§37. Ohmic Scaling Based on Current Diffusive Ballooning Mode

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

Recently, theory of anomalous transport has shown progress, and that based on the current diffusive ballooning mode (CDBM) has shown considerable success in explaining the L-mode transport [1]. It is shown that the same theoretical formula can explain the Ohmic confinement simultaneously [2]. This strengthens the applicability of the theory.

The electron thermal transport coefficient was derived for micro turbulence due to CDBM as

$$\chi = F(s, \alpha) q^2 (-R\beta')^{3/2} \left(\frac{c}{\omega_p} \right)^2 \frac{v_A}{R}, \quad (1)$$

where $F(s, \alpha)$ is a dimensionless geometrical factor. By use of the dimensional argument, the energy confinement for the Ohmic plasma satisfies the relation

$$\tau_E^{OH} = C_0 n_{e0} T_{e0}^{5/2} R^2 q^2 Z_{eff}^{-1} B_t^{-2} \quad (2)$$

where C_0 denotes the effect of the temperature profile. Eliminating T_{e0} from Eqs.(1) and (2), and representing the profile effect in terms of the internal inductance, one has

$$\tau_E^{OH} \propto \ell_i^{2.2} n_{e0}^{3/8} a^{35/16} R^{7/16} q(a)^{-1/2} Z_{eff}^{-3/8} B_t^{1/2} \quad (3)$$

where ℓ_i is the internal inductance.

The so-called Alcator scaling law can be understood by considering the colinearity in the tokamak Ohmic discharges.

First, the effective charge Z_{eff} is not an independent variable. It has been reported that there is a colinearity such as [3]

$$Z_{eff} - 1 \propto n_e^{-1.1} \quad (4)$$

If one substitutes it into Eq.(3), one obtains

$$\tau_E^{OH} \propto n_e^{3/8} Z_{eff}^{-3/8} \simeq n_e^{0.78} \quad (5)$$

which is close to the observation in the 'linear Ohmic regime'. Next, the q -dependence may be explained through the MHD dynamics. When the central q value is limited near unity due to the sawtooth activity, there appears the colinearity

$$\ell_i \propto q(a)^{0.65} \quad (6)$$

Substituting Eq.(6) into Eq.(3), the q -dependence turns to be

$$\tau_E^{OH} \propto q(a)^{1.32} \quad (7)$$

This strong q -dependence is also consistent with the observations.

These results suggests that the Ohmic confinement is also explained in the framework of the anomalous transport due to CDBM turbulence.

- 1) A. Fukuyama et al., Plasma Phys. Contr. Fusion 37 (1995) 611.
- 2) M. Yagi, et al., J. Phys. Soc. Jpn. 65 (1996) 11.
- 3) F. Wagner et al., Plasma Phys. Contr. Fusion 35 (1993) 1321.