§16. The Strike Point Pattern on Local Island Divertor in LHD

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The Local Island Divertor (LID) is one of the divertor concepts [1] involved in the Large Helical Device (LHD) configuration and it utilizes an m/n=1/1 island formed at the edge region of the LHD. The LID has been proposed to control the edge plasma of the LHD. Control of the edge plasma by means of the LID aims to achieve high temperature divertor operaton (HT-operation). It is important to investigate whether or not the particle flux cross the island separatrix is successfully guided to the rear side of the island where the target plates are placed to receive the particle load. If the particles strike on the front part of the LID head, then the particles neutralized on the front part cannot be pumped out, because the front part is not coverd by the pumping duct. Thus, optimization of the particle orbits in the island region is the key to realize HT-operation by means of the LID.

Assuming HT-operation is achieved it is expected that the neoclassical effect on the edge transport becomes important. Since the edge plasma in HT-operation is collisionless, the orbits of charged particles become complex compared to the field lines; i.e. the effect of the Coulomb collision causes the transition between a passing particle orbit in the 3D field line structure and a trapped particle orbit in toroidal and helical ripples (localized and/or blocked particle orbits). Thus, according to the ratio of the mean free path to the connection length, the pitch angles of the particles which contribute the particle flux to the LID head is expected to vary; in the present study it is called the neoclassical effect on the edge transport phenomena. Here, the connection length is given as a length along a field line connecting the core region to the LID head estimated as Lc=100 m. Monte Carlo simulation based on test particle representation is carried out in order to investigate on strike point patterns of ions on the LID head in the 3D field line structure, the edge plasma transport under HT-operation.

The strike point patterns on the LID head have been numerically observed by tracing the orbits of the guiding centers in the fixed magnetic field under the effects of the Coulomb collisions and the anomalous diffusion.

The change in strike point pattern was seen according to the change in l/Lc. When the mean free path l is estimated as l/Lc=3, the strike point pattern becomes almost symmetric, and peak of strike point pattern corresponds to the intersection of the island separatrix on the LID head. In this case, the passing particles mainly contribute the particle flux to the head, thus the particles contributing the transport follow the orbits along field lines of the island separatrix. When the mean free path l is estimated as l/Lc=0.03, the particles escaping into the island region suffer the pitch angle scattering sufficiently and are carried to a far region from the island separatrix. In this case the particles strike mainly the inside in front of the LID head and decrease the number of particles that reach rear side separatrix. When the mean free path l is estimated as l/Lc=0.3 as shown in Fig1, the strike point pattern becomes not symmetric, and peak of the strike point pattern is located at the edge of the head. In this case, the particles transit between a passing particle orbit and a trapped particle orbit in toroidal and helical ripples. So trapped particle orbits escaping into the island region suffer the pitch angle scattering and are carried to inside of region from the island separatrix. Passing particle orbits move along field lines of the island. Around the head, $B\times\nabla B$ motion of particles are downward as shown in Fig.2. Therefore, the particle that approaches the head from the upper part reaches the head easily, and the particle that approaches from the lower side doesn't reach the head easily. Broken symmetry of strike point pattern is caused by this effect.

The neoclassical effect plays the important role in determining the strike point patterns on the LID head. The performance is improved according to the rise of l/Lc. The above results are not easily treated in fluid representation.

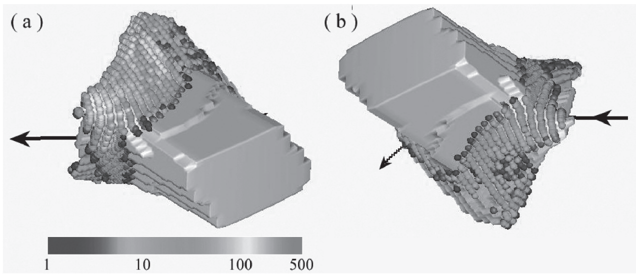

Fig. 1. The strike point pattern on the LID head for the Case of Rax=3.6 m, E=300 eV and l/Lc=0.3: (a) the rear-view of the pattern, (b) the opposite -side-view of the figure (a). The color of the pattern indicates strength (A.U.) of the number of test particles striking the head.

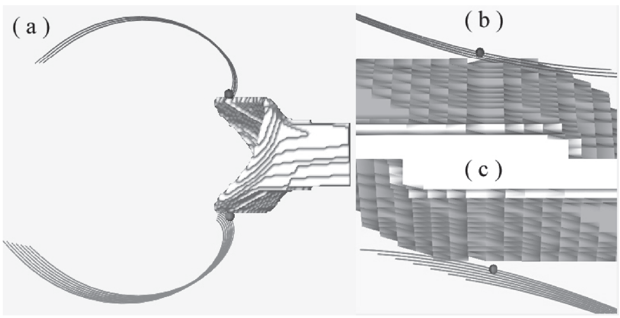

Fig. 2. Illustration of guiding center orbit; (a) side view, (b) closeup of back view (upper part), (c) closeup of back view (lower part), spheres are the initial positions of particle.

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