§18. 2D Modeling of LHD Divertor for Monte Carlo Code of Impurity Transport

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Impurity transport in a fusion plasma is one of essential issues for improvement of energy confinement and long-time discharges. Since SOL and divertor plasma depend on configuration of the device strongly, a modeling of the plasma and the geometry is necessary for each device, e.g. ERO[1)] for TEXTOR and IMPGYRO[2)] for JT-60U. In this work, we made a 2D simulation model of the divertor of Large Helical Device (LHD) and implemented it to ERO. Figure 1(A) shows the LHD configuration of the plasma, super-conducting coils and divertor plates. The LHD plasma is twisted by the helical magnetic field created by a pair of the helical coils and the SOL plasma has an ergodic magnetic field. Therefore, a global modeling requires a 3D plasma profile with fine resolution. The computational resources for the 3D simulation is, However, huge and it takes much time to development a code. As a preliminary to such realistic simulation, we developed 2D simulation model with 1D plasma profile in divertor legs of LHD.

We chose the 2D simulation box to be normal to the inboard-side divertor plates, which is shown in Fig. 1(b) as x-z plane. The poroidal cross section and simulation box are shown in Figs 2(a) and (b), respectively. We can safely assume the up-down symmetry to reduce the size of the simulation box to the bottom half by introducing virtual reflections of impurity particles at the upper boundary, $z = 0.4$ [m]. The magnetic field in each divertor leg is assumed to be uniform with incident angle of 82° from the surface normal of the divertor plate. The perpendicular direction, i.e. y-direction, is assumed to be uniform, and thus periodic boundary condition is employed. Since our interest is in the impurity deposition on the first wall and the density profile in the divertor leg, impurity particles are removed from the simulation when they move into the core plasma region shown as

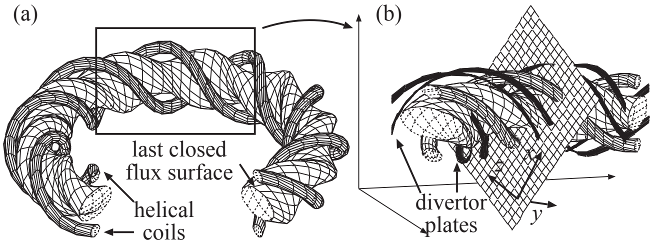

Fig. 1: (a) Schematic illustration of the plasma and the helical coils in the LHD. (b) enlarged illustration of the rectangular section. A plane with x-z axes represents a cross section of LHD divertor chamber used in ERO.

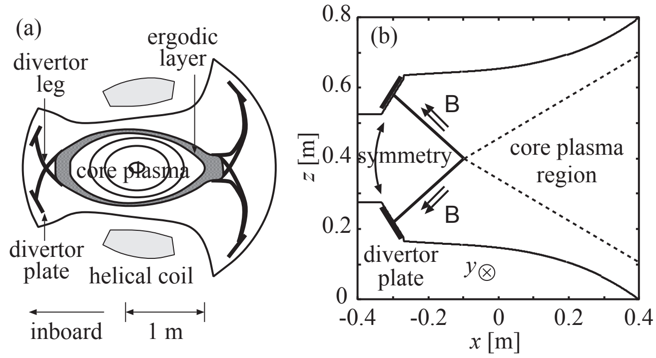

Fig. 2: (a) a poroidal cross section of the LHD plasma and the first wall. (b) the x-z plane used in the ERO code. The latter plane was generated by a CAD system and the perpendicular direction to the figure, i.e. along the y-axis, is locally uniform.

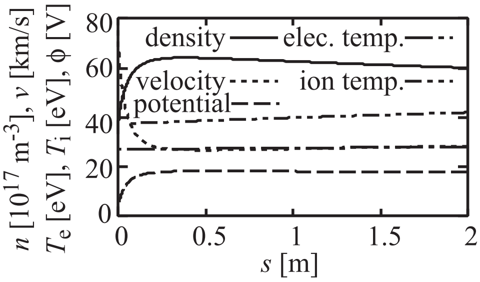

Fig. 3: 1D plasma profiles along the magnetic field for a typical set of plasma parameters.

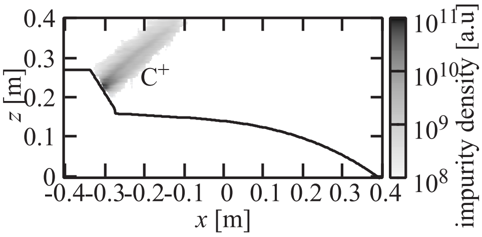

Fig. 4: Distribution of Carbon ion in the divertor leg.

dotted lines in Fig. 2(b).

The background plasma shown in Fig. 3 is calculated by a 1D fluid model[3)]. The spatial coordinate s is taken along the magnetic field from the divertor plate, i.e. $s = 0$ at the wall. We curried out the Monte Carlo calculation by using ERO with our 2D model and obtained a result of impurity distribution shown in fig. 4. It indicates localization of the carbon impurity near the divertor plate. The reason is understood as follows. Since LHD divertor plasma has a strong flow, the friction force toward the divertor plate acts on the carbon ion. Although other results for different plasma parameters are not given here, we confirmed that high-density plasma tends to confine the impurities efficiently in the divertor region.

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