§4. Simulation Study of LHD Magnetic Field Optimization by Control of Vertical Field Coil Currents

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Volume enclosed with the last closed magnetic surface, $V_{\rm lcfs}$, is one of the most important parameters for the plasma confinement performance. In the LHD, $V_{\rm lcfs}$ is determined by the helical pitch parameter γ and $R_{\rm ax}$.

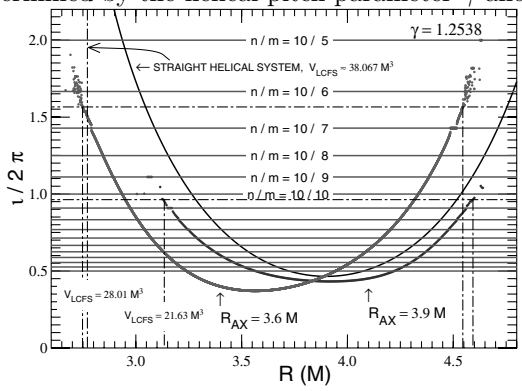

Fig. 1: Effect of inward shift of magnetic axis for the rotational transform $\iota/2\pi$. The positions of the last closed flux surface are plotted together with the values of the plasma volume $V_{\rm lcs}$. Results for the straight helical systems are also shown.

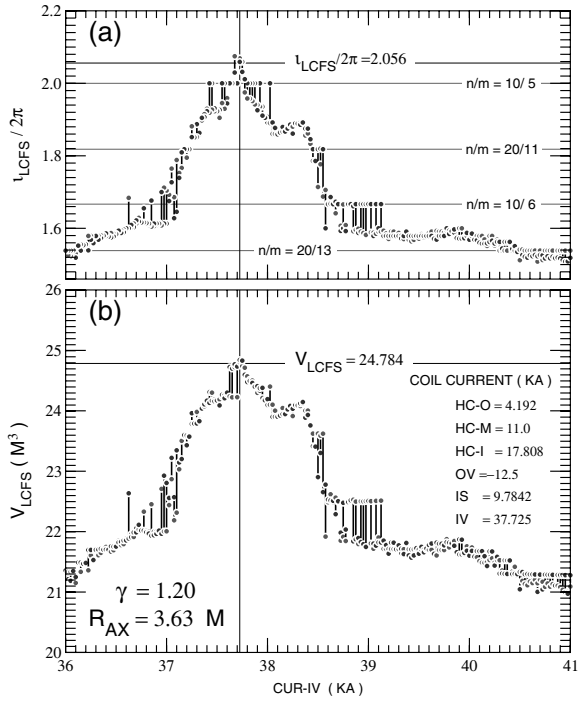

Fig. 2: Change in $\iota_{\rm lcfs}/2\pi$ (a) and $V_{\rm lcfs}$ (b) at IV coil current sweep. Helical coil currents, OV coil current and $R_{\rm ax}$ are fixed.

The helical pitch parameter dependency of equilibrium and the stability of the high beta plasma in the LHD type magnetic configuration is studied numerically. It is confirmed that the small γ configurations are favorable for the LHD-type fusion reactors in the point of robustness of high beta equilibrium, compatibility of easy ignition and high output power of core plasma, in addition to a sufficient space for blankets [1].

The inner shift of the magnetic axis increase the $V_{\rm lcfs}$, due to the increase of average toroidal magnetic field which intensifies the adiabaticity of the equation of the lines of force (Fig.1).

We have confirmed that $V_{\rm lcfs}$ is also, possible to be maximized by the control of the current distribution of three sets of vertical field coils (OV, IS and IV coils), under the specified value of the $R_{\rm ax}$ and γ. Perturbed magnetic field components, which cause magnetic surface breaking, can be decreased by control of vertical field coil currents distribution. Therefore, the increases of $\iota_{\rm lcsf}/2\pi$ and $V_{\rm lcfs}$ are linked as shown in Fig.2.

Rotational transform and Poincaré plot of lines of force are shown in Fig.3 and Fig.4, for the case of the maximized $V_{\rm lcfs}$.

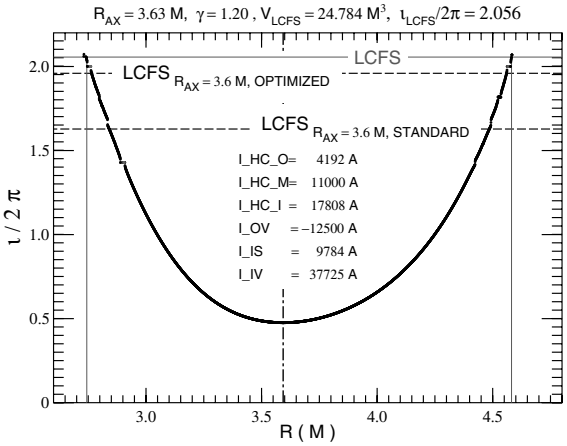

Fig. 3: Distribution of the rotational transform.

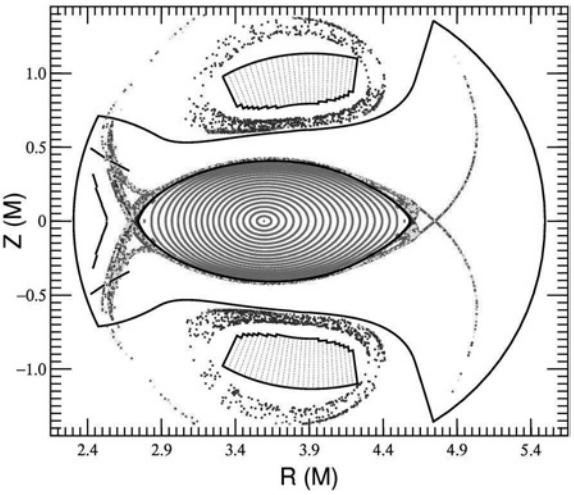

Fig. 4: Poincaré plot of lines of force. Coil currents are shown in Fig.2.

1) T. Watanabe and H. Hojo, "Helical pitch parameter dependency of high beta equilibrium of helical plasmas", Plasma Fusion Res. (submitted, 2010).