§9. A Simulation Model of MHD Self-Organization

Yabuki, K. (Grad. Univ. Advanced. Studies)
Watanabe, K., Sato, T.
The Complexity Simulation Group

Our purpose of this study is to make up the general theory of the MHD self - organization, namely, to clarify the scenario of the formation and maintenance of the structure . The key factors of the self - organization have been unveiled by recent self - organization studies, i. e. ;

1. Injection of energy into the system from the external environment,
2. Structural instability due to the increase of free energy deposit,
3. Structure transformation and energy exchange of inside the system,
4. Ejection of *some* randomness to the outside.

Therefore, we expected that the following parameters are important to control the self - organization processes.

1. Injection speed of energy ,
2. Dynamic response time of the system (growth rate of the structural instability),
3. Dissipation rate of energy,
4. Ejection speed of the randomness.

As the first step, shown here is the new simulation model and code which can reveal the MHD self - organization processes, changing above parameters.

We developed the MHD self - organization model based on the model of the coupling system between fully ionized plasma and weekly ionized plasma.

The equations are followings;

$$\rho \frac{d}{dt}\mathbf{v} = -\nabla p + \mathbf{j} \times \mathbf{B} + \nu_1 \Delta \mathbf{v} + \nu_2 \nabla(\nabla \cdot \mathbf{v}) , \qquad (1)$$

$$\mathbf{j} = \frac{1}{\mu} \nabla \times \mathbf{B} , \qquad (2)$$

$$\frac{\partial}{\partial t}\mathbf{B} = - \nabla \times \mathbf{E}, \qquad (3)$$

$$\mathbf{E} + \mathbf{v} \times \mathbf{B} = 0, \qquad (4)$$

$$\frac{\partial}{\partial t}\rho = - \mathbf{v} \cdot \nabla \rho - \rho \nabla \cdot \mathbf{v}, \qquad (5)$$

$$\frac{\partial}{\partial t}p = - \mathbf{v} \cdot \nabla p - \gamma p \nabla \cdot \mathbf{v}, \qquad (6)$$

$$\frac{\partial}{\partial t}N + \frac{\mathbf{E} \times \mathbf{B}}{B^2} \cdot \nabla_{\perp} N = - \frac{j_{//} - j_{//0}}{eh} - \alpha (N^2 - N_0^2), \qquad (7)$$

$$\nabla_{\perp} \cdot \mathbf{j}_{\mathrm{I}} = - \frac{j_{//}}{h}, \qquad (8)$$

$$\mathbf{j}_{\mathrm{I}} = eNM_P\mathbf{E} - eNM_H \frac{\mathbf{E} \times \mathbf{B}}{B}, \qquad (9)$$

where ν_1, ν_2 are the viscous coefficients; $\mathbf{j}_{\mathrm{I}}, N$ are the current and the density in the dissipative plasma, respectively; h is the thickness of the dissipative plasma; M_P and M_H are the Pedersen and the Hall mobilities, respectively; α is the recombination coefficient; $j_{//}$ represents the field aligned current flowing into the dissipative plasma from the non - dissipative plasma; 0 denotes the background quantity. The equations (1) ~ (6) govern the non - dissipative plasma (magnetosphere), and the others do the dissipative plasma (ionosphere).

Now, we have developed the simulation code and start the simulations. Our next step is analysis of the results of the simulations.

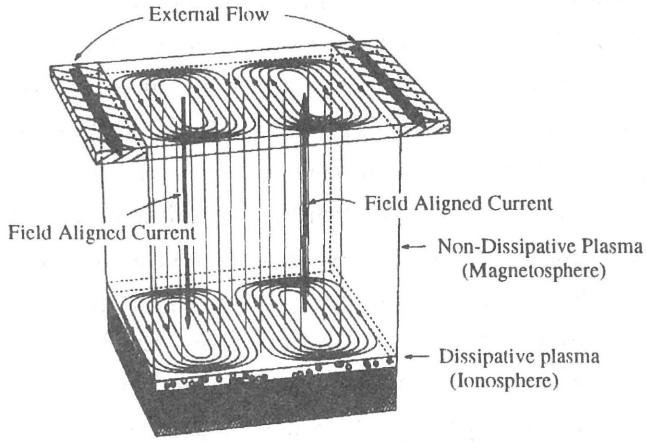

Fig. 1. MHD Self-Organization model