§56. Twisted Cauchy-condition Surface to Identify the Last Closed Magnetic Surface in the Large Helical Device

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1. Introduction

A 3-dimensional Cauchy-condition surface (CCS) method code, 'CCS3D', is now under development to identify the last closed magnetic surface (LCMS) in the Large Helical Device (LHD) [1, 2]. The present report describes the very recent results of LCMS, which is obtained from the magnetic field profiles reconstructed using a new CCS method model with magnetic sensor signals.

2. Twisted CCS

A new model named "twisted CCS" has been introduced, whose elliptic cross section rotates with the variation in plasma geometry in the toroidal direction. The image is shown in Fig.1. Independent of the toroidal angle, this CCS can be placed at a certain distance from the last closed magnetic surface (LCMS).

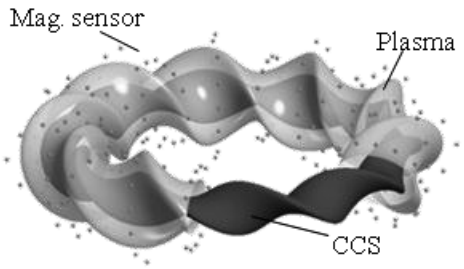

Fig.1 Image of twisted CCS

3. Numerical results

With this new CCS, it has been found that the numerical accuracy in the reconstructed field has been improved.

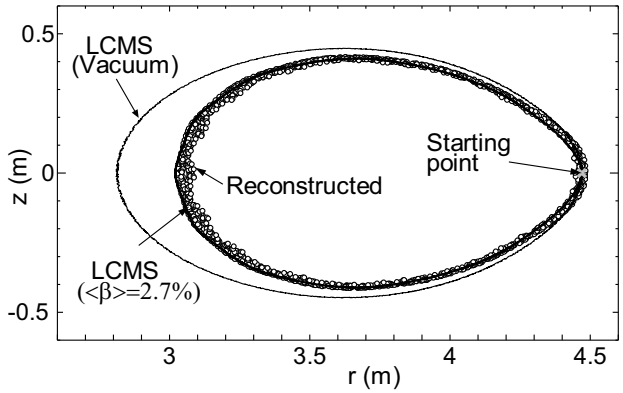

Fig.2 Poincaré plots of the field line

Figure 2 shows the Poincaré plots on the horizontally elongated cross section for traces originating at the same starting point, which formed the LCMS when following the reference field. The solid closed line is the reference LCMS, while the round symbols denote the Poincaré plots based on the reconstructed field obtained using the twisted CCS. The scatter of the plot points is narrower than in the case of the axisymmetric CCS, which was described in the previous report [2]. That is, the accuracy in the reconstruction has been significantly improved.

A novel idea for determining the LCMS numerically has also been proposed. The Poincaré plot is converted to contours of a 'quasi' magnetic surface function using the expansion of radial basis functions. Introducing the 'inside/outside' ratio related to the scatters in the Poincaré plot, the most probable contour has been extracted as the LCMS, which agrees well with the reference LCMS (see Fig.3).

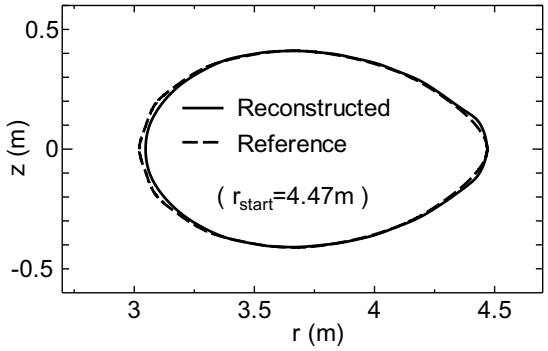

Fig.3 Reconstructed LCMS

4. Summary

The magnetic field line tracing based on the twisted CCS indicates the LCMS more precisely than with the use of the axisymmetric CCS. A novel idea to determine the LCMS numerically has also been proposed.

5. Further remarks

(i) Reduction of the number of unknowns and hence the number of sensor signals.
(ii) Investigation of the effect of sensor signal noise to the solution accuracy and stability.

[1] Itagaki, M. et al., Plasma Phys. Control. Fusion, 53[10], 105007 (2011).
[2] Itagaki, M. et al., Annual Report of NIFS April 2010 - March 2011, p.66.