Some new developments in spectral element methods for incompressible flow

Chuanju Xu
(School of Mathematical Sciences, Xiamen University, China)

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Abstract

There are two principal ways to discretize the Navier-Stokes equations in time. One way is to keep the velocity and the pressure coupled, and at each time step it needs to solve the generalized Stokes problem, then an additional splitting technique is applied to yield a Poisson-like equation for the pressure. Another way to discretize the Navier-Stokes equations is provided by the class of projection methods. By using the projection methods, the original problem is reformulated into two simpler problems. The development in this direction have been recently reported by several authors.

The first part of this talk is to discuss some recent development of the efficient temporal discretizations in the frame of spectral element spatial discretization. The treatment of the nonlinear convection term in both Uzawa-based and projection type methods is addressed. Especially, we will present some stability analysis for the aforementioned time schemes when the convection term is involved. We will give a systematic numerical comparison on the stability property between different schemes when applied to the SEM computations of high Reynolds number incompressible flows.

In the second part, we will discuss the problem of outflow boundary conditions and present a new method to deal with the Navier-Stokes equations in unbounded domains. Finally we address large eddy simulations of the turbulent flow by using spectral element methods.