§25. Alpha Effect and Hydrodynamical Helicity of Anisotropic Turbulence in Reversed Field Pinch

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Turbulence caused by high plasma current in reversed field pinch (RFP) organizes the reversed toroidal magnetic field near the wall. Bessel function model (BFM) provides the clear and elegant explanation of the global feature of the relaxation of the turbulent discharge. BFM is consisted by the alpha and beta dynamo effect which are familiar in the study Earth's magnetic field. Especially, alpha effect is important to cause and sustain the reversed magnetic field. To confirm this, we performed a three-dimensional resistive magnetohydrodynamical (MHD) simulation [1]. In isotropic turbulence, the alpha effect is governed by the residual helicity $H = \langle (\mathbf{b}, \text{rot } \mathbf{b}) \rangle - \langle (\mathbf{u}, \text{rot } \mathbf{u}) \rangle$ where $\mathbf{b}$ and $\mathbf{u}$ are turbulent component of magnetic field and velocity, respectively. Fig. 1 shows the Fourier component of velocity and magnetic field of dominant turbulence. The amplitude of turbulence of velocity is the same as that of magnetic field and the scale length of the velocity is smaller than that of magnetic turbulence. Therefore the hydrodynamical helicity $h_H = \langle (\mathbf{u}, \text{rot } \mathbf{u}) \rangle$ is dominant rather than magnetic helicity $h_M = \langle (\mathbf{b}, \text{rot } \mathbf{b}) \rangle$. Fig. 2 (a) shows the h_H is positive at each point. This is in contradiction to the alpha effect theory in isotropic turbulence [2]. It is well known that the parallel flow does not distort the magnetic field lines. This suggests that we must use the perpendicular helicity $h_T = \langle (\mathbf{u}_T, \text{rot } \mathbf{u}_T) \rangle$ instead of h_H . Fig. 2 (b) shows that h_T from the simulation result is negative which is expected to sustain the reversed field. From this point of view, we generalized the quasi-linear theory of alpha effect in isotropic turbulence to that in anisotropic one.

References

- 1) S. Koide, J. Phys. Soc. Jpn. 59 (1990) 3952.
- 2) H. K. Moffatt, *Magnetic Field Generation in Electrically Conducting Fluids* (Cambridge University Press, 1978)

Fig. 1 The Fourier component of velocity (a) and magnetic field (b) turbulence.

Fig. 2 (a) ordinal hydrodynamical helicity h and (b) perpendicular helicity h_T .