§41. Divertor Particle Flux Profiles in LHD

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1. INTRODUCTION

The analyses of the divertor particle flux (Γ_{div}) profiles on the divertor plates and the particle deposition profile in the helical divertor are very important for the understanding of the particle transport in the open field line region, and for the design of the next divertor configuration, such as the closed helical divertor in LHD. The profiles of Γ_{div} were measured by the embedded Langmuir probe arrays at different positions in the helical divertor. The Γ_{div} profiles depend on the magnetic axis (R_{ax}), and are also affected by β value. In this report, the relationships between the Γ_{div} profiles and R_{ax}, β values are briefly described.

2. Γ_{div} PROFILES ON THE DIVERTOR PLATE

Figure 1 shows the variations of the Γ_{div} profiles on the inboard-side divertor tile for different R_{ax}. The connection lengths of the magnetic field lines (L_c) were calculated along the probe array, and are also indicated in fig. 1. The L_c profiles consists of 3 groups; the 'short' L_c, the 'medium' L_c and the 'long' L_c groups. The field lines with the 'short' L_c surround the open-field line region, and do not approach the ergodic region. The field lines with the 'medium' L_c are between the field lines with the 'long' L_c, and reflect the structure of the edge surface region [1]. The 'long' magnetic field lines connect the ergodic region and the divertor plates directory. Therefore, the peaks of Γ_{div} appear at the positions of the 'long' magnetic field line region. On the other hands, the Γ_{div} are much smaller at the region of the 'short' magnetic field lines. This tendency is independent of R_{ax} as shown in fig. 1. The width of the Γ_{div} profiles is determined by the L_c profile and the diffusion from the region of the 'long' magnetic field lines to the 'short' L_c region.

Figure 2 shows the normalized Γ_{div} profiles for different β values obtained on the divertor plate near the lower port. At this divertor plate, the structure of the edge surface region is considered to connect this plate with relatively large spatial scale, and it appears in the Γ_{div} profile in the low β case, that has two peaks of Γ_{div}. In the case of high β value, the interior region between the peaks is filled with the particle flux. This result is considered to be caused by the modification of the magnetic structure in the open field line region. The results of the magnetic field lien tracing including the effects of finite β [2] supports this idea, qualitatively.

3. PARTICLE DEPOSITION PROFILES IN THE HELICAL DIVERTOR

The calculation of the field line tracing with random walk process, that simulates the diffusion process [2], shows the non-uniformity of the particle deposition profiles in the helical divertor even in the helical direction [3], and the R_{ax} dependence of it. For instance, the dominant particle deposition place is the inboard for R_{ax} = 3.6 m, and the upper and lower side for R_{ax} = 3.75 m. Although this calculation does not include the effects of the drift, particle sources in the open field line region and so on, the calculated results agree with the results of the Langmuir probe array measurements qualitatively in the case of relatively low β discharges. In the case of high β discharges ($<\beta> > 2\%$), the change of particle deposition profile is observed.

4. DISCUSSIONS

The divertor particle flux profiles on the divertor plates and in the helical divertor were investigated by the Langmuir probe measurements and the calculation with magnetic field line tracing. The 'long' magnetic field lines are considered to be the main path of the energy and particles from the open field lines region to the divertor in the case of the 'thin' divertor legs (in fig. 1, R_{ax} = 3.9, 3.75 m). The magnetic structure of the 'thick' (in fig. 1, R_{ax} = 3.6 m and in fig. 2) divertor legs is considered that the structure of the edge surface region connects to the divertor with large spatial scale. In this case, the diffusion from the 'long' magnetic field group to the region with 'medium' L_c is not negligible. Therefore, the particle flux profile is considered to be changed with the operation parameters, such as the magnetic field strength, ion density and temperature etc. β value also affect the profiles as described in the sections 2 and 3. Such changes of the profiles must be taken into consideration for the design of the next divertor, such as closed type divertor.

REFERENCES

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[2] T. Morisaki, et al., Contr. Plasma Phys., 40(2000) 221. (also in this annual report.)
[3] S. Masuzaki, et al., 14th PSI conference (2000).

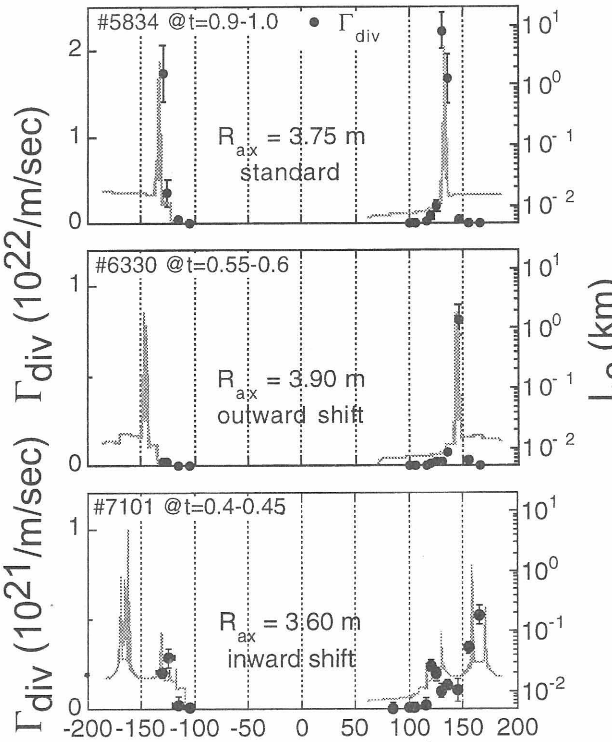

Fig. 1: The profiles of the divertor particle flux on the divertor plate at inborad side for various R_{ax}.

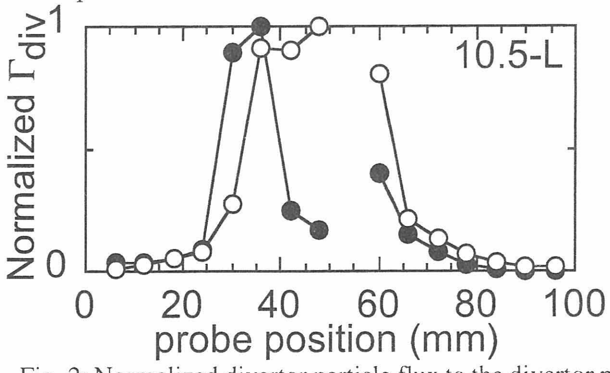

Fig. 2: Normalized divertor particle flux to the divertor plate near 10.5-L port. Closed circles: #11708 ($<\beta> < 1\%$) Open circles: #15042 ($<\beta> > 2\%$)