§16. Magnetohydrodynamic Dynamo

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Magnetohydrodynamic (MHD) dynamo is an energy transformation process from kinetic energy of an electrically conducting fluid into magnetic energy.

Kageyama et al. 1) obtained the first report on numerical simulation of dynamical flip-flop type transition of the magnetic energy level and its association with the reversals of the dipole and octupole field polarity in a rotating spherical shell. In Ref. 1, the magnetic field grows by superimposing a weak random magnetic field at t=577 after the convection motion has reached the saturated state.

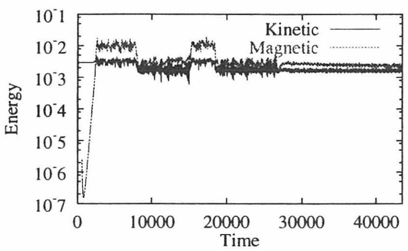

Fig. 1. The development of magnetic field and convection kinetic energy.

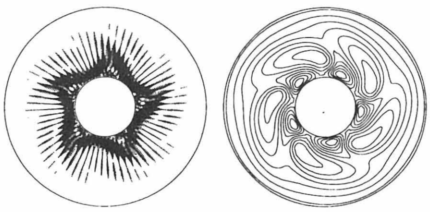

Fig. 2(a). Velocity distribution (left) and contour line of density (right) in the equatorial plane at t=568.

In Fig. 1, the behavior of the development of magnetic field and convection kinetic energy in the final stage is quite different from that in other stages, the velocity distribution and contour line of density in the equatorial plane nearly remain unchanged as shown in Fig. 2(b), and there are 8 pairs of convection columns. It suggests that the system reaches a stable state. But in the initial stage, there are 5 pairs at t=568.

We carry out a new simulation run with the same parameters as those used in Ref. 1) but a weak seed of a random magnetic field was introduced at the beginning. The system quickly develops to a state with 8 pairs of convection columns as shown in Fig. 4. Fig. 3 is the development of magnetic field and convection kinetic energy in new run.

In the case of Ref. 1), the magnetic field energy becomes larger than the convection kinetic energy, and finally the system reaches a stable state, which primarily depends on the balance between magnetic stesses and the kinetic stress. The reversals of the dipole and octupole field polarity occur during the process from convection saturated motion state to the final stable state. This process is important for understanding the reversal mechanism of the polarity in MHD dynamo.

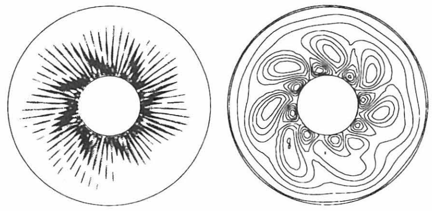

Fig. 2(b). The same as Fig. 2(a), but at t=42120.

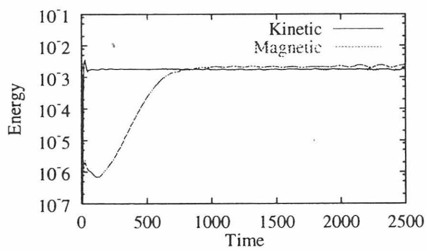

Fig. 3. The development of magnetic field and convection kinetic energy in new run.

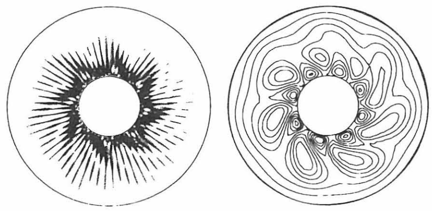

Fig. 4. Velocity distribution (left) and contour line of density (right) in the equatorial plane at t=568 in new run.

Reference

1) Kageyama, A. Ochi, Marcia M. and Sato, T., Phys. Rev. Lett., **82**, (1999)5409