A Class of Numerical Methods Based on Local Vorticity Boundary Conditions and Local Pressure Boundary Conditions

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Abstract: In this talk, I will review a class of numerical methods for 2D and 3D unsteady incompressible Navier-Stokes equations with large Reynolds number based on local vorticity boundary conditions or local pressure boundary conditions. Conventional stable explicit time stepping is used for the momentum equation; the incompressibility constraint is realized by appropriate discrete Poisson equations.

The local vorticity boundary conditions and local pressure boundary conditions are used so that the dynamic and kinetic equations are decoupled, resulting in a class of very efficient Navier-Stokes solvers. At each time step, only one Poisson solver is being used for a 2nd order finite difference approximations, and there is only a modest increase in cost for higher order compact finite difference, finite element and spectral approximations. Some patch mesh refinement can be easily incorporated into the scheme to resolve highly unstable boundary layer separation. Various numerical experiments will be presented, demonstrating the accuracy and efficient of this class methods; these include the flow past cylinder at the Reynolds number up to 200,000, air bubble arising from water, etc.