§1. Improvement of Electron Confinement by Neoclassical Internal Transport Barrier on CHS

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To investigate the heat transport characteristic of the ECH plasma with Neoclassical Internal Transport Barrier, the transport analysis has been carried out by Proctr-MOD code [1] with the power balance equation described below. In the steady state, the heat conduction Q_{cond} can be expressed as

$$Q_{cond} = \frac{3}{2}\nabla(T_e\Gamma_e) - 3\frac{m_e}{m_p}\frac{n_e}{\tau_e}[Z](T_e - T_i) + Q_{ion} + Q_{ech}. \quad (1)$$

Here, Γ_e is the radial electron flux that is determined by ambipolarity condition. The next two terms indicate the plasma convection and the rethermalization factor between the electrons and the ions. Q_{ion} indicates the radiation loss by neutrals.

Q_{ech} indicates an ECH deposition power. We estimate the absorbed power using the I. Fidone and G. Granata formula [2]. In the low density high electron temperature plasma, all the injected power is absorbed at the resonance zone inside $\rho = 0.1$. Even in the low electron temperature plasma, the absorption rate is more than $\sim 90\%$.

The χ_e can be calculated from the following equation.

$$\chi_e = \frac{Q_{cond}}{(n_e\nabla(T_e))} \quad (2)$$

We used an ion temperature of a typical ECH plasma that has almost same electron temperature and density. The center ion temperature is $\sim 130eV$ measured with a charge exchange spectroscopy with a diagnostic NBI which is considerably lower than the electron temperature ($\sim 2.2keV$), because the calculated rethermalization factor is below 10% of the deposition power to the electrons.

The electron thermal diffusivity is shown as a solid line in Fig.1 for both plasmas with N-ITB with the range of the error bar estimated. χ_e is $5m^2/s$ around the barrier point for the plasma with N-ITB. The χ_e steeply reduces at location of the large electron temperature gradient.

The error is mainly derived from the uncertainly of the electron temperature gradient. The plotted error is estimated by the uncertainty of measured data from the fitting curve. Because of the small gradient, the error is large in plasma center and edge region.

We compare the χ_e of the ECH plasma with N-ITB ($P_{inj} = 200kW$) with that without N-ITB ($P_{inj} = 150kW$). In spite of the high electron temperature, χ_e of the plasma with N-ITB is significantly lower than that of the plasma without N-ITB. On the other hand, in the region outside $\rho = 0.5$, there is no difference in χ_e between the plasma with N-ITB and without N-ITB.

Therefore, the improvement of the electron thermal transport by the formation of N-ITB is confirmed.

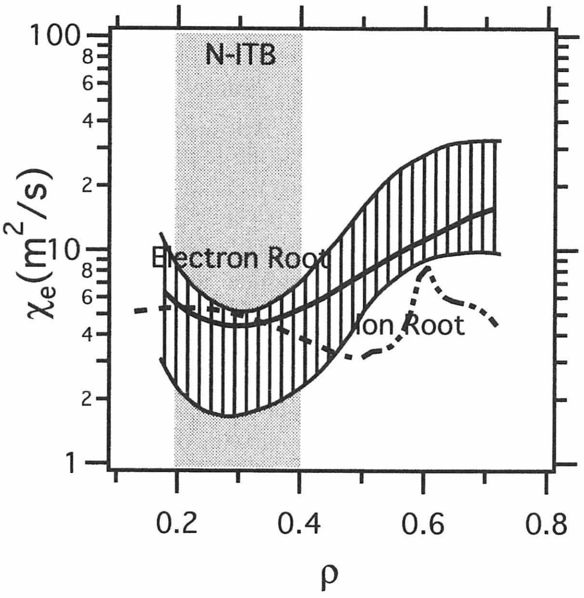

Fig.1: Comparison of the experimental electron thermal diffusivity and the neoclassical calculation calculated form the ambipolar condition. The experimental χ_e is on the level of the neoclassical transport on N-ITB.

References

[1] H. C. Howe, Rep. ORNL/TM-11521, TN(1990)

[2] I. Fidone and G. Granata, Nucl. Fusion 11 (1971) 133