§23. Simulation of Turbulence Generation Using Single Fluids 3-D MHD Code

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The aim of this study is turbulence simulation with a single fluid model. One of authors (N.N.) showed that the non-uniform heating on the same magnetic field line generates the filament structures [1]. Thus, the computer simulation will help us to investigate what condition to generate the filament structures is needed.

The government equations are as follows,

$$\frac{\partial \rho_m}{\partial t} + \nabla \cdot \rho_m \mathbf{v} = 0$$

$$\rho_m \frac{\partial \mathbf{v}}{\partial t} + \rho_m \mathbf{v} \cdot \nabla \mathbf{v} = -\nabla p + \mathbf{j} \times \mathbf{B}$$

$$\frac{\partial \boldsymbol{p}}{\partial \boldsymbol{t}} + \nabla \cdot (\boldsymbol{p}\mathbf{v}) = -(\gamma - 1)\boldsymbol{p} \nabla \cdot \mathbf{v}$$

And Maxwell equations and charge conservation and generalized Ohm's law.

$$\frac{\partial \mathbf{B}}{\partial t} = -\nabla \times \mathbf{E}$$

$$\frac{1}{\mu_0} \nabla \times \mathbf{B} = \mathbf{j} + \varepsilon_0 \frac{\partial \mathbf{E}}{\partial t} \approx \mathbf{j}$$

$$\varepsilon_0 \nabla \cdot \mathbf{E} = \rho$$

$$\nabla \cdot \mathbf{B} = 0$$

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \mathbf{j} = 0$$

$$\mathbf{E} = -\mathbf{V} \times \mathbf{B} + \eta \mathbf{j}$$

Developed three-dimensional code used Yee grid double mesh system to solve the electro-magnetic field with the guarantee of the zero divergence of the magnetic field and it used CIP method to solve the fluid motion. Solving one-dimensional shock wave problem with this code we confirmed that this code work very well expect the region, which has the reconnection of the magnetic field and discontinuity of the fluid [2].

This code does not have thermal conduction effect and viscosity effect yet. Therefore, we do not use supercomputer this year. At first we developed two-dimensional code including above two effects, and we use high-speed PC to testify the developing code.

Initial calculation result of one-dimensional shock wave problem the density and pressure would be higher than that of predicted value of theory. Therefore, there should be a small bug in this developing code. Now we are trying to take this bug away. After that we will apply this collaborative activity.

1) Nishino, N., Nuclear Fusion **46** (2006) S658
2) J. Plasma Fusion Res. SERIES, **6** (2004) 395