§64. Study on MHD Wall Shear Turbulent Flow on High Reynolds Number via Paralleled Direct Numerical Simulation

Satake, S. (Tokyo University of Science),
Kunugi, T. (Kyoto University)

Turbulent simulation is possible to apply to the large Reynolds number via developing large scale computer, and the computation is close to the realized engineering facilities. In the high Reynolds number computation, the large scale structures must be understood by not local structures but that of whole region in computational domain. Therefore, we need large memory for not only main computer but also visualization computer. On the other hand, the large scale computation under a magnetic field have not been carried out, the previous studies is limited for low magnetic number and low Reynolds number computations. In this study, the objective is to calculate the large scale turbulent structures with the large Reynolds and Hartmann number by SX-7 at NIFS.

2. Numerical method for direct numerical simulations

The governing equation for velocity and magnetic fields are

$$\nabla \cdot \mathbf{u} = 0 \qquad (1)$$

$$\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} = -\frac{1}{\rho} \nabla p + \nu \nabla^2 \mathbf{u} + Al(\mathbf{j} \times \mathbf{B}) \qquad (2)$$

$$\mathbf{J} = \mathrm{Re}_m \left(-\nabla \phi + \mathbf{u} \times \mathbf{B} \right) \qquad (3)$$

$$\nabla^2 \phi = \nabla \cdot (\mathbf{u} \times \mathbf{B}_0). \qquad (4)$$

Where Al, $\mathbf{u}$, p, $\mathbf{j}$, ϕ, $\mathbf{B}$ are Alfven number, velocity vector, pressure, current, potential and the applied magnetic density, respectively.

We developed the paralleled algorithm by MPI library for our code by ourselves. The special descretization is used of finite difference method and spectral method. The time descrization is nonlinear terms and additional magnetic terms for third order Runge-Kutta methods, and the other terms for Crank-Nicolson method. The solver is FFT and TDMA method. The program language is FORTRAN 90 with Module command. The parallel library is MPI: mpi_send, mpi_isend, mpi_irev, mpi_allreduce. The our code already have been high performance computation for some computers in Fig. 1. In the computation at 4 PEs, the grid number is 256 x 128 x 128 for pipe geometry.

3. Problem for computation at NIFS SX-7

Our computation was no good for NIFS SX-7, although our code can be paralleled already. Because file system for NQS is quite different from MPI. However our code just has been changed from MPI to HPF for compiler of NIFS SX-7.

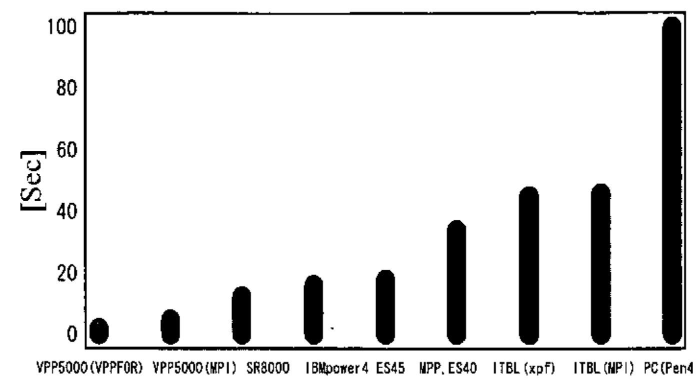

Figure 1 Our DNS code of computational performance for some computer.

4. Futures plan

We are successful for the computation of turbulent channel flow with described by HPF. We will apply to a turbulent flow by faster algorithm with our code by HPF in the near future.