§18. Study on H-alpha Emission and Neutral Density Distribution

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Neutral particle transport is an important issue not only to study plasma particle/energy balance but also to improve core plasma confinement. Dominant neutral particle source is due to the recycling at the first wall, limiter, and divertor plates. In devices such as Stellarator/Heliotron, nested magnetic surfaces are surrounded by the so-called separatrix layer, which consists of open field lines with various connection length to the vacuum chamber wall and/or divertor plates. In Compact Helical System (CHS) , magnetic configuration for the plasma confinement changes from the material limiter type to the magnetic divertor type with shifting the magnetic axis position (R_{axis}) along torus outward direction. The distribution of neutral recycling on the vacuum vessel is also expected to change with the magnetic axis shift.

In the so-called standard configuration ($R_{axis} = 0.921[\mathrm{m}]$) , the configuration is the limiter like, and the recycling occurs the inner wall of vertically elongated poloidal cross sections, where core plasma has direct contact with the vacuum chamber. The DEGAS neutral transport simulation code (ver.63) has already been applied to evaluate neutral behavior in CHS standard configuration.[1, 2] In outward shifted configuration, however, the distribution of recycling source is not so clear yet. KMAGN code is widely used to obtain vacuum magnetic surface data of Stellarator/Heliotron. Though plasma diffused from LCFS flows along divertor field lines, it will be neutralized at foot points (sometimes called as strike points) where field lines hit chamber wall. We use the KMAGN results and develop the new model on the distribution of the neutral particle recycling. [3] One example is shown in Fig. 1. On three dimensional chamber wall, neutral source intensity due to recycling is plotted as a contour. Black area is recycling source and white area is no source. Due to the requirement of DEGAS code, the equatorial plane was shifted as $Z = 0 \rightarrow 40[\mathrm{cm}]$. The recycling area is localized not only poloidally but also toroidally.

Though Hα emission intensity is often used as the measure of recycling particle flux, this must be checked carefully, since Hα emission has deep relationship with the profile of atomic/molecular hydrogen, which is very complicated in helical systems like CHS. One example of simulation results with different source model is shown in Fig.2. This is the Hα emission profile from the atomic hydrogens on cross section 8P (toroidal angle $\phi = 30.4$ [deg.].). If the neutral recycling source is changed from limiter-type to divertor-type, neutral distribution is drastically changed. In this cross section, neutral density has the peak around the major axis of elliptic cross section on the chamber wall. So the signal of 8P Hα detector, whose sight is nearly parallel to major axis, becomes large in Fig.2(b), although this detector does not see the maximum Hα emission region in Fig.2(a). Experimental observation confirms the result of Fig.2, since Hα signal of 8P detector increases with outward magnetic axis shifting.

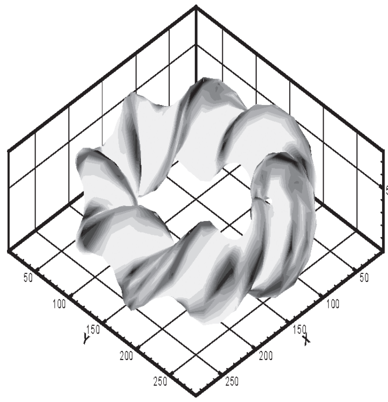
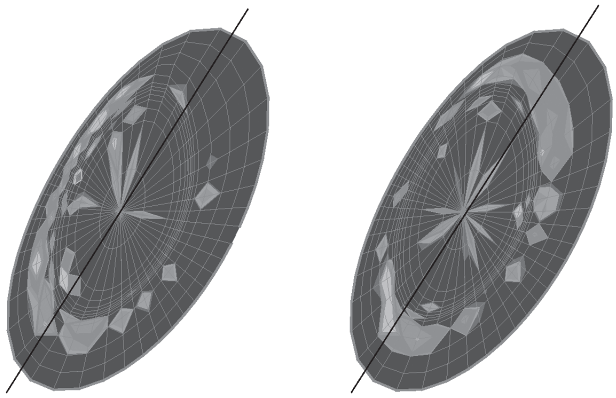


Fig. 1: Estimated neutral source distribution from the foot point distribution of CHS divertor field lines. Magnetic axis position is $R_{axis} = 0.961[\mathrm{m}]$.



(a) Limiter source (b) Divertor source

Fig. 2: the Hα emission profile from the atomic hydrogens on cross section 8P. Solid line is the sight of the detector.

References

1) H.Matsuura et al.: J. Plasma Phy., 72 (2006) 1105
2) H.Matsuura et al.: J. Nucl. Mater., 363-365 (2007) 806
3) H.Matsuura et al.: Trans. Fusion Sci. Tech., 51 (2007) 364