§10. 3D Edge Transport Study of LID Configuration in LHD with a Monte Carlo Scheme

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The inherent three dimensionality of the magnetic field structure in LHD always brings severe difficulties in modelling the edge transport with any simplified 1D or 2D treatments. Recently, the edge transport physics has been analyzed using the 3D fluid edge transport code, EMC3$^{1)}$, coupled with the kinetic neutral transport code, EIRENE$^{2)}$. With an advantage of the Monte Carlo scheme, the code can treat almost any complex three dimensional geometry of plasma, magnetic field and plasma facing components, and provide 3D profiles of plasma parameters, i.e., n_e, T_e, T_i, $V_{//}$, neutrals etc. For the first step of the application of the codes to LHD, the configuration was selected as follows. The LID head was set at r_{head} = -118 mm, and the plasma parameters of the analysis correspond to those of shot number 41691 (r_{head} = -148 mm, t = 0.62s) and 41696 (r_{head} = 98 mm, t = 1.52s) with ~ 1.4 MW input power and the density at inner separatrix (n_{eup}) of ~ 1.2×10^{19} m^{-3}.

The results of the EMC3-EIRENE prediction are shown, in Fig. 1, electron density described as the logarithmic scale normalized by the maximum value of 2.5×10^{20} m^{-3}, and in Fig. 2, particle flux ($nV_{//}$), on the poloidal cut at the center of LID head. From the figures, it can be seen that the parallel flow is established along the island separatrix towards LID head, and also the highest density is achieved at the striking point of the outer island separatrix on the LID head, being in accordance with a picture that particles diffused out from the confinement region are guided to the LID head along the island separatrix. The flow profile shows a small particle deposition onto the front side of the LID head and at the leading edge, as observed in the experiments. In the simulations, 20% of total particle flux onto the head was found to be deposited at the front side, then be neutralized and recycled. The particle correction efficiency of the LID head would be a key factor in determining the best divertor performance of LID, for which the head design has to be optimized taking into account the edge transport process.

The closed structure of the divertor and baffle plates gives rise to the high confinement for neutrals, up to 3.1×10^{20} m^{-3}. This leads to a strong recycling, resulting in T_e = 5 eV, n_e = 10^{19}~10^{20} m^{-3}, with a mean free path of ionization of neutrals of several centimeters, which is comparable with the plasma size in the divertor. The reproduced n_e and T_e in the simulation at the probe positions were found to be consistent with the measurement of the ion saturation current in experiments. Keeping rather high temperature divertor plasma is one of the goals of this configuration to realize a high confinement in core region$^{3)}$. The dependence of the edge temperature profile on the input power will also be investigated by the modelling in terms of an edge transport. As mentioned above, the high recycling and the neutral compression, resulted from the efficient pumping, are predicted by the simulation. The EMC3-EIRENE code estimates the pumping efficiency at 50 – 60 %.

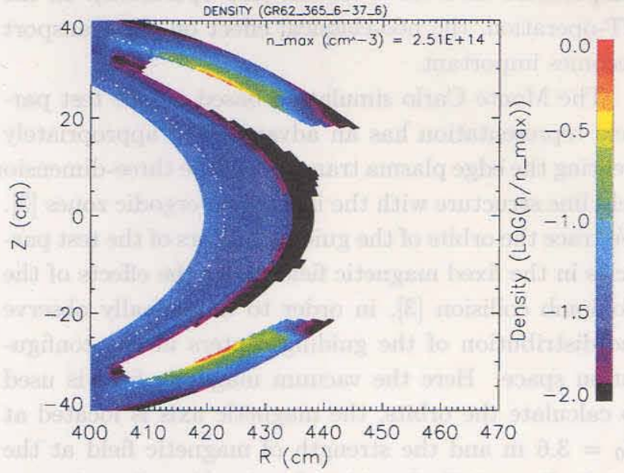

Fig. 1 Density profile in poloidal cross section at the center of LID head. The cross section of the LID head is outlined on the white background. The island separatrix are also depicted with white dots.

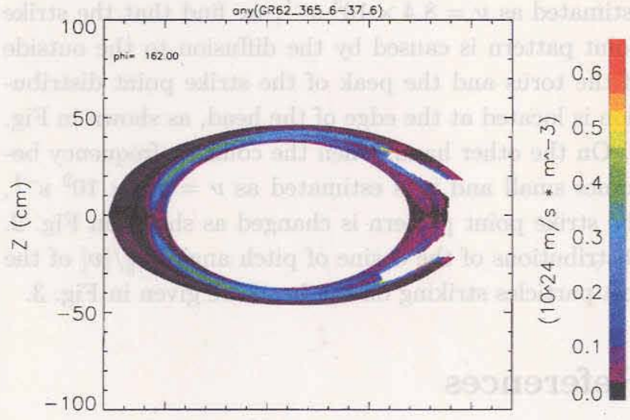

Fig. 2 Particle flux profile ($nV_{//}$) in the poloidal cross section.

Reference

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3) Ohyabu, N., et al, J. Nucl. Mater. **145-147**, (1987) 844.