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INTRODUCING THE METHOD OF DIRECTLY DEFINING THE INVERSE MAPPING (MDDiM) FOR CONVECTION-DIFFUSION EQUATIONS: A NOVEL SEMI-ANALYTICAL METHOD

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The main aim of this paper is to introduce a semi-analytical method, known as the Method of Directly Defining the inverse Mapping (MDDiM), for obtaining approximate solutions to the convection-diffusion (CD) equation. This novel method is applied for the first time to convection-diffusion problems. This equation is a parabolic partial differential equation that describes the movement of physical quantities such as heat, particles, or energy within a system, due to the combined effects of convection and diffusion. Traditionally perturbation and asymptotic techniques have been widely used to obtain analytical approximations for nonlinear problems. However, due to the strong nonlinearity, perturbation and asymptotic approximations often fail. The Homotopy Analysis Method (HAM) was introduced by Shijun Liao in 1992 to solve highly nonlinear problems. HAM does not depend on physical parameters and ensures a convergent series solution. Moreover, it provides great flexibility in the selection of base functions, initial guesses, and linear operators. However, it still requires calculating the linear operator to find unknown functions. In scientific computing, a substantial amount of time is required to calculate the inverse operator for the differential equation. To overcome this obstacle, the MDDiM was introduced by Liao in 2016, allowing the inverse linear mapping to be directly selected. Finally, a numerical example is given to illustrate the accuracy and stability of this method. MDDiM is compared with the Optimal Homotopy Analysis Method (OHAM), HAM, and the Homotopy Perturbation Method (HPM). The results show that MDDiM is more accurate than the others. It is shown by the comparison of the approximate and exact solutions that the proposed method is highly effective and computationally efficient.

Keywords: Convection-diffusion equation, Homotopy Analysis Method, Method of Directly Defining Inverse Mapping, Nonlinear partial differential equations, Semi-analytical methods