§20. Investigation of Flow Pattern for Dynamo
Effect on Reversed Field Pinch

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We investigate the mechanism of field reversal sustenance of the reversed field pinch (RFP) using by semi-implicit numerical code. We investigated the internal electric field to measure the dynamo effect. It is found that the one $m>0$, $n>0$ Fourier mode causes the dynamo effect at one time and the other mode plays an important role of dynamo at the other time. We investigate the alpha effect in this dynamo effect. Figure 1 shows the characteristic profiles of magnetic field, current density and magnetic shear. The reversed toroidal magnetic field is caused the poloidal current as shown the second part of the figure 1. The externally induced poloidal magnetic field in the third part of the figure 1 causes the current by the alpha effect. The magnetic shear must be positive as shown in the fourth part. It is expected that the fluid helicity is negative according to the ordinal description of the relation between the fluid helicity and induced electric field. We detected the fluid helicity in this calculation as shown in figure 2. The ordinal fluid helicity $h = \mathbf{v} \cdot \boldsymbol{\omega}$ is shown in the figure 2(a). The cylinder in the figure corresponds to the wall of the reversed field pinch device. The area of the circle describe the absolute value of helicity at each point. The black circle means positive and white means negative value. Figure 2 (a) shows that ordinal fluid helicity is almost positive which is not consistent with alpha effect model. The conventional relation between the fluid helicity and induced electric field has been yield based on the assumption of isotropic turbulence. Though the flow in RFP is very complex and not isotropic. Furthermore the flow along the mean magnetic field does not play a role of alpha dynamo. We derive the general relation between the fluid helicity and induced electric field without the isotropic assumption. This description shows that the helicity of the flow perpendicular to the mean magnetic field $h_{\perp} = \mathbf{v}_{\perp} \cdot \boldsymbol{\omega}_{\perp}$ is important. We detect the perpendicular fluid helicity $h_{\perp}$ as shown in figure 2 (b). The helicity is negative almost everywhere. This flow is caused by the MHD instability such as kink or tearing instability. This reversed magnetic field sustenance is explained by the alpha effect.

Fig. 1. Typical profiles of magnetic field, current density and magnetic shear of RFP plasma.

Fig. 2. (a) The ordinal fluid helicity $h = \mathbf{v} \cdot \boldsymbol{\omega}$ (b) The helicity of the flow perpendicular to the mean magnetic field $h_{\perp} = \mathbf{v}_{\perp} \cdot \boldsymbol{\omega}_{\perp}$.