§27. Theory of Pseudo-Classical Confinement and Transition to L-Mode

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In the sperator experiments, the Pseudo-classical transport was observed[1]. The form of $\chi \propto \nu_e \rho_{pe}^2$ was proposed (ν_e: electron collision frequency, ρ_{pe}: electron gyroradius evaluated by the poloidal magnetic field). We present the theory for the simultaneous explanation of the L-mode and Pseudo-classical confinement as well as the transition between them [2].

The eigenvalue equation for the anomalous transport coefficient is given as

$$\frac{\alpha}{\hat{\delta}\hat{\chi}} = g(1+g_1\rho N^2)(1+\rho N^2)^{-2}(1-N^4)^{-2}\left[1 + \frac{2s^2}{g}\frac{1+\rho N^2}{1+g_1\rho N^2}N^4\right] \quad (1)$$

where ρ is the ratio $\rho = \hat{\delta}\hat{\lambda}(\alpha/\hat{\chi}\hat{\mu})^{1/2}$, N is the normalized mode number $N = nq(\hat{\chi}\hat{\mu}/\alpha)^{1/4}$, and (g, g_1) are coefficients $g = 1/2+\alpha+s^2-s$, $g_1 = (1/2+\alpha-s)/g$.

For the resistive plasma, Eq. (1) gives

$$\chi = 4(\varepsilon/\hat{L}_p)\, \nu_e \rho_{pe}^2 \quad (2)$$

where $\hat{L}_p$ is a normalized pressure gradient scale length, $d\beta/d\hat{r} = \beta/\hat{L}_p$. Apart from a geometrical numerical factor of order unity, Eq. (2) is the Pseudo-classical diffusion coefficient. The thermal conductivity in the current diffusive limit is given by that of the L-mode [2].

The change from the Pseudo-classical transport to the L-mode transport occurs at the condition $\nu_e \sim v_{Ti}/\sqrt{\hat{L}_p} R$, where v_{Ti} is the ion thermal velocity.

Figure 1 compares the theoretical predictions with experiments on spherator. (Typical parameters are used: $n_e = 10^{17} m^{-3}$, R = 0.4m, R/a = 6, $\hat{L}_p = 0.4$.) For the set of parameters, the turnover from Pseudo-classical to L-mode transition is predicted to occur at around 8eV. In Fig. 1, the coefficients of order unity is adjusted to recover the original line of the Pseudo-classical law of Yoshikawa (solid line of Fig. 1) in low temperature limit. The theoretical results seem to explain the Pseudo-classical transport and transition to neo-Bohm transport in the spherator experiments.

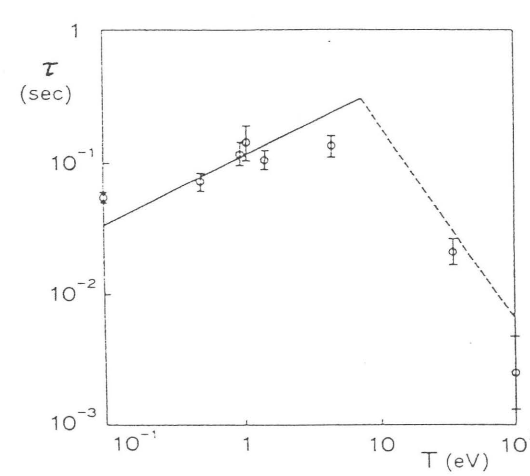

Figure 1: T_e dependence of confinement time in spherator.

References

[1] S. Yoshikawa: Phys. Rev. Lett. **25** (1970) 353.

[2] K. Itoh, et al.: Phys. Fluids B **5** (1993) 3299.