§6. Plasma Boundary Condition for Edge Transport Barrier Formation

Okamura, S., Akiyama, T., Suzuki, C., Minami, T., Isobe, M., Nagaoka, K., Yoshimura, Y., Nishimura, S., Matsuoka, K.

It is generally discussed for tokamaks and stellarators that the formation of the transport barrier is very sensitive to the rotational transform value of the magnetic surface. In CHS, the edge transport barrier (ETB) is created in the standard magnetic configuration ($R_{ax} = 92.1$ cm) when the heating power is above the threshold. The last closed magnetic surface (LCMS) of this configuration is determined by the vacuum chamber wall and no magnetic diverter structure exists. The rotational transform value is 1.03 at the LCMS for vacuum configuration and it increases for finite beta equilibrium (1.16 for 1% beta). In this report, the effect of plasma boundary condition on the formation of ETB is studied from the aspect of the rotational transform value and the magnetic limiter structure.

At first, the viewing position of Hα emission monitor is discussed. Figure 1 shows the viewing angle of the present Hα detector with the magnetic surfaces for the vacuum configuration at two toroidal positions. When the ETB is formed in CHS, a sharp drop of Hα emission signal is observed which is a typical observation in the H-mode discharges. Since the CHS standard configuration has a contacting point of the LCMS on the vacuum chamber wall, it is important to examine whether the Hα detector looks directly at such a contacting point. Figure 1 shows that the viewing area of the present Hα detecter does not include the direct contacting point, which allow us to interpret the Hα emission level as showing the particle outward flux.

Owing to the flexibility of the poloidal field control of CHS, it is possible to vary two basic poloidal field parameters separately which are the dipole field and the quadrupole field. Former one gives the magnetic axis shift and the latter one toroidal averaged ellipticity control. Both parameters change the rotational transform of LCMS. Since the magnetic axis shift brings large changes of magnetic surface quantities, we use the quadrupole control for the purpose of studying the sensitive effect of characteristics of LCMS on the ETB formation. Figure 2 shows the vacuum magnetic surfaces for the configuration of higher elongation and the lower elongation relative to the standard configuration already shown in the left picture of Fig. 1. Those two configurations has a finite distance between the vacuum chamber wall and the LCMS.
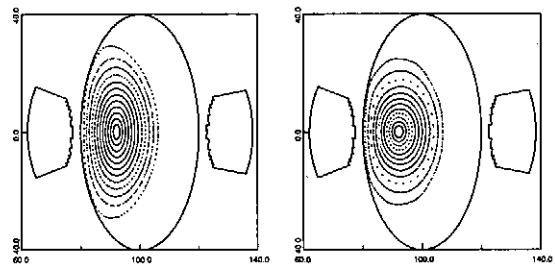
Fig. 2   Magnetic surfaces for high and low ellipticities

The rotational transforms at the magnetic axis and the LCMS are calculated for vacuum with five values of ellipticities shown in Fig. 3. Bq is the controlling parameter for the quadrupole field and -50 corresponds to the standard configuration. Larger Bq value gives the higher longitudinal elongation. The experiments for the ETB formation were made for those five configurations. Strong ETB was formed for Bq = -50 and 0 and weaker one is formed for Bq = -100. These results suggest that the condition of the rotational transform at LCMS close to unity is necessary for ETB formation. It is also shown that the distance between the wall and the LCMS is not essential condition.
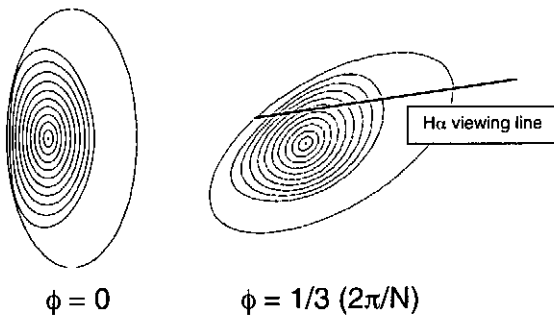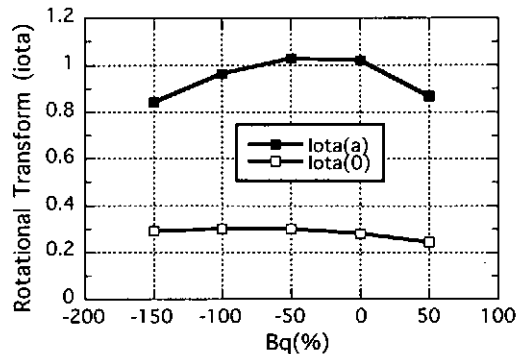
Fig. 1   Schematic cross sections of magnetic surfaces and the vacuum chamber wall. Plasma boundary is limited at the cross section near $\phi = 0$. Hα detector is installed at the cross section shown at right and its viewing line is shown.

Fig. 3   Rotational transform at LCMS and magnetic axis for different ellipticities (standard configuration is for Bq = -50)