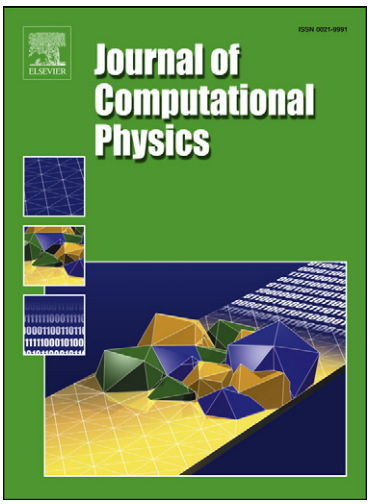

A method based on the Jacobi tau approximation for solving multi-term time–space fractional partial differential equations

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A method based on the Jacobi tau approximation for solving multi-term time-space fractional partial differential equations

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Abstract. In this paper, we propose and analyze an efficient operational formulation of spectral tau method for multi-term time-space fractional differential equation with Dirichlet boundary conditions. The shifted Jacobi operational matrices of Riemann-Liouville fractional integral, left sided and right sided Caputo fractional derivatives are presented. By using these operational matrices, we propose a shifted Jacobi tau method for both temporal and spatial discretizations, which allows us to present an efficient spectral method for solving such problem. Furthermore, the error is estimated and the proposed method has reasonable convergence rates in spatial and temporal discretizations. In addition, some known spectral tau approximations can be derived as a special cases from our algorithm if we suitably choose the corresponding special cases of Jacobi parameters θ and ϑ. Finally, in order to demonstrate its accuracy, we compare our method with those reported in the literature.

Keywords: Multi-term time fractional wave-diffusion equations; power law wave equation; advection-diffusion equation; telegraph equation; spectral method; Operational matrix.

1 Introduction

During the last decades, some major contributions have been made to both the theory and applications of the fractional differential equations motivated by various practical engineering and physical problems. These applications cross diverse disciplines, such as chemical physics [1], viscoelasticity [2], electricity [3], finance [4], control theory [5], biomedical engineering [1], fluid mechanics [6] and other sciences (see [6, 7, 8] and references therein). In fact, it has been found that the fractional-order models are more adequate than the previously used integer-order models [9, 10, 11], because fractional-order derivatives and integrals enable the description of the memory and hereditary properties of different substances.