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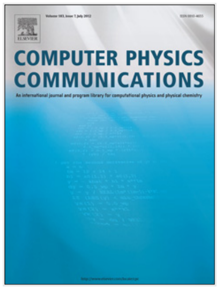

Fourth-order compact schemes for the numerical simulation of coupled Burgers' equation

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Fourth-order compact schemes for the numerical simulation of coupled Burgers' equation☆

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Abstract

This paper introduces two new modified fourth-order exponential time differencing Runge-Kutta (ETDRK) schemes in combination with a global fourth-order compact finite difference scheme (in space) for direct integration of nonlinear coupled viscous Burgers' equations in their original form with out using any transformations or linearization techniques. One scheme is a modification of the Cox and Matthews ETDRK4 scheme based on $(1,3)-$Padé approximation and other is a modification of Krogstad's ETDRK4-B scheme based on $(2,2)-$Padé approximation. Efficient versions of the proposed schemes are obtained by using a partial fraction splitting technique of rational functions. The stability properties of the proposed schemes is studied by plotting the stability regions, which provide an explanation of their behavior for dispersive and dissipative problems. The order of convergence of the schemes is examined empirically and found that the modification of ETDRK4 converges with the expected rate even if the initial data are nonsmooth. On the other hand, modification of ETDRK4-B suffers with order reduction if the initial data are nonsmooth. Several numerical experiments are carried out in order to demonstrate the performance and adaptability of the proposed schemes. The numerical results indicate that the proposed schemes provide better accuracy than other schemes available in the literature. Moreover, the results show that the modification of ETDRK4 is reliable and yields more accurate results than modification of ETDRK4-B, while solving problems with nonsmooth data or with high Reynolds number.

Keywords: Compact scheme; Exponential time differencing scheme; Padé approximation; Coupled viscous Burgers' equation; Partial fraction splitting technique

1. Introduction

Burgers' equation is one of the most common nonlinear time dependent partial differential equation (PDE) in fluid mechanics, which consists both of nonlinear propagation and diffusive effects. The equation has been widely used as a simplified model for several physical phenomena, such as

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