§11. Suppression of Plasma Turbulence by Asymmetric Hot Ions

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Influence of inhomogeneity of plasma flow on the magnetic surface, which is driven by the anisotropic hot ions, on the micro turbulence of the low/negative magnetic shear tokamak is investigated [1]. It is found that the poloidal inhomogeneity is effective in suppressing the current-diffusive ballooning mode turbulence which has large nonlinear growth rate. This new mechanism of turbulence suppression provides the model of improved confinement associated with the reversed magnetic shear.

A high aspect-ratio and cylindrical tokamak is employed and the quasi toroidal coordinates (r, θ, ζ) are used. The reduced set of equations with electrostatic approximation is employed. We take into account of the poloidally-asymmetric hot ions, its pressure gradient is characterized as $\partial p_{hot}(\psi, \theta)/\partial\psi = \Gamma\,(1 + \cos\theta)\partial p_0(\psi)/\partial\psi$. Here, ψ is the label of the magnetic surface (the minor radius here) and Γ is the parameter that indicates the magnitude. When the energy of hot ions is much higher than that of bulk plasma particles, the toroidal rotation frequency, $\Omega = V_\zeta / R$, is obtained [2] as $\Omega = \Omega_0(r) + \hat{\Omega}(r, \theta)$ with

$$\hat{\Omega}(\theta) \simeq \left(\frac{\Gamma}{2}\frac{1}{e\bar{n}}\frac{dp_0}{d\psi}\right)\theta^2,$$

where we defined Ω_0 as $\Omega_0 = \Omega(\theta = 0)$.

In the presence of this flow, the nonlinear stability and the associated transport of the current-diffusive ballooning mode are analyzed, by use of the method of the dressed test mode. Nonlinear eigenmode is obtained as is illustrated in Fig.1. The level of self-sustained turbulence is solved. the suppression factor of the turbulent transport coefficient is finally given as

$$\frac{\chi}{\chi_L} = \frac{1}{\left(1 - \Gamma/2 + C_1\Gamma^2\Gamma_c^{-2}\right)}$$

where χ_L is the turbulent conductivity of the L-mode plasma [3],

$$\Gamma_c = 2\sqrt{2}\,q\sqrt{m_e/m_i}$$

and C_1 is a numerical coefficient of the order unity.

In summary, we here theoretically analyzed the new mechanism of the reduction of turbulent transport in high temperature tokamaks. The critical level of the asymmetric pressure gradient is obtained, and this mechanism is found to be very effective in reducing the turbulent transport of the electrons.

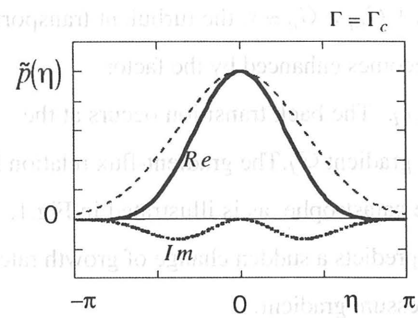

Fig.1 Eigenmode structure for the case of $\Gamma = \Gamma_c$. Solid line and dashed line show the real and imaginary parts, respectively. Thin and dotted line indicates the case with $\Gamma = 0$.

References

[1] K. Itoh, et al., Research Report NIFS-515 (1997).
[2] T. Ohkawa, *Research Report* NIFS-484 (1997).
[3] A. Fukuyama, et al., *Plasma Phys. Contr. Fusion* **37** (1995) 611.