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Original Article

An efficient analytical technique for fractional partial differential equations occurring in ion acoustic waves in plasma

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Abstract

In this work, we apply an efficient analytical algorithm namely homotopy perturbation Sumudu transform method (HPSTM) to find the exact and approximate solutions of linear and nonlinear time-fractional regularized long wave (RLW) equations. The RLW equations describe the nature of ion acoustic waves in plasma and shallow water waves in oceans. The derived results are very significant and imperative for explaining various physical phenomenons. The suggested method basically demonstrates how two efficient techniques, the Sumudu transform scheme and the homotopy perturbation technique can be integrated and applied to find exact and approximate solutions of linear and nonlinear time-fractional RLW equations. The nonlinear expressions can be simply managed by application of He's polynomials. The result shows that the HPSTM is very powerful, efficient, and simple and it eliminates the round-off errors. It has been observed that the proposed technique can be widely employed to examine other real world problems.

Keywords: Sumudu transform scheme; Homotopy perturbation technique; RLW equations; Ion acoustic wave; Shallow water waves in oceans.

1. Introduction

Over the last decades, fractional differential equations have been investigated due to their wide uses in the field of science and engineering. Several phenomenon's in material science, viscoelasticity, electromagnetics, electrochemistry, acoustics and plasma physics are characterized by fractional partial differential equations. Numerical solutions of fractional differential equations are of significant interest. There is no method that gives an exact solution for fractional differential equation. Approximate solutions can only be obtaining by applying series solution methods or linearization [1–6].

There exist various methodologies that deal with the approximate solutions of fractional differential equations of physical problems, called perturbation methods. These methods have some limitations. Since many nonlinear physical systems have no small parameters. So, small parameters are the basic requirement for approximate solution which shows complication sometimes. In many cases, unsuitable choices of small parameter introduce serious effects in the solutions. There exists an analytical approach, which does not need a small parameter in the equation. In past decades, researchers developed some new methods which are very simple in implementation and cost effective. These methods solve nonlinear fractional differential equations very precisely and effectively. The developed methods known as iterative techniques like homotopy analysis technique, Adomian decomposition scheme, homotopy perturbation technique, Laplace decomposition scheme, variational iteration approach, Tanh scheme, Backlund transformation technique, etc. [7–14].

Recently, homotopy perturbation Sumudu transform method (HPSTM) have been suggested by Singh et al. [15] for

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