§12. Plasma Potential Measurements with HIBP in the Core Plasma of LHD

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In helical devices, the radial electric field is produced due to its non ambipolar diffusion property in the neoclassical context. This field is important, because it can reduce the ripple loss transport in 1/ν regime. In LHD, the radial electric field in the core plasma was measured by using a heavy ion beam probe, and the observed radial electric field was compared with that calculated from the neoclassical theory. In the experiment, the toroidal magnetic field strength, the major radius of magnetic axis, the pitch parameter and the quadropole field were 1.5 T, 3.75 m, 1.254, 100% in this experiment. The energy of probe beam was 1.376 MeV.

In Fig.1, the temporal evolution of line averaged electron density and the heating methods are shown. The plasma was produced by ECH, and was sustained by NB injection. Both of NB#1 and #3 were counter injected beam lines. The line averaged density increased with time. By sweeping the injected probe beam, the radial profile of potential was measured from the phase A to E in Fig. 1. The line averaged density and the central electron temperature were 0.2×10^{19} m^{-3}, 2.7 keV in the phase A, and 0.5×10^{19} m^{-3}, 1.0 keV in the phase E. The measured radial potential profiles are shown in Fig.2. The observable region was limited in the region $\rho < 0.6$. This limitation was caused by the structure of diagnostic port and deflector. The potential at the center was positive in the phase A, and it decreased as the density increased.

By using the polynomial function of ρ^2 as a fitting function, the radial electric field, E_r, was obtained from experimental data of potential profile. In the phase A (ECH phase), the radial electric field was positive. In other phases (NBI phase), the radial electric field was slightly negative. In Fig. 3, the experimental results of radial electric field profile and the calculated profile in the phase A and C are shown. In the calculation, the GSRAKE code[1)] based on the neoclassical theory was used. In the phase C (open diamonds), the region where $\rho > 0.28$, multiple roots were predicted from the neoclassical theory. They are so called electron root (positive one) and ion root (negative one). In the phase A (open circles), only the electron root was predicted from the calculation in the plasma core region. The experimental result in the phase A (filled circles) coincides with the calculation result, and also in the inner region $\rho < 0.28$ in the phase C (filled diamonds). However, in the region where multiple roots are predicted from the neoclassical theory, experimental data have values between two roots as in the region $\rho > 0.3$ of phase C. Other cases of B, D, E also showed similar tendency. The reason for this discrepancy is not clear at the present, so we will study detail of physics in the future.

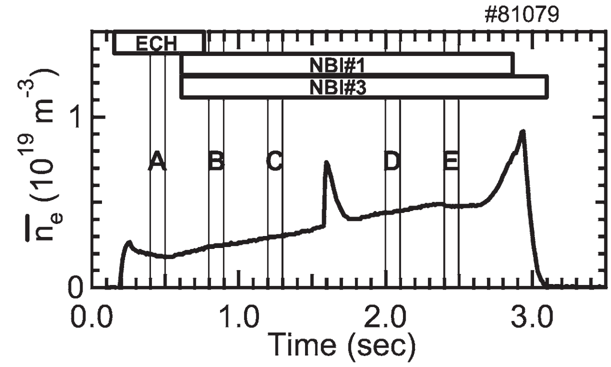

Fig.1 The temporal evolution of line average density and heating methods. In the phase from A to E, the radial profile of potential was measured with HIBP.

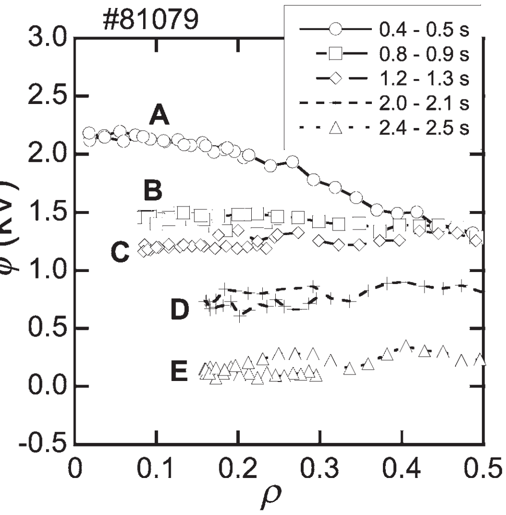

Fig. 2 Radial profiles of potential measured with HIBP. Alphabets from A to E correspond to the phase A to E in Fig. 1.

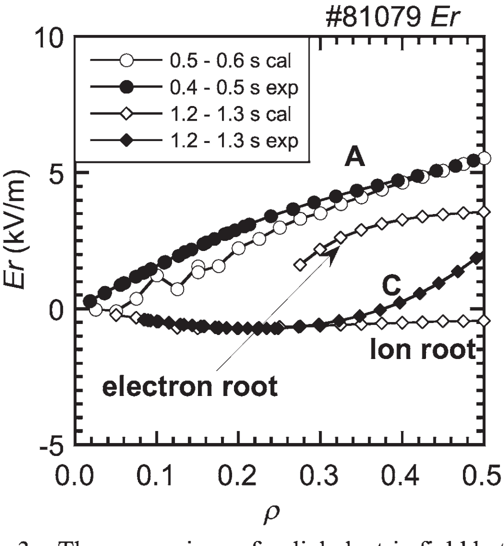

Fig.3 The comparison of radial electric field between experimental results and calculation results.

1) C. D. Beidler, W. D. D'haeseleer, Plasma Phys. Control. Fusion **37** (1995) 463.