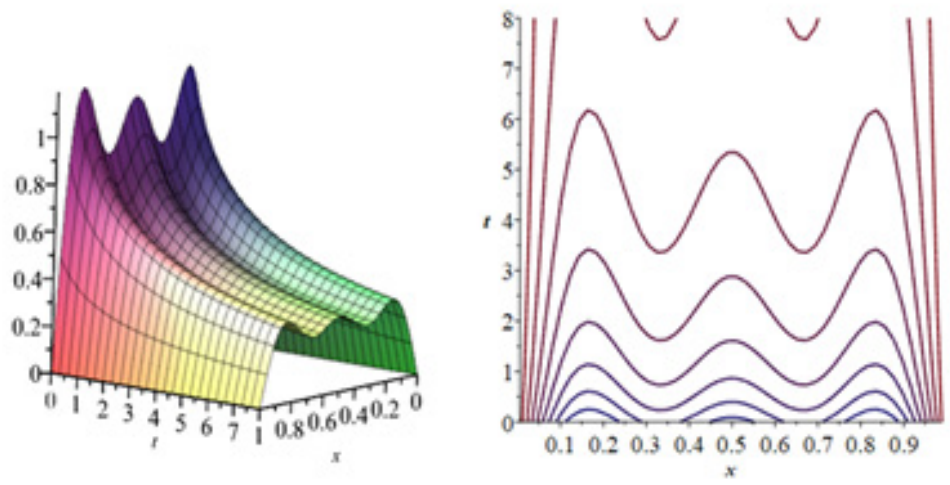

Figure 1: diagrams of analytical solution differential by AYM solution for p=1.

The time-location diagram is shown below in location x=L /2 as: (Figure 2)

ii) For p=3, AYM answer as:

$$u(x,t) = A\sum_{n=1}^{\infty}\sin\left(\frac{n\pi x}{L}\right)e^{Lm(t)}$$
$$Lm(t) = -\frac{1}{5}\,\text{LambertW}\left(-\frac{88A^5\alpha n^5\pi^5}{7L^6}\left((-1)^n-1\right)t\right) \quad (7)$$

The graphs of the solution of the differential equation by AYM according to the physical values Eqs. (4) and Eq. (5) for p=3 as follows: (Figure 3)

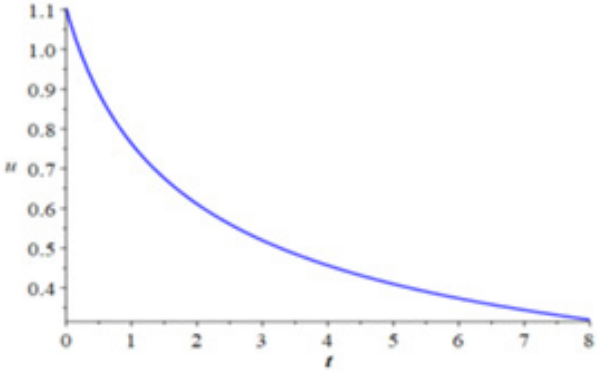

Figure 2: Time chart for location x=L /2 and p=1.

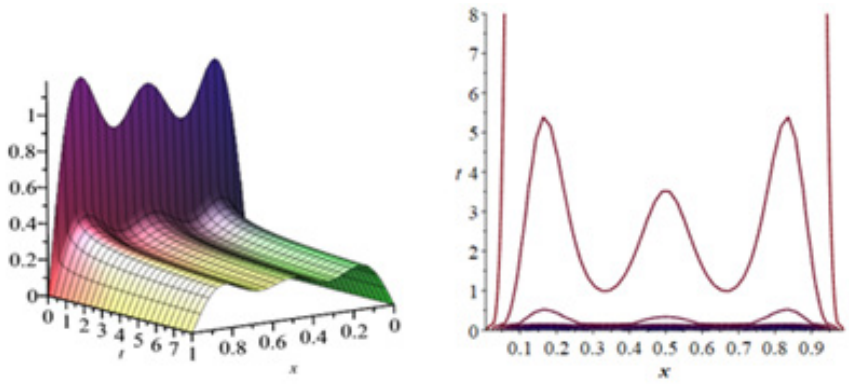

Figure 3: diagrams of analytical solution differential by AYM solution for p=3.

The time-location diagram is shown below in location x=L /2 as: (Figure 4)

Comparison of derivative orders (p=1,3,5) for contour plot u(x-

iii) For p=5, AYM answer as:

$$u(x,t) = A\sum_{n=1}^{\infty}\sin\left(\frac{n\pi x}{L}\right)e^{Lm(t)}$$
$$Lm(t) = -\frac{1}{9}\,\text{LambertW}\left(-\frac{29056A^9\alpha n^9\pi^9}{77L^{10}}\left((-1)^n-1\right)t\right) \quad (7)$$

The graphs of the solution of the differential equation by AYM according to the physical values Eqs.(4)and Eq.(5) for p=5 as follows: (Figure 3)

,t) as diagram below: (Figure 5)

Comparison of derivative orders (p=1,3,5) for u(t) in the x=L/2 as diagram below: (Figure 4)

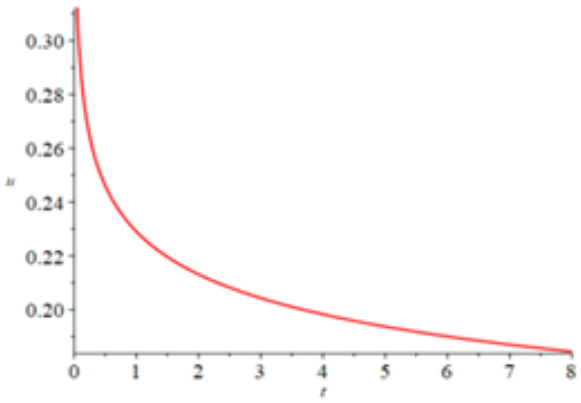

Figure 4: Time chart for location x=L /2 and p=5.

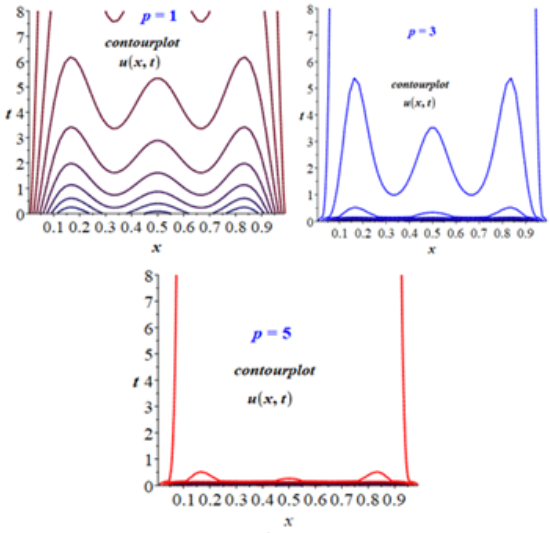

Figure 5: Comparison of diagrams for analytical solution differential by AYM solution for p=1,3,5.

Conclusion

In this article, we proved conclusively that new method (AYM) can all kinds of complicated practical problems related to nonlinear partial and ordinary differential equations in the engineering field and basic sciences and they can be easily solved analytically. Obviously, most of the phenomena of physically are nonlinear, so it is quite difficult to study and analyze nonlinear mathematical equations in this area, also we wanted to demonstrate the strength, capability and flexibility of the new methods. This methods are newly created and they can have high power in analytical solution of all kinds of industrial and practical problems in engineering fields and basic sciences for complicated nonlinear differential equations.

History of AGM, ASM, AYM, AKLM, MR.AM and IAM, WoLF, a method

AGM (Akbari-Ganji Methods), ASM (Akbari-Sara's Method) , AYM (Akbari-Yasna's Method) AKLM (Akbari Kalantari Leila Method), MR.AM (Mohammad Reza Akbari Method)and IAM (Integral Akbari Methods), WoLF, a method (Women Life Freedom, Akbari), have been invented mainly by Mohammadreza Akbari (MR Akbari) in order to provide a good service for researchers who are a pioneer in the field of nonlinear differential equations.

- AGM method Akbari Ganji method has been invented mainly by Mohammadreza Akbari in 2014. Noting that Prof. Davood Domairy Ganji co-operated in this project.
- ASM method (Akbari Sara's Method) has been created by Mohammadreza Akbari on 22 of August, in 2019.
- AYM method (Akbari Yasna's Method) has been created by Mohammadreza Akbari on 12 of April, in 2020.
- AKLM method (Akbari Kalantari Leila Method) has been created by Mohammadreza Akbari on 22 of August, in 2020.

- MR.AM method (Mohammad Reza Akbari Method) has been created by Mohammadreza Akbari on 10 of November, in 2020.
- I AM method (Integral Akbari Method) has been created by Mohammadreza Akbari on 5 of February, in 2021.
- WoLF, a method (Women Life Freedom, akbari) has been created by Mohammadreza Akbari on 5 of February, in 2022.

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Conflicts of Interest

No conflicts of interest.

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