§6. Detailed Physics Analyses of FFHR-d1 Core Plasma in Collaboration with the Numerical Simulation Research Project II

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Detailed physics analyses of FFHR-d1 core plasma are ongoing in collaboration with the Numerical Simulation Research Project. Adding to the profile data reported in the last annual report [1], which is named "Case A", a new profile data named "Case B" as shown in Fig. 1 has been analyzed [2]. These data were chosen from the high-beta experiment in LHD carried out at the inward-shifted and high aspect ratio configuration of R_{ax} = 3.60 m, B_0= 1.5 T, and γ_c = 1.20. The profile data in the reactor shown in Fig. 1 are obtained by using the DPE method [3,4].

MHD equilibriums in the Case B reconstructed by HINT2 are shown in Fig. 2. For the beta profile shown in Fig. 1(c), a large Shafranov shift of the magnetic axis from ~14 m in vacuum (Fig. 2 (a)) to ~16 m and destruction of the magnetic surfaces in the peripheral region are expected as shown in Fig. 2(b). This is the same situation as in the Case A [1,2], where both the neoclassical thermal loss and the alpha particle loss were large. However, the Shafranov shift is mitigated by controlling the vertical magnetic field, B_v, as shown in Fig. 2(c). In this case, the magnetic axis is pushed back to the inward-shifted position and the peripheral magnetic surfaces are reformed. This is different from the result of Case A, where B_v control was not successful to move the magnetic axis position inward [1].

The radial profile of neoclassical thermal loss, $Q_{neo}S$, where $Q_{neo} = Q_{neo}(\rho)$ and $S = S(\rho)$ are the neoclassical heat flux and the area of the magnetic surface at the normalized minor radius, ρ, calculated by GSRAKE and FORTEC-3D for the Case B, is shown in Fig. 3. In the core region of ρ < 0.5, the neoclassical thermal loss is in the same level with the plasma heating power given by the alpha heating power, P_α, minus the Bremsstrahlung loss, P_B.

The alpha heat deposition profile in the Case B calculated by GNET is relatively broad, presumably due to the hollow density profile as seen in Fig. 1(a). This is not consistent with the assumption used in the DPE method that the alpha heating profile will be peaked in the reactor. Therefore, the profile data with a peaked density profile as in the Case A obtained in the high aspect ratio configuration as the Case B is desired for the next step.

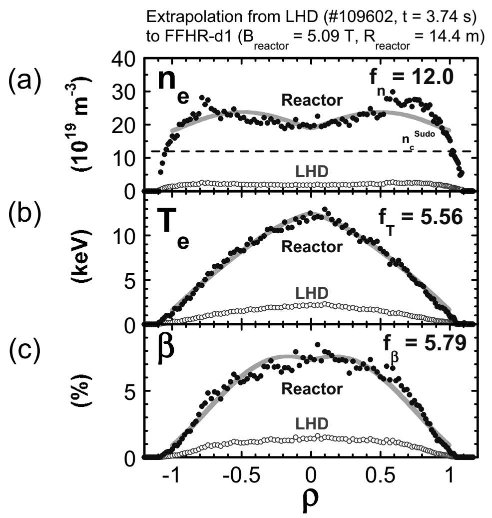

Fig. 1. Radial profiles of (a) the electron density, n_e, (b) the electron temperature, T_e, and (c) the plasma beta, β, extrapolated to FFHR-d1 for the Case B.

1) J. Miyazawa, et al., Ann. Rep. NIFS (2012) 240.
2) J. Miyazawa, et al., 24th IAEA FEC, FTP/P7-34.
3) J. Miyazawa, et al., Fusion Eng. Des. **86** (2011) 2879.
4) J. Miyazawa, et al., Nucl. Fusion **52** (2012) 123007.

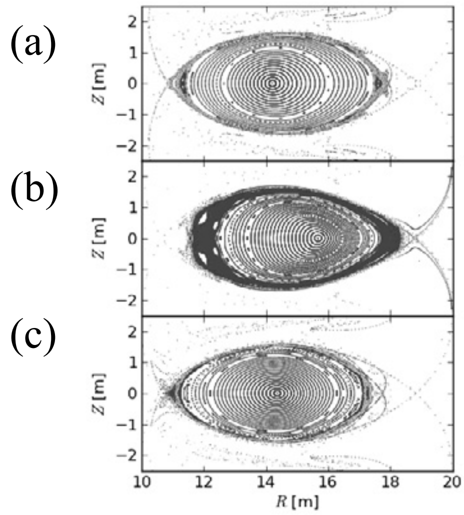

Fig. 2. Magnetic surfaces in FFHR-d1 calculated by HINT2 for the cases of (a) w/o plasma, (b) w/ plasma and w/o B_v control, and (c) w/ plasma and w/ B_v control. The profiles shown in Fig. 1 are used for the MHD equilibrium analysis by HINT2.

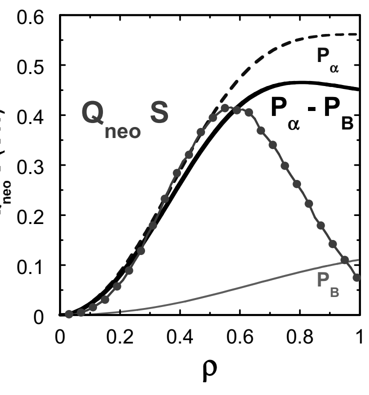

Fig. 3. Radial profiles of the neoclassical thermal loss, $Q_{neo}S$, the alpha heating, P_α, and the Bremsstrahlung loss, P_B.