§25. Potential Profile Measurements with HIBP

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In potential measurements with HIBPs, a singly charged heavy ion beam (primary beam) is injected into a target plasma, and then doubly charged ions created with an electron impact ionization (secondary beam) come out with the energy change corresponding to the plasma potential at the ionization point. In case of toroidal helical devices, the secondary beams coming from different observation points may be widely distributed in entrance positions and angles at the energy analyzer. This problem causes a restriction of observation range and energy measurement errors due to an uncertainty in the beam injection angle.

An introduction of secondary beam sweep system gives the following advantages to the CHS HIBP; (1) a wider observation range, (2) reduction in the energy measurement errors, and (3) allowance for the energy analyzer location with a sufficient distance from the plasma to avoid UV loading and strong magnetic field.

Figure 1a demonstrates obtained potential profiles in steady states of ECH and NBI plasmas. The open and closed circles indicate the potential profiles of low ($ne=3x10^{12}cm^{-3}$) and medium density ($ne=8x10^{12}cm^{-3}$) ECH plasmas, respectively. The central electron temperatures of the low and medium density cases are Te(0) = 900eV, Te(0) = 400eV, respectively. The squares indicate the potential profile of a co-injected NBI plasma where the electron density is $ne=8x10^{12}cm^{-3}$, and the electron and ion temperatures are Te(0)=300eV, Ti(0)=200eV, respectively.These profiles are obtained by an averaged profiles for about 20ms of steady states, and the error bars mean standard deviations.

The potential is positive with the center value of about 200 V for a low density ECH plasma where electrons are almost in a collisionless regime since the electron collisionality is ν_e^* (a/2)=1.4. The definition of the collisionality here is $\nu^*(r)=\nu_{eff}(r)/\omega_b(r)$ with $\nu_{eff}=\nu/\varepsilon_h$ and $\omega_b=\iota\varepsilon_h(T/m)^{1/2}/2\pi R$, where ι is the rotational transform.

In the medium density ECH plasma, the potential exhibits an interesting characteristic; the electric field is positive around core, while it has a large negative value (=70 V/cm) near the edge. The electron collisionality is $\nu_e^*(a/2)=13.1$, and the electron is in the plateau regime.

On the other hand, the potential in the low density NBI plasma is negative with the center value of about -200 V. The collisionalities of electrons and ions are $\nu_e^*(a/2)=6.0$, $\nu_i^*(a/2)=8.2$, respectively. The electrons and ions are both in the plateau regime.

Figure 1b shows that the deduced radial electric field profiles, together with the predicted radial electric field from the neoclassical theory.

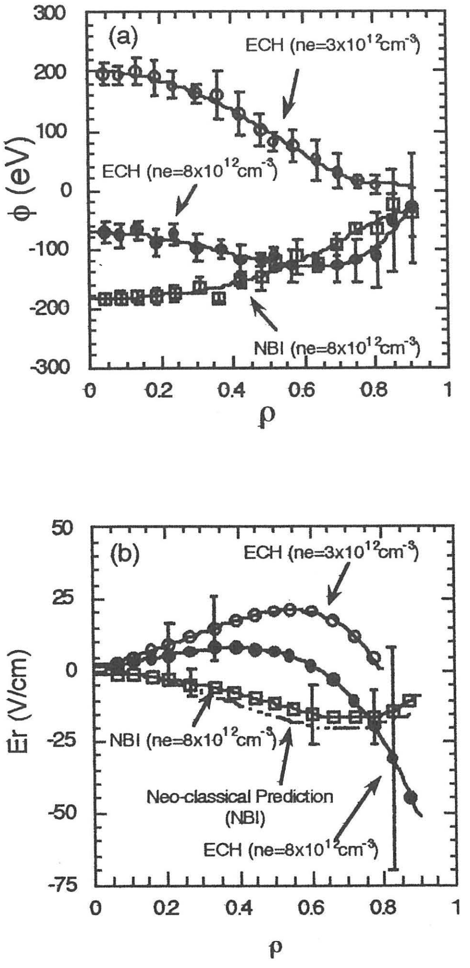

Fig. 1. (a) Potential profiles measured with the 200keV HIBP.(b) Deduced radial electric field profiles.