APPLICATION OF A STABILIZED SPECTRAL/FINITE ELEMENT SOLVER TO DNS TEST CASES

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Turbulent flows are found all around us including everything from flow over an airplane about to stall to the water coming out of a faucet. Understanding the physics of these flows is critical if informed engineering decisions are to be made. One method of learning more about a turbulent flow is to solve the discretized Navier-Stokes equations for the instantaneous velocity and pressure. In the past this has been accomplished with Finite difference and spectral methods which are confined to relatively simple geometries.

A solver for complex planar geometries has been developed using a Spectral/Finite Element discretization. The finite element discretization allows unstructured meshing of complex geometries while the spectral discretization gives good accuracy and improves the solver efficiency. Parallelization of the algorithm is accomplished with MPI using a unique data structure where parallelization is performed in both physical space and Fourier space.

The turbulent fields computed with this solver must be verified with published results for simple geometries before it is applied to more complex geometries. The purpose of this project was to develop three test cases which will evaluate the solvers performance in Direct Numerical Simulations. The code has also been extended and improved as necessary to compute these test cases. The test cases are: decaying isotropic turbulence, fully developed turbulent channel flow, and flow over a periodic hill. Isotropic turbulence decay provides a fully 3D test which determines the dissipative nature of the code. A turbulent channel flow shows how the solver predicts wall bounded turbulence. Finally, the periodic hill assesses the ability of the solver to predict separation and reattachment. A diagram of each test case is shown below. Results from these tests exhibit good agreement with published results, indicating the solver is ready to tackle more complex problems such as the flow over an airfoil.

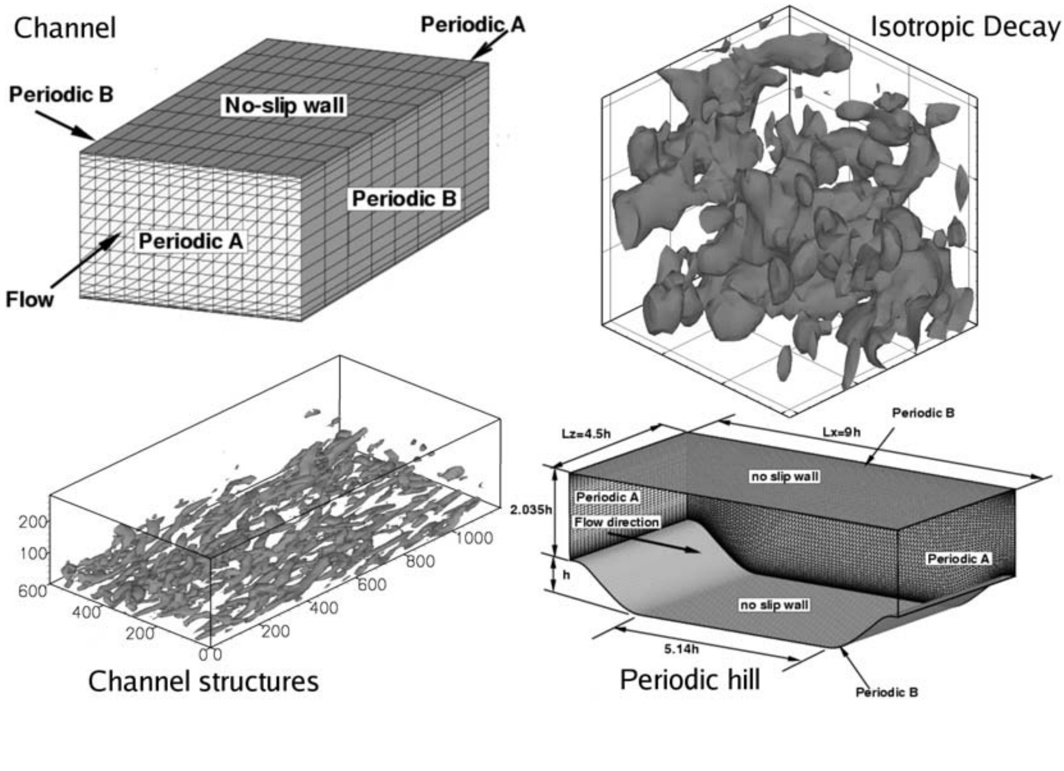

Figure 1: Test cases used to verify the solver