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Iterated pressure-correction projection methods for the 2d Navier-Stokes equations based on the scalar auxiliary variable approach

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Abstract

In this talk, the first-order iterated pressure-correction projection methods based on the scalar auxiliary variable approach is proposed and studied for the 2d Navier-Stokes equations and Boussinesq equations.

In the literature, enormous amounts of work have contributed to the study of numerical schemes for computing the Navier-Stokes equations. In general, two of the main numerical difficulties for solving Navier-Stokes equations are the incompressible condition and the nonlinear term. One of the approaches to deal with the incompressible condition is the so-called projection. The typical projection method only needs to solve the Poisson type of equations depending on the nonlinear term's treatment, which is efficient. However, the pressure-correction projection methods suffer from the splitting error, leading to spurious numerical boundary layers and the limitation of accuracy in time. In the literature, an iterated pressure-correction projection method has been proposed to overcome the difficulty.

As for the nonlinear term treatment, it is better to treat the nonlinear term explicitly so that one only requires to solve the corresponding linear system with constant coefficients at each time step. However, such treatment often results in a restricted time step due to the stable issue. Recently, the scalar auxiliary variable approach has been constructed to have an unconditional energy stable numerical scheme.

In this work, a new iterated pressure-correction projection method based on the scalar auxiliary variable's simple choice is proposed. We find that this new scheme can enjoy two properties, including reducing the splitting errors and having unconditional energy stability. The proofs of the energy stability and error convergence are provided and analyzed. Finally, numerical examples are provided to illustrate the theoretical work. This is joint work with Tony Chang.