§15. Current Diffusive Interchange Mode Turbulence at Low Magnetic Shear

K. Itoh

S.-I. Itoh, M. Yagi (RIAM, Kyushu University)

A. Fukuyama (Faculty of Engineering, Okayama University)

Theory of turbulent transport is developed for the plasma near the pitch minimum radius [1]. The enhancement of the turbulence level and the suppression of the local pressure gradient are derived.

We study the high-aspect-ratio plasma with magnetic hill. In the vicinity of the mode rational surface, $r = r_s$, $k_{||}$ is expanded as $k_{||} = -k_{\theta}\{s(r - r_s) + C(r - r_s)^2 + \dots\}$, with $s = q'(r_s)/q(r_s)$ and $C = q''(r_s)/2q(r_s)$. The equation for the turbulence is given as

$$\left(C^2 \frac{d^4}{dk^4} - 2isC \frac{d^3}{dk^3} - s^2 \frac{d^2}{dk^2} \right) \phi - (H - g_1 k^2 - g_2 k^4 - g_3 k^6) \phi = 0$$

where $H = \lambda G_0 / \chi - \mu \lambda k_{\theta}^4$, $g_3 = \mu \lambda k_{\theta}^2$, $g_1 = \mu \lambda k_{\theta}^2$ and $g_2 = \mu \lambda$. (The driving term $G_0 = \beta_p \Omega'$ is the combination of the pressure gradient and magnetic field gradient.) As is in the previous analysis [2], the terms $g_1 k^2$ and $g_2 k^4$ are neglected in comparison with $g_3 k^6$ for the simplicity.

In the strong shear limit, turbulent transport coefficients obtained, in a normalized form, as

$$\chi \approx (\delta/a)^2 s^{-2} G_0^{3/2},$$

where δ is the collisionless skin depth.

The boundary for the strong shear limit, s_c , is given as $s_c \approx \sqrt{\delta/a} C^{1/2} G_0^{1/4}$. In the weak shear limit, $|s| < s_c$, conductivity is derived as

$$\chi \approx (\delta/a) C^{-1} G_0.$$

On the basis of the obtained formula of turbulent transport coefficient, the radial profiles in the vicinity

of the location at the pitch-minimum are analyzed. For the radially constant heat flux, the pressure gradient and fluctuation level are self-consistently solved. The radial profile in the vicinity of the pitch-minimum surface is illustrated in Fig.1.

The depletion of the pressure gradient and the localization of the fluctuations are predicted. The self-consistent calculation of turbulent transport is necessary in order to evaluate the influence of the Bootstrap current on the generation of the pitch minimum in Heliotron/torsatron. The result also suggests that strong localization of fluctuations could be useful in detecting the location of the pitch minimum in the system like Heliotron/torsatron.

Fig.1 Profile of the pressure gradient and the fluctuation level in the vicinity of the radius of the pitch minimum. The normalizing radius, Δr , is the distance between the pitch minimum radius, r_{min} , and the radius at which $s = 1$ holds. (Parameters are: $C \sim 1$ and $|\Omega'| \sim 1$, $q \sim 1$, $q_r \sim \epsilon^{5/2} |\Omega'|^{3/2} (\delta/a)^2$, $\epsilon = 1/4$ and $a/\delta = 50$.)

References

- [1] K. Itoh, et al. *Plasma Phys. Contr. Fusion* **39** (1997) 1561.