§21. Confinement Improvement in H-Mode-Like Plasmas in Helical Systems

Itoh, K., Sanuki, H.
Itoh, S.-I. (Kyushu Univ.)
Fukuyama, A. (Okayama Univ.)
Yagi, M. (JAERI)

Recently, theory for the self-sustained turbulence has been progressed. By solving the interchange-mode turbulence by this new method, theory of the L-mode transport in helical system was given. The influence of the inhomogeneous radial electric field was then analysed for the tokamaks [1]. We here apply this formalism to toroidal helical plasmas and present the unified formula of the anomalous transport coefficient for the L and H-like mode in helical systems.

The reduced set of equations is employed. The basic equations consist of the equation of motion, generalized Ohm's law, and the energy balance equation. The $E \times B$ nonlinear interactions are renormalized in a form of χ , μ and λ . The detailed derivation was reported in [2]. The doppler shift of frequency is offset for the homogeneous $E \times B$ rotation. Only the contribution of E_r' to d/dt is retained.

We solve the mode structure in the vicinity of the mode rational surface, r_s . The marginal stability condition is obtained by setting $\gamma=0$. The parameter ω_{E1} , which denotes the radial electric field shear, $\omega_{E1} = \tau_{Ap} (mdE_r/d\tilde{r}) (rB)^{-1}$, is introduced. This eigen equation determines the relation between the anomalous transport coefficients $\{\chi, \lambda, \mu\}$ and the plasma inhomogeneity $\{\beta', E_r'\}$.

By the perturbation method, the anomalous transport coefficient in the presence of the inhomogeneous E_r is obtained as

$$\chi = \frac{\chi_L}{1 + G\tilde{\omega}_{E1}^2}$$

and

$$\chi_L = \frac{0.8D_0^{3/2}\tilde{\lambda}}{\tilde{\chi}_S^2}$$

(We use the normalization $r/a \rightarrow \tilde{r}$, $t/\tau_{Ap} \rightarrow \tilde{t}$, $\chi\tau_{Ap}/a^2 \rightarrow \tilde{\chi}$, $\lambda\tau_{Ap}/\mu_0 a^4 \rightarrow \tilde{\lambda}$, $\tau_{Ap} \equiv a/\mu_0 m_i n_i/B_p$, and $s = r(dq/dr)/q$, $D_0 = \Omega^2 \beta' / 2\varepsilon^2$.) The form of $\tilde{\chi}_L$ is the anomalous transport obtained for the L-mode plasma. The coefficient λ/χ is given by δ^2/a^2 where δ is the collisionless skin depth. This result quantifies the effect of E_r' on the thermal conductivity, unifying the L- and H-mode plasmas. It is emphasized that the coefficients are given explicitly in terms of the equilibrium quantities. (See ref. [2] for explicit formula.) This is because the self-sustained turbulence is solved by our theoretical formalism. The suppression of the anomalous transport and fluctuation level is prominent when $\tilde{\omega}_{E1} \sim \sqrt{D_0}$.

References

- [1] Itoh S-I, Itoh K, Fukuyama A, Yagi M: Phys. Rev. Lett. **72** (1994) 1299.
- [2] Itoh K, Itoh S-I, Fukuyama A, Yagi M, Azumi M: Plasma Phys. Contr. Fusion **36** (1994) 223.