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有限ベータLHDプラズマにおける周辺磁場構造指標の数値的評価
Numerical evaluation of indexes on the peripheral magnetic field structure in LHD finite beta plasmas

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The design of the magnetic configuration with a good plasma confinement performance is very important issue to develop the nuclear fusion reactor. But in helical devices, it is well-known that a peripheral magnetic surface structures are destroyed and a plasma confinement performance falls as the beta value goes up. A goal of this study is to find a good index which represents the degradation of well-defined magnetic surfaces well, and leads to a good index of the confinement performance on the magnetic configuration. In order to consider the index of the degradation level of the magnetic surfaces in the region where the magnetic surfaces are no defined, it is important to define the quasi-magnetic surfaces which should be a reference against the destroyed magnetic surfaces.

In this study, we define the quasi-magnetic surfaces by smoothing the Poincare plots of the magnetic field lines based on the RBF(Radial Basic Function) expansion. At first, all the Poincare plots are labeled by using the r-coordinate of the starting points of the magnetic field lines on the equatorial plane at the horizontally elongated poloidal cross-section, r_{start}. Then we evaluate the weight coefficients, w_i to minimize the difference between the quasi surface quantity, Ψ and r_{start} by least square fitting. Here Ψ is expressed by the weight coefficients as follows

$$\Psi(r,z)=\sum_{i=1}^{100} w_i f_i(r,z;r_i,z_i),\quad f_i(r,z;r_i,z_i)=\exp\left\{-\left((r-r_i)^2+(z-z_i)^2\right)/\sigma^2\right\} \qquad (1)$$

Figure.1 shows the contours of constructed quasi surfaces(black lines; Ψ=constant.) and the Poincare plots for a typical finite beta LHD equilibrium with the averaged beta of 6%. The contours almost coincide with Poincare plots in the well-defined magnetic surface region, which suggests that the constructed quasi surfaces are available. Figure.2 shows the standard deviation of the magnetic field lines from the quasi surfaces. This figure shows that the standard deviation increases sharply near $r_{start}=4.50$. Because this region almost corresponds to the stochastic magnetic surface region, the standard deviation from Ψ would be one of the indexes which represents a degradation of nested magnetic field structure.

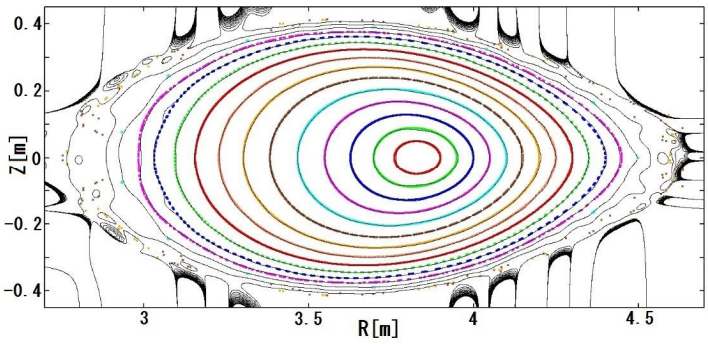

Fig.1 contours of quasi magnetic surface and poincare plots at $\beta=6.02\%$ ($r_{start}=3.90\sim4.60$ m, interval:0.05m)

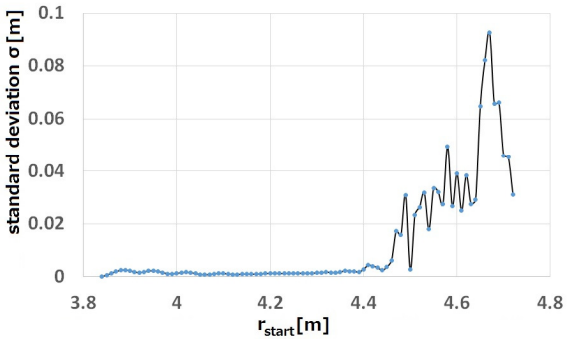

Fig.2 distribution of standard deviation at $\beta=6.02\%$

Reference

[1] M.Itagaki et al.; Plasma Phys. Controll. Fusion 54 (2012)