§71. Role and Contribution of the Open Field Line Region in the LHD

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The LHD has a triplex structure of the magnetic field lines composed of the the diverter legs, chaotic field line region and magnetic surface region as shown in Fig.1.

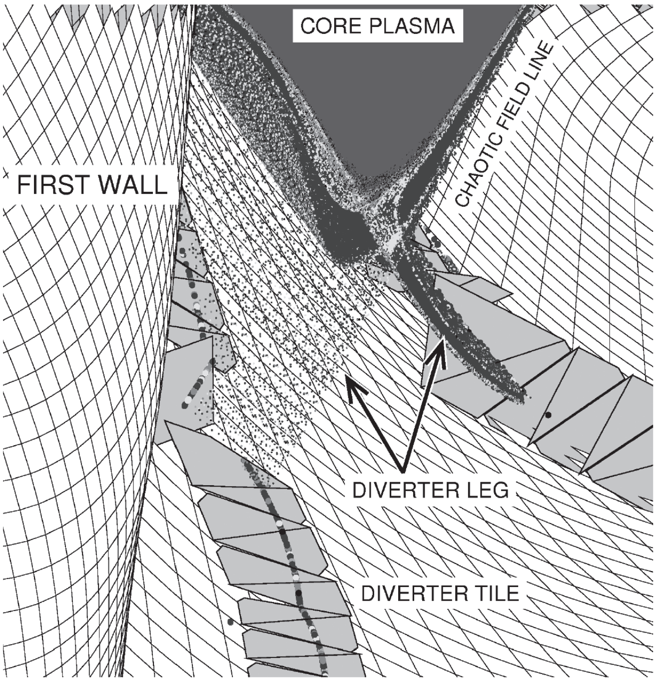

Fig.1 Triplex structure of the LHD magnetic field with $R_{\rm ax} = 3.6\,{\rm m}$. Divertor footprints are also shown.

A high temperature and high density core plasma is confined in the magnetic surface region. The diverter legs and chaotic field line region are the open field line region of the LHD. Role and contribution of the open field line region in the LHD are discussed.[1] Open field line region plays the key role for steady state operation of the LHD and greatly contributes to the high-performance plasma confinement in the LHD.

Chaotic field line region, produced by high magnetic shear and nonaxisymmetry of the magnetic field, is present outside the last closed flux surface of the LHD.

Coalition of magnetic surface and the chaotic field line region actualize the excellent high energetic particle confinement.[2] The numerical result has been confirmed by the high-energy particle spectrum with energies up to 2.6 MeV in the ICRF long pulse experiments in 10th campaign of the LHD.

The chaotic field line layer can sustain ambient plasma due to the long connection length of lines of force, presence of the embedded magnetic islands and mirror confinement effect of helical ripple nature of the magnetic field. This ambient plasma plays a role of an impregnable barrier for the core plasma confinement. Because the lines of force has no regularity in the chaotic field line layer, the ambient plasma can stabilize the interchange mode due to the neutralization of the charge separation that causes the instability. Neutral atoms that cool the core plasma can be shielded by the ambient plasma.

The diverter legs, that is the lines of force slipped out from the chaotic field line region, reach diverter tiles very soon and are frozen to the vacuum vessel wall. Then, it is expected that the diverter legs can suppress the ballooning mode instabilities by the conducting end plate effect of the field lines.

Slow and small periodic sweeping of magnetic axis position can control the deconcentration of divertor heat flux in the LHD as shown in Fig.2. The control using chaos can be essentially done in a low power level. Then it is expected that magnetic axis position sweeping scheme become a fundamental technology in fusion reactors.

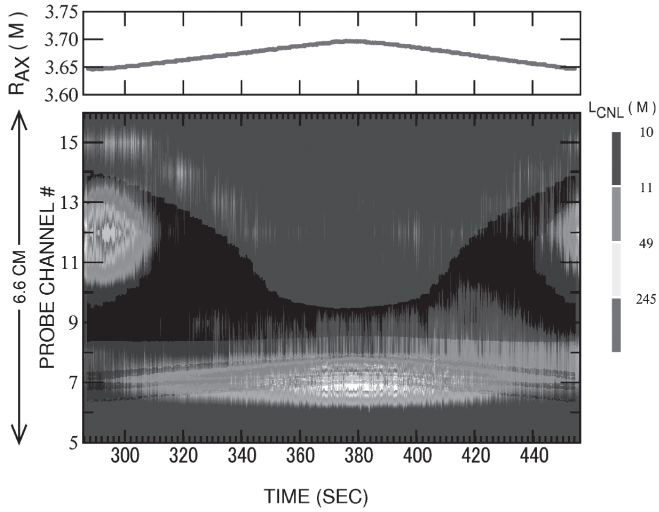

Fig.2 Overprint of distributions of ion saturation current and connection length of lines of force on a probe array in a diverter tile(#118). The abscissa represents the time and the temporal change of magnetic axis position is shown also.

References

1) T. Watanabe, S. Masuzaki, Y. Nakamura, and H. Hojo, *Fusion Science and Technology*, **51** (2007) 147

2) T. Watanabe, Y. Matsumoto et al., *Nucl. Fusion*, **46** (2006) 291.