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LHDの低βプラズマに対する最外殻磁気面の数値的決定

Numerical determination of the last closed magnetic surface for low beta plasmas in the LHD

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Introduction: The 3-D Cauchy condition surface (CCS) method code, 'CCS3D', is now under development to reconstruct the 3-D magnetic field profile outside a non-axisymmetric fusion plasma using only magnetic sensor signals [1]. A numerical technique to determine the LCMS has also been tested for the plasma with $\langle\beta\rangle = 2.7\%$ in the LHD [2]. Using the radial basis function (RBF) expansion, the Poincaré plot is converted to contours of a 'quasi-magnetic surface' as a function of the r-coordinate of the starting point (r_{start}) in the magnetic field line tracing. Introducing the 'inside/outside' ratio related to the scatter in the Poincaré plot, the contour where the ratio jumps is taken as a best estimate for the location of the LCMS. This scheme is based on the assumption that there is much difference in the level of numerical dirtiness between the regions inside and outside the LCMS, which is caused by the vacuum field assumption in the CCS method. Considering the assumption, it should be tested whether the method ends in failure for a low β plasma configuration.

Test calculations and results: The same procedure for the plasma with $\langle\beta\rangle = 2.7\%$ was repeated for plasmas with $\langle\beta\rangle = 1.0\%$ and $\langle\beta\rangle = 2.0\%$ in the LHD. After obtaining the Poincaré plot points, the variations in the 'inside/outside' ratio were given as shown in figure 1. The ratio jumps at $r_{start} = 4.38\text{m}$ for the $\langle\beta\rangle = 1.0\%$ case. The contour of quasi-magnetic surface corresponding to this starting point was extracted as shown in figure 2.

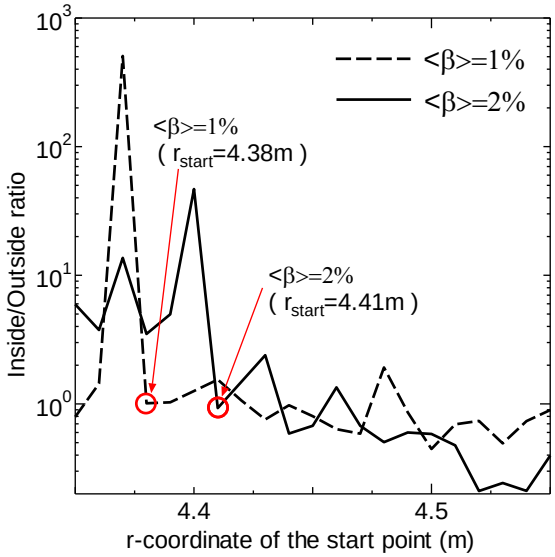

Figure 1. Variation in the 'inside/outside' ratio for low β plasmas

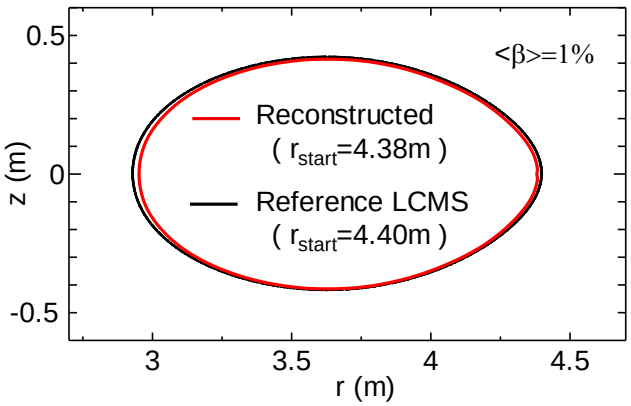

Figure 2. Reconstructed LCMS for $\langle\beta\rangle = 1.0\%$. The reference LCMS was given from the field line tracing based on the field profile calculated using the 3D MHD equilibrium code HINT2 [3].

Conclusion: The extracted LCMS agrees fairly well with the reference LCMS even for $\langle\beta\rangle = 1.0\%$. The authors believe that the accuracy of an extracted LCMS is acceptable at least for operating control purposes.

References

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