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A New Integral Transform-Based Numerical Analysis of Fractional Gas Dynamics Equation

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Abstract

Gas dynamics equations arise as mathematical representations of the fundamental conservation laws of mass, momentum, and energy in physical systems. Gas dynamics, a significant branch of fluid dynamics, investigates the motion of gases and the effects of this motion on physical systems [1, 2]. Studies in gas dynamics contribute significantly to the understanding of many critical physical phenomena, such as the formation of shock waves around aircraft and aerodynamic heating occurring on vehicle surfaces during atmospheric re-entry. Therefore, gas dynamics equations occupy an important position in both theoretical and applied sciences. Fractional gas dynamics equations represent a generalized form of classical gas dynamics models and have been developed to more realistically describe complex physical phenomena, particularly memory effects and anomalous diffusion [1, 2]. With the introduction of fractional derivative concepts into physical systems, these equations have gained considerable attention in the literature and have become an active area of research in engineering and physics. In recent years, various semi-analytical methods have been proposed to effectively handle the complex structure of these equations. In this context, hybrid approaches formed by combining integral transform techniques with analytical or algebraic methods have emerged as powerful tools for solving fractional differential equations. These methods have found widespread application in the literature due to their computational efficiency and their ability to generate rapidly convergent series solutions. In this study, the Kashuri–Fundo Decomposition Method (KFDM) is employed to solve fractional gas dynamics equations [3, 4]. The method is based on the decomposition of nonlinear terms through Adomian polynomials, enabling the solution to be obtained in the form of a rapidly convergent series. The results demonstrate that KFDM can produce highly accurate solutions of the series expansion and yields results that are consistent with those reported by other semi-analytical methods in the existing literature. These findings indicate that KFDM provides an effective and reliable alternative approach for solving fractional differential equations.

***K*eywords** Fractional gas dynamics equation · Kashuri Fundo decomposition method · fractional differential equation · Adomian decomposition method

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