

### §43. Numerical Transport Study in the LHD High Temperature Divertor Plasma Operation

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The high temperature divertor plasma operation is proposed as one of the LHD divertor operation modes to control the edge plasma behavior, as well as the high recycling mode and SHC (the simultaneous attainment of the H-mode and radiative cooling) boundary<sup>1)</sup>. In this operation, the pumping efficiency,  $\eta$ , is increased up to 10 ~ 25 % by, for example, the local island divertor (LID). The edge temperature is considered to be high (~ some keV) with such high pumping efficiency.

With considering the particle balance in a steady state NBI plasma, the NBI particle flux,  $\Gamma_b$ , and the divertor particle flux,  $\Gamma_{div}$ , are related by  $\Gamma_{div} = \Gamma_b/\eta$ . If the radiation power is assumed to be low, the divertor heat flux,  $Q_{div}(= \gamma T_{edge}\Gamma_{div})$  almost equals  $E_b\Gamma_b$ , where  $T_{edge}$  is the edge temperature and  $E_b$  is the beam energy of NBI. Then,  $T_{edge}$  is estimated by  $T_{edge} = E_b\eta/\gamma$ . It will become 2.5 keV in the case of  $\eta = 0.1$ ,  $\gamma = 7.18$  and  $E_b = 180$  keV.

In order to confirm the effectiveness of this operation on the improvement of the core plasma transport, the transport simulation with such edge plasma condition has been done.  $T_{edge}$  and the edge density,  $n_{edge}$ , are estimated for a given  $\eta$  and fixed during the calculation. The numerical simulation is carried out by using TRST code<sup>2)</sup> to investigate the neo-classical transport dominant plasma. The radial profiles of some plasma parameters in the steady state are derived. Fig.1 shows the results of (a)  $n_e$ , (b)  $T_e$  and  $T_i$ , (c) electron heat conductivities,  $\chi_e$ , and (d) radial electric field,  $E_r$ . In this case,  $B = 3$  T,  $P_{NBI} = 20$  MW, the anomalous transport coefficients  $\chi_e^{anom.} = \chi_i^{anom.} = 1.0$  m<sup>2</sup>/s and  $D^{anom.} = 0.1$  m<sup>2</sup>/s are used. An external particle source is added at  $r = 0.25$  m to form the density gradient. While  $T_i(0)$  exceeds 10 keV because of the low  $\chi_i^{anom.}$  in the peripheral region,  $T_e$  is lower because of the large  $\chi_e^{ripple}$  in the  $\rho \geq 1/2$  region. Although  $E_r$  is positive in the whole plasma region, the absolute value of  $E_r$  is large only at the edge and the suppression of  $\chi_e^{ripple}$  by positive  $E_r$  is hardly seen in the inner region. Therefore, it is important to form steep gradient in  $n_e$  and  $T_e$  at the edge to sustain the inner plasma pressure.

In this calculation, a problem exists that the radial mesh number for  $E_r$  is quite less than the mesh

number for the other plasma parameters. For the more precise analysis especially in the edge region, the transport simulation including the time evolution of  $E_r$  is in preparation.

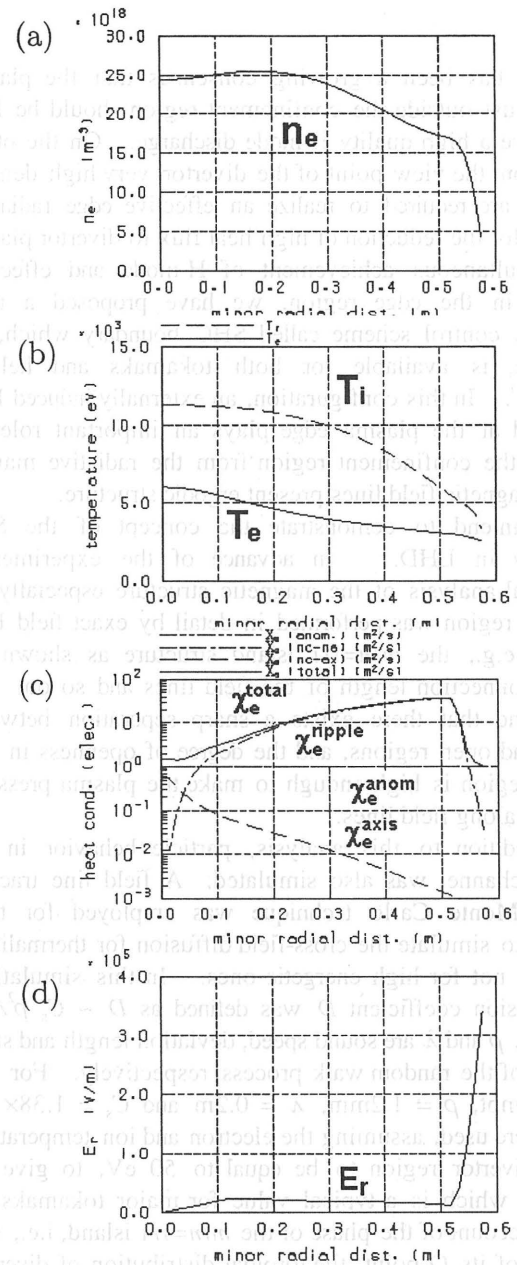


Fig.1. Transport simulation results in the case of pumping efficiency,  $\eta = 0.10$ .

(a)  $n_e$ , (b)  $T_e$  and  $T_i$ , (c)  $\chi_e$ , (d)  $E_r$

#### References

- 1) N.Ohyabu, A.Komori, *et al*, Abstract of Joint Conf.11th Intern. Stellarator Conf.and 8th Intern. Toki Conf. Plasma Phys. and Controlled Nucl. Fusion, 1997, LW-3.
- 2) Y.Nakamura and M.Wakatani, PPLK-R-24(1988).