§1. Vacuum Configurations of LHD with Multi Layer Helical Coils

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Each helical coil in the LHD is composed of three layers which are called the outer (O) , the mid (M) and the inner (I) layers. The choice of the combination of the layers determins the effective minor radius of the helical coils. Here we use the coil parameter defined by

$$\gamma_c \equiv \frac{m}{\ell}\frac{a_c}{R}, \qquad (1)$$

where m and ℓ denote the number of period and the pole number of the helical coils, respectively. a_c and R are the minor and the major radii of the helical coils, respectively. There are five kinds of the combination of the layers in the LHD device. The standard configuration corresponds to $\gamma_c = 1.25$, where all three layers are used for generating the confinement magnetic field. If only the O-layer is used, the radius of the helical coil becomes large and γ_c increases to 1.38, while γ_c decreases to 1.12 in the case of only the I-layer. At first, we calculate the vacuum configurations corresponding to the combinations of the layers. In the calculation for each combination, the same ratios of the currents flowing between the poloidal field coils as those of the standard configuration are used, while the total amount of the currents of all the poloidal field coil is adjusted so that the position of the magnetic axis should be located at 3.75m. Figure 1 shows the poincare plots of the vacuum magnetic field lines in the cases of $\gamma_c = 1.12$, 1.25 and 1.38. From this figure, the average radius of the outermost surface increases as γ_c becomes large. We also obtained that increasing γ_c decreses the rotational transform, because the distance between the magnetic surfaces and the helical coils changes.

In the standard configration, the magnetic hill spreads in the whole region inside the outermost surface. The magnetic hill is reduced as γ_c increases, and very shallow magnetic well appears in the vicinity of the magnetic axis in the case of $\gamma_c = 1.38$. On the other hand, the magnetic hill is enhanced when γ_c becomes small. This can be explained by the ellipticity of the magnetic surfaces.

The confinment of the deeply trapped particles can be approximately estimated by plotting the contour of the mod$|B|$. It is obtained that the dependence of the fraction of the confinment region of the deeply trapped particle on γ_c is weak. The deeply trapped particle in about 80% region inside the outermost surface will be confined in the range of $1.12 \le \gamma_c \le 1.38$.

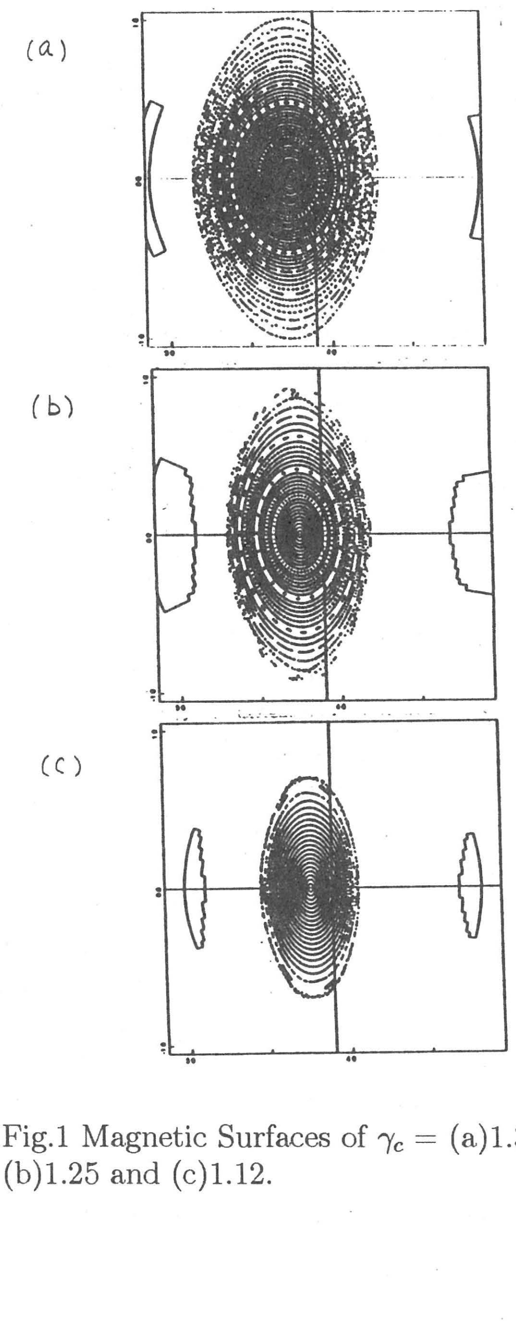

Fig.1 Magnetic Surfaces of $\gamma_c =$ (a)1.38, (b)1.25 and (c)1.12.