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On a high–order Newton linearization method for solving the incompressible Navier–Stokes equations

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Abstract

The present study aims to accelerate the nonlinear convergence to incompressible Navier–Stokes solution by developing a high–order Newton linearization method in non–staggered grids. For the sake of accuracy, the linearized convection–diffusion–reaction finite–difference equation is solved line–by–line using a nodally exact one–dimensional scheme. The matrix size is reduced and, at the same time, the CPU time can be considerably saved owing to the reduction of stencil points. This Newton linearization method is effective and is demonstrated to outperform the classical Newton method through computational exercises. (Fig.1)

Keywords: incompressible; Navier–Stokes solution; non–staggered grids; Newton linearization; convection–diffusion–reaction; nodally exact.

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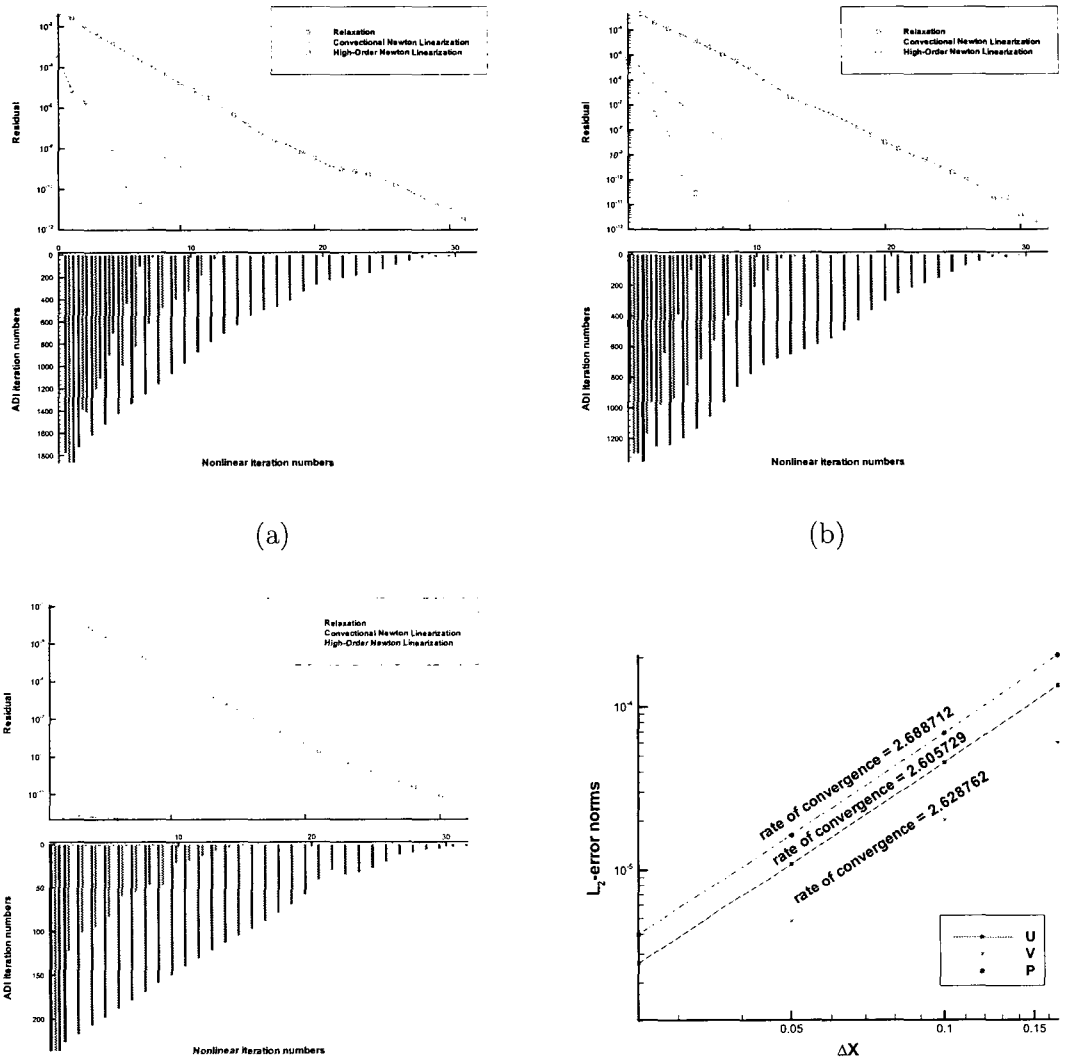

Figure 1: Comparison of the convergence histories for solving the nonlinear Navier–Stokes problem, which has the analytic solutions at $Re = 1000$. (a) convergence histories for u; (b) convergence histories for v; (c) convergence histories for p; (d) the computed rates of convergence.