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A spectral element method for fluid dynamics: Laminar flow in a channel expansion. (English)

Zbl 0535.76035
J. Comput. Phys. 54, 468-488 (1984).

Summary: A spectral element method that combines the generality of the finite element method with the accuracy of spectral techniques is proposed for the numerical solution of the incompressible Navier-Stokes equations. In the spectral element discretization, the computational domain is broken into a series of elements, and the velocity in each element is represented as a high-order Lagrangian interpolant, through Chebyshev collocation points. The hyperbolic piece of the governing equations is then treated with an explicit collocation scheme, while the pressure and viscous contributions are treated implicitly with a projection operator derived from a variational principle. The implementation of the technique is demonstrated on a one-dimensional inflow-outflow advection-diffusion equation, and the method is then applied to laminar two-dimensional (separated) flow in a channel expansion. Comparisons are made with experiment and previous numerical work.

MSC:

76D05 Navier-Stokes equations for incompressible viscous fluids
76M99 Basic methods in fluid mechanics

Keywords:

spectral element method; high-order Lagrangian interpolant; Chebyshev collocation points; pressure; viscous contributions; variational principle; one-dimensional inflow-outflow advection-diffusion equation; laminar two-dimensional (separated) flow; channel expansion

Full Text: DOI

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