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An efficient numerical scheme to solve fractional diffusion-wave and fractional Klein-Gordon equations in fluid mechanics

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Abstract

The numerous applications of time fractional partial differential equations in different fields of science especially in fluid mechanics necessitate the presentation of an efficient numerical method to solve them. In this paper, Galerkin method and operational matrix of fractional Riemann-Liouville integration for shifted Legendre polynomials has been applied to solve these equations. Some definitions for fractional calculus along with some basic properties of shifted Legendre polynomials have also been put forth. When approximations are substituted into the fractional partial differential equations, a set of algebraic equations would be resulted. The convergence of the suggested method was also depicted. In the end, the linear time fractional Klein-Gordon equation, dissipative Klein-Gordon equations and diffusion-wave equations were utilized as three examples so as to study the performance of the numerical scheme.

Key words: fractional Klein-Gordon equation, fractional diffusion-wave equation, fractional dissipative Klein-Gordon equation, shifted Legendre polynomials, operational matrix

1 Introduction

In recent years, with the rapid development of nonlinear sciences, the theory of fractional differential equations have developed progressively and researchers have found that derivatives and integrals of non integer order are more suitable and accurate than integer-order equations for modeling some real world problems. These equations have attracted substantial attention of many investigator because they have practical applications in diverse areas of science and engineering such as bioengineering [1], anomalous transport [2], solid mechanics [3], continuum and statistical mechanics [4], nonlinear oscillation of earthquakes [5], economics[6], fluid dynamic [7], colored noise [8], viscoelastic damping [9] -[11] and modelling

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