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Development of Real-Time Magnetic Coordinate Mapping System in LHD
LHDにおける磁気座標リアルタイムマッピングシステムの構築

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We have newly constructed a large-scale equilibrium database and a magnetic coordinate mapping system for the Large Helical Device (LHD) experiment. Once the parameters designating vacuum magnetic configuration and pressure/current and their peaking factors are given, results of inverse mapping between real and magnetic coordinates as well as additional equilibrium parameters can be retrieved from the data server. Additional database composed of pre-calculated mapping results along several lines of sights for frequently used diagnostics has been prepared to accelerate mapping procedure. Real-time mapping and display of electron temperature/density profiles as functions of effective minor radius are thus realized and utilized for further transport analyses.

1. Introduction

Because raw experimental data of position dependent quantities such as electron temperature are expressed in real coordinates, it is important for further analyses to map real coordinates onto magnetic coordinates by specifying an appropriate equilibrium. In the Large Helical Device (LHD) experiment, it is reasonable to choose an equilibrium minimizing the discrepancy between inboard and outboard sides of the electron temperature profile because reliable Thomson scattering diagnostic data are available with high spatial resolution [1]. In order to solve this inverse problem, it is necessary to construct a database composed of a lot of three-dimensional equilibria beforehand.

In this work we have newly developed a large-scale database composed of many LHD equilibria under wide ranges of pressure and plasma current and their profiles, which can cover special conditions such as strongly peaked pressure profiles often observed in high density discharges. Additional tools for more efficient data handling and processing have also been developed to achieve automated real-time mapping into magnetic coordinates for all the time frames of Thomson scattering data.

2. Equilibrium Database

In LHD, vacuum magnetic configuration is designated by three parameters: magnetic axis position (R_{ax}), quadruple magnetic field (B_q) and pitch parameter (γ). We have calculated the free-boundary LHD equilibria by the latest VMEC code [2] in the parameter space shown in Table I, which generates more than 7000 equilibria for each vacuum configuration. This process takes about 5 days for each vacuum configuration under multi-CPU environment.

Then a library routine for the database access has been developed to run an inverse mapping program on a server and get equilibrium parameters such as effective minor radius, components of magnetic field, etc. by giving real cylindrical coordinates (R, Z, Φ), and seven input parameters specifying an equilibrium: R_{ax}, B_q, γ, p0 (central beta), pf (pressure peaking factor), ip (plasma current) and ipf (current peaking factor). In this routine, any values are allowed as an input and the output parameters are automatically interpolated when the given values are intermediate in the parameter space mesh, and extrapolated when the given real coordinates are outside of the calculation boundary.

Table I. Parameter ranges in the database for central beta (p0), pressure peaking factor (pf), plasma current (ip) and current peaking factor (ipf).

	Range	Mesh points
p0	0–10%	11
pf	1.41–5.00	5
ip	-150–150 kA/T	13
ipf	-12.60–4.00	11

3. Line-of-Sight Database

Because the inverse mapping program is not fast enough for real-time processing of all the time frames of Thomson scattering data, we have also prepared "Line-of-sight database" which tabulates pre-calculated results of the mapping along several frequently used lines of sights (Thomson, Charge Exchange Spectroscopy, Interferometer, etc.) for all the mesh points of input parameters. A function to retrieve the output parameters by designating the name of the line of sight was added to the library to achieve real-time mapping.

4. Real-time Mapping and Viewer

In the procedure to search the best-fitted equilibrium parameters from the experimental data of Thomson scattering, pf and ipf are assumed to be appropriate initial values and Rogowski coil data is used for ip. By reading the line-of-sight database, error between inboard and outboard sides of the electron temperature profile is calculated with scanning p0 step by step for each time frame. This procedure is repeated until the minimum error is obtained to determine the best-fitted equilibrium parameters. The other parameters such as electron kinetic energy, magnetic axis position, etc. are calculated at the same time. Once all the frames are processed, the results are automatically registered as an analyzed data for the Kaiseki Data Server System [3] with a diagnostic name "tsmap".

We have also developed a viewer program to display electron temperature/density profiles as functions of effective minor radius. A screenshot of the viewer program is shown in Fig. 1, where absolute electron density is automatically calibrated using interferometer data, and time evolutions of several parameters (p0, pf, magnetic axis position, electron kinetic energy) for the best-fitted equilibrium are also displayed.

Database generation including the line-of-sight database has been completed for 23 vacuum configurations, which results in coverage of more than 90% of the shots in the LHD experiment. The "tsmap" data are useful specifically for further studies on particle/heat transport and neutral beam deposition based on experimental profiles.

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References

[1] K. Narihara, I. Yamada, H. Hayashi, and K. Yamauchi: Rev. Sci. Instrum. **72** (2001) 1122.

[2] S. P. Hirshman and J. C. Whitson: Phys. Fluids **26** (1983) 3553.

[3] M. Emoto, S. Ohdachi, K. Watanabe, S. Sudo, and Y. Nagayama: Fusion Eng. Des. **81** (2006) 2019.

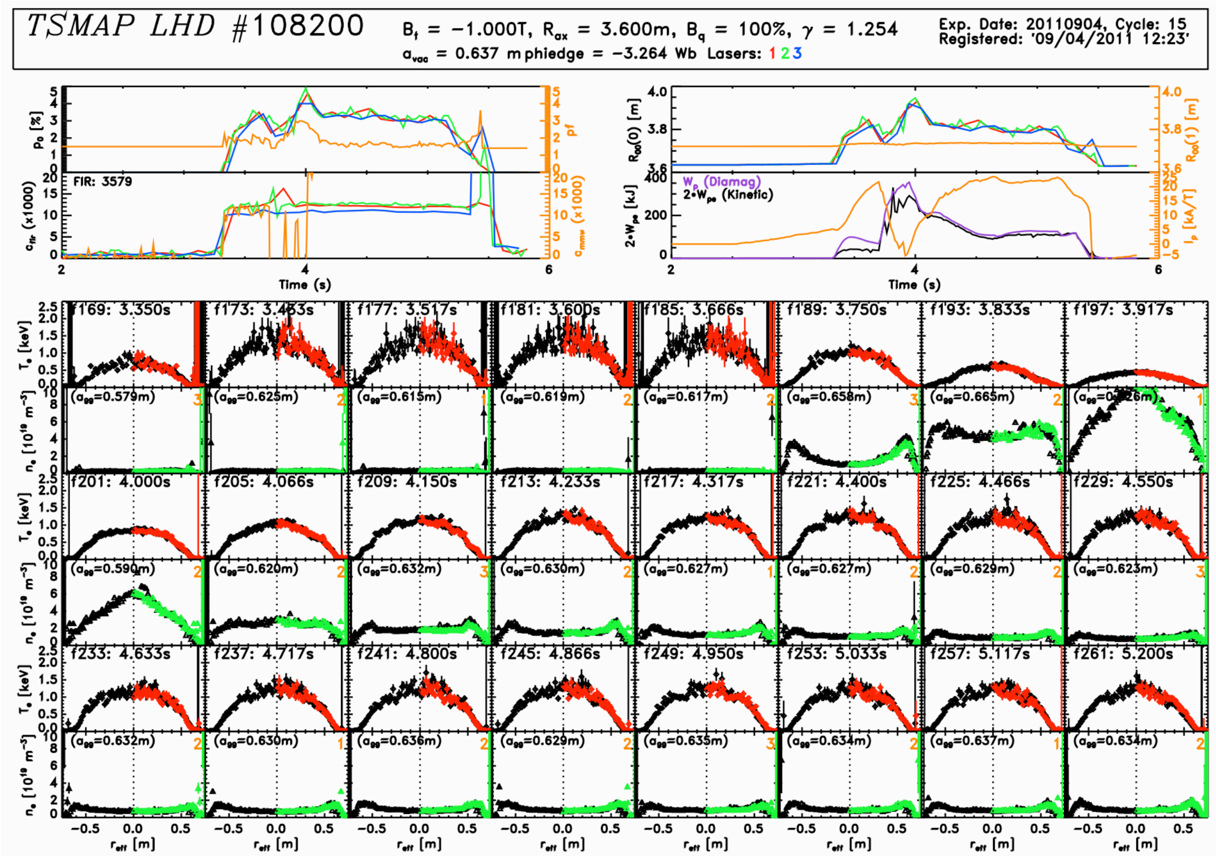

Fig.1. Screenshot of the "tsmap" viewer program.