§32. Current-Diffusive Ballooning Mode in Second-Stability Region of Tokamaks

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Recently a new theoretical approach has been proposed to understand the anomalous transport phenomena in tokamaks [1]. Since the origin of fluctuations is the plasma pressure associated with the bad curvature, the improved stability and transport is expected in the region of the second stability against the high-n MHD ballooning mode (n: toroidal mode number). We present the transport coefficient in the region of very weak or negative shear region.

The eigenmode equation is reduced to the ordinary differential equation [1] as

$$\frac{d}{d\eta}\frac{F}{\hat{\gamma}+EF+AF^2}\frac{d\phi}{d\eta}+\frac{\alpha[\kappa+\cos\eta+(s\eta-\alpha\sin\eta)\sin\eta]\phi}{\hat{\gamma}+XF} - (\hat{\gamma}+MF)F\phi = 0. \qquad (1)$$

In Eq. (1), length and time are normalized to a and $\tau_{Ap} \equiv a\sqrt{\mu_0 m_i n_i}/B_p$. Notation: s is the shear parameter, $s = r(dq/dr)/q$, q is the safety factor, $F=1+(s\eta-\alpha\sin\eta)^2$, $\kappa=-(r/R)(1-1/q^2)$ is the average well, α denotes the normalized pressure gradient, $\alpha=-q^2\beta'/\varepsilon$.

From Eq. (1), it is seen that the mode becomes more stable when the shear parameter becomes very small or negative. The potential $[\kappa+\cos\eta+(s\eta-\alpha\sin\eta)\sin\eta]$ is the driving source of the high-n ballooning mode both for the cases with dissipation and ideal MHD model. When the geodesic curvature is small or negative, the coefficient $(1/2+\alpha-s)$ becomes larger, so that the eigen mode is more strongly localized near the origin, $\eta=0$. This lead to the better stability and lower transport coefficient. The anomalous transport coefficient is given

$$\chi = \frac{q^2}{f(s,\alpha)}\left[R\frac{\partial\beta}{\partial\hat{r}}\right]^{3/2}\delta^2\frac{v_A}{R}. \qquad (2)$$

Figure 1 illustrates the contour of the anomalous transport coefficient in the α-s plane [2]. The region of instability against high-n ideal MHD ballooning mode is also shown by the dashed line. It is demonstrated that the transport coefficient is reduced in accordance with the second stability region.

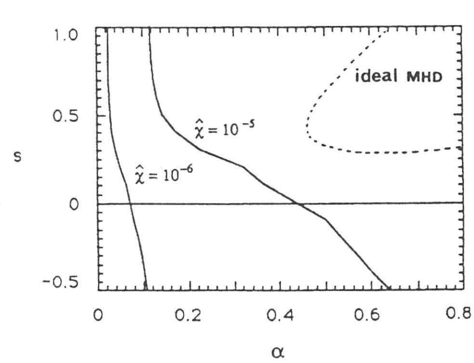

Figure 1: contour of the normalized anomalous transport coefficient on the α-s plane.

References

[1] Itoh K, et al.: Plasma Phys. Cont. Fusion **35** (1993) 543.

[2] Yagi M, et al.: J. Phys. Soc. Jpn. **63** (1994) 10.