A High Order Pointwise Solution of Compressible Navier-Stokes Equations in Lid-Driven Cavity Flows

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Abstract

In this paper, we propose a high order Galerkin discretization scheme for solving steady compressible Navier-Stokes equations. The pointwise numerical fluxes are separated into convective fluxes, acoustic fluxes, and viscous fluxes. The separation of convective flux and viscous flux is to avoid round off errors. The separation of the acoustic flux is due to non-central scheme employed near the wall. The adiabatic boundary condition is explicitly implemented which limits the current scheme to have an upper limit of eighth order. The orders of discretization from second, fourth, sixth, to eighth are investigated. The overall residual is integrated using fourth-order Runge-Kutta scheme with a preconditioning matrix. No numerical smoothing is required. Using the eighth order scheme, the resolution is improved around the recirculation corners in lid-driven cavity flow. However, a fourth order scheme is suggested to have a better balance between the numerical resolution and computational cost. Numerical experiments for several Reynolds numbers confirm the high resolution and a good quality of our compressible scheme to resolve the incompressible flow field without spurious numerical oscillations.

Keyword：Galerkin discretization, Reynolds number (Re), compressible Navier-Stokes equations, lid-driven flows, precondition matrix