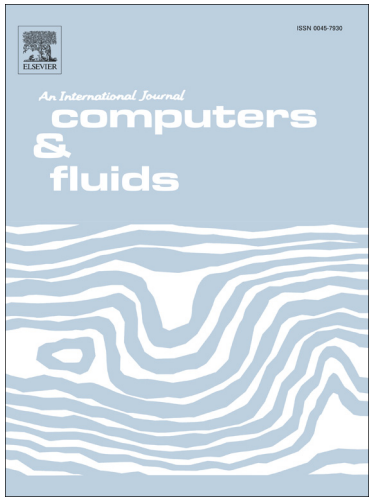

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A compact finite differences exact projection method for the Navier-Stokes equations on a staggered grid with fourth-order spatial precision

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Abstract

An exact projection method for the numerical solution of the incompressible Navier-Stokes equations is devised. In all spatial discretizations, fourth-order compact finite differences are used, including domain boundaries and the Poisson equation that arises from the projection method. The integration in time is carried out by a second-order Adams-Bashforth scheme. The discrete incompressibility constraint is imposed exactly (up to machine precision) by a simple and efficient discretization of the Poisson equation. Spatial and temporal accuracies, for both velocity and pressure, are verified through the use of analytical and manufactured solutions. The results show that the method converges with fourth-order accuracy in space and second-order accuracy in time, for both velocity and pressure. Additionally, two popular benchmark problems, the flow over a backward facing step and the lid-driven cavity flow, are used to demonstrate the robustness and correctness of the code.

Keywords: Navier-Stokes equations, compact finite differences, exact projection, high-order methods

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