§22. Anomalous Transport Mechanism of Plasma in Field Reversed Configuration (FRC)

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A field reversed configuration(FRC) plasma has a promising potential for a burning one in D-^{3}He fusion reactor because of its intrinsic features, i.e. its high β value and open field configuration outside the plasma. In designing the fusion reactor the most unclear part is the confinement property of FRC plasma.

It had been tried to applied lower-hybrid-drift (LHD) microinstability to particle and trapped-flux transport of FRC plasma as an origin of its resistivity anomalous compared with the classical one.

In small range of its parameters, the LHD micro instability seemed to cause the anomalous transport and to reveal a confinement time scaling of r_s^2/r_i (r_s: plasma radius and ρ_i: ion gyroradius evaluated in the external field B_e). The scaling failed, however, to cover wide range of the plasma parameters, i.e. results in other many experiments.

In fact, nearly classical one is experimentally obtained confinement time of particle and trapped magnetic flux in OCT-S2 (Osaka Univ.) and STP-L (IPP, Nagoya) as shown below.

We numerically simulated the transport of the particle-flux in FRC[1] using one dimensional MHD model[2]. The resistivity was assumed as uniform and classical (Spitzer's one). The one dimensional model based on the experimental fact that $r_s <<$ plasma length ℓ_s. For the two unknown parameters, we used a ratio of particle loss time to magnetic flux decay one ($\alpha = \tau_N/\tau_\phi$) and volume averaged plasma beta $<\beta>$.

Here, we compared experimental results typical in 10 experiments and the simulated results using experimental values of α and Barn's condition ($<\beta> = 1-x_s^2/2$, x_s: ratio of r_s to wall radius) for each case.

Then it was found that a ratio (f) of calculated confinement time to experimental one correlated to a plasma aspect ratio(ε) intensely as shown Fig.1, in which f was plotted versus an half reversed aspect ratio ($r_s/\ell_s = 1/2\varepsilon$).

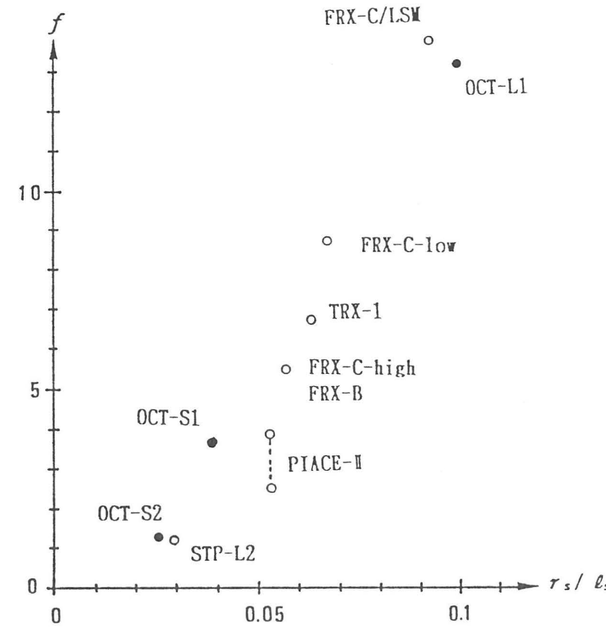

Fig.1 Anomaly(f-1) of confinement time in experiments compared with 1-D MHD simulation

This plotting shows the r_s/ℓ_s dependence of f as

$$f = 1 + 8\times 10^3\ (r_s/\ell_s)^{2.7}\ .$$

Fig. 2 shows plasma pressure contours in 2-D equilibrium with $p(\psi)$ obtained in the simulation for $\alpha=0.7$ and $x_s=0.4$. Value of r_s/ℓ_s (.032,.050, .10) was varied by input$<\beta>$(.930,.925, .915).

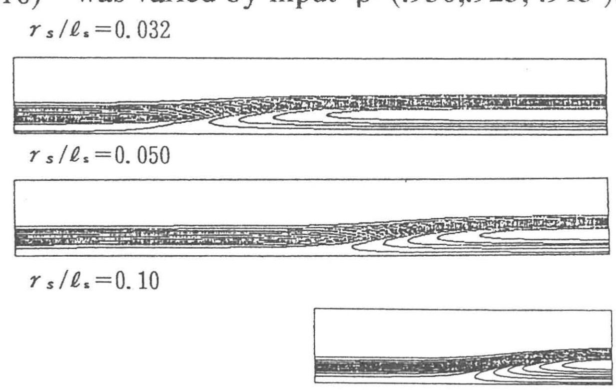

Fig.2. Plasma pressure contours for $\alpha=0.7$ and $x_s=0.4$ in 2-D equilibrium.

This figure indicates that the assumption of 1-D transport model may be acceptable around or below $r_s/\ell_s=0.3$ and that it is defeated above 0.5.

The conclusion is that the transport in FRC is basically classical and the anomaly attributes to geometrical 2-D effect to the transport of the particle-flux. Now, 2-D modeling is under study.

References

1) Ohi,S., NIFS Annual Report, 1991,206.
2) Hamada,S., Nuclear Fusion, 26 (1986), 729.