§42. Diverted Particle Flux Distributions in SHC Boundary Configuration

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There has been a growing consensus that the plasma density just outside the confinement region should be low to achieve a high quality H-mode discharge. On the other hand, from the view point of the divertor, very high density plasmas are required to realize an effective edge radiative cooling for the reduction of high heat flux to divertor plates. For simultaneous achievement of H-mode and effective cooling in the edge region, we have proposed a new boundary control scheme called SHC boundary which, in principle, is available for both tokamaks and helical systems[1]. In this configuration, an externally induced low m island at the plasma edge plays an important role to separate the confinement region from the radiative mantle where magnetic field lines present ergodic structure.

We intend to demonstrate the concept of the SHC boundary in LHD. In advance of the experiments, numerical analysis of the magnetic structure especially in the edge region was performed in detail by exact field line tracing, e.g., the m/n=1/1 island structure as shown in Fig.1, connection length of the field lines and so on. It was found that there exists a sharp separation between closed and open regions, and the degree of openness in the ergodic region is high enough to make the plasma pressure constant along field lines.

In addition to this analysis, particle behavior in the divertor channel was also simulated. A field line tracing with a Monte Carlo technique was employed for this purpose to simulate the cross-field diffusion for thermalized particles, not for high energetic ones. In this simulation the diffusion coefficient D was defined as $D \sim C_s\,\rho^2/\lambda$ where C_s, ρ and λ are sound speed, deviation length and step distance of the random walk process, respectively. For the first attempt, ρ = 1.2mm, λ = 0.2m and C_s = 1.38×10^5 m/sec were used, assuming the electron and ion temperature in the divertor region to be equal to 50 eV, to give D ~1m^2/sec which is a typical value for major tokamaks. Taking account of the phase of the m/n=1/1 island, i.e., the position of its O-point, the toroidal distribution of diverted particle flux in the SHC boundary configuration was investigated. Particle sources were distributed just inside the last closed flux surface (LCFS) to simulate the outward flux from the confinement region. After a number of toroidal turns, particles which come to the wall or divertor plates through the divertor channel were counted along the traces of divertor striking points in whole torus. A result of the calculation is shown in Fig.2. Although there are 4 divertor legs in the heliotron device, no distinction between each leg was made in the calculation. In this figure, Φ =0° is the toroidal position where the poloidal cross section of the plasma is horizontally elongated and the O point of the m/n=1/1 island locates outside of the torus. It is clearly seen that there exist 10 periodic peaks enclosed with a large envelope whose toroidal mode number is 1. The 10 peaks are corresponding to the helical period number, which shows the existence of intrinsic strong toroidal/poloidal asymmetry of the helical divertor flux in the heliotron configuration. Meanwhile the envelope structure is thought to be the effect of the island.

To get more information about the relationship between the toroidal distribution of diverted particle flux and the phase of the island, for the next step, it is necessary to clarify the escaping path of the diverted particles in the edge region. Furthermore, the particle flux dependence on the ergodicity, island size and/or D must be studied quantitatively in future.

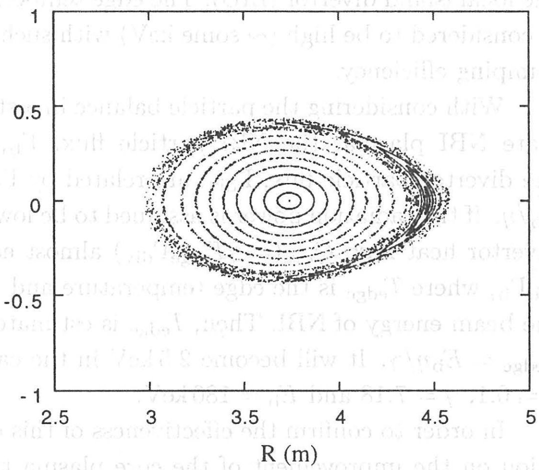

Fig.1. SHC boundary configuration in LHD.

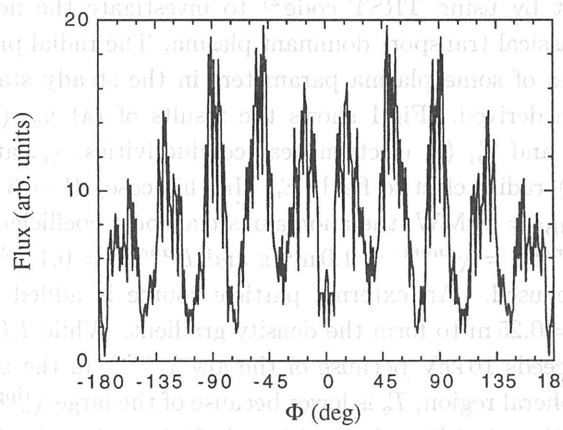

Fig.2. Toroidal distribution of diverted particle flux in SHC boundary configuration.

Reference

1) Ohyabu, N. : J. Plasma and Fusion Res. 71 (1995) 1238.