A Padé ADI Scheme of Higher-Order For Unsteady Convection-Diffusion Problems

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Abstract

We propose a hybrid high-order Padé ADI scheme for solving unsteady convection-diffusion problems. The present scheme employs standard high-order Padé approximations for spatial first and second derivatives in the convection-diffusion equation. Multistep methods combined with the approximate factorization introduced by Beam and Warming are applied for time integration to achieve higher-order temporal accuracy. The scheme is carried out by repeatedly solving a series of pentadiagonal linear systems producing a computational cost effective solver. The effect of the approximate factorization on the stability of the scheme is examined. In contrast to the HOC-based schemes in which the phase and amplitude characteristics of a solution are altered by the variation of cell Reynolds number, the present scheme retains the characteristics of the modified wave numbers for spatial derivatives regardless of the magnitude of cell Reynolds number. The superiority of the proposed scheme compared to other high-order ADI schemes for solving unsteady convection-diffusion problems is discussed in detail. A comparison of different time discretizations based on multistep methods is also given.

Key words - Unsteady convection-diffusion equation, High-order compact scheme, Padé approximations, Approximate factorization, ADI method, Finite difference method.