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Experimental evaluation of Langmuir probe sheath potential coefficient and the Bi-Maxwell electron on the edge of tokamak

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Systematic calibration experiment of Langmuir probe sheath potential coefficient Λ, which is a critical coefficient for estimating plasma sheath potential $V_p = V_f + \Lambda T_e$, has been carried out in the HL-2A and J-TEXT tokamak deuterium plasmas. Flat carbon probe was used in order to obtain good I-V characteristics. The voltage swept frequency are 1 kHz for equilibrium measurement and 30 kHz for fluctuation measurement. Three kinds of sheath potential coefficient, $\Lambda_t == 2.8$, $\Lambda_p = (V_p - V_f)/T_e$ and $\Lambda_I = \ln(|I_{se}/I_{si}|)$, were compared.

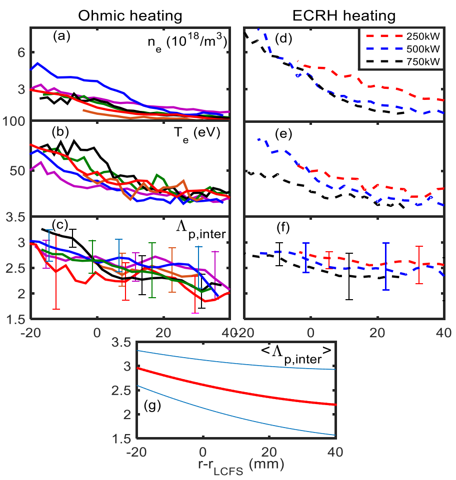

Figure 1 The statistics of 6 Ohmic discharges (left) and 3 ECRH L-mode discharges (right). (a) and (d) plasma density; (b) and (e) electron temperature; (c) and (f) Λ_p and (g) the

Figure 1 shows the 10 shots' statistics in equilibrium measurement, including Ohmic and ECRH heating discharge. It was found that the estimated Λ_p coefficient, which is calculated by plasma potential measured by the V-I characteristic directly and is most credible, monotonically increased from ~2.2 to ~2.9 while Langmuir probe is moved from 40 mm outside last-closed-flux-surface (LCFS) to 20 mm inside LCFS. This measured coefficient is closed to the commonly used value $\Lambda_t == 2.8$ for hydrogen plasmas, which is often assumed to be a constant throughout plasma. Further analysis indicated that the alpha coefficient correction only affected the quantity of radial electric field but had little impact on the trends of it and its shear.

Figure 2 shows the results of these methods. By using the first derivative curve method, it is found that the electron is Maxwell EEPF outside LCFS, and the results of 3 methods are similar. But inside LCFS, the EEPF changes to bi-Maxwell. As figure 2(b) and (d) show, the temperature of heat electron T_{eh} increases from ~40eV to ~80eV quickly while the temperature of cool electron T_{el} almost stays at ~40eV. At the same time, the density of cool electron n_{el} increases from ~0.5×10^{18}/m^3 to ~2.5×10^{18}/m^3 but the density of heat electron n_{eh} increases only from ~ 0.5×10^{18}/m^3 to ~0.8×10^{18}/m^3. The total density $n = n_{el} + n_{eh}$ and effective

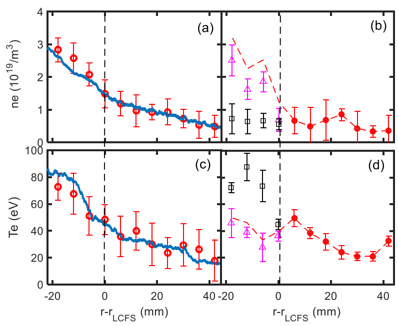

Figure 2. the radial distribution of electron density and temperature in the edge and SOL of HL-2A. (a) and (c) are the results calculated by the three-tips probe (blue curve) and the classical V-I characteristic estimation (red empty circle) with the Maxwell distribution assumption. (b) and (d) are the estimations by using first derivative curve method. The triangles and squares indicate the low and high temperature electron respectively, of the bi-Maxwellian EEPF. The solid circle correspond to the Maxwellian EEPF. The red dotted lines are the total electron density and the effective electon temperature.

temperature $T_{eff} = nT_{el}T_{eh}/(n_{el}T_{eh} + n_{eh}T_{el})$ are also calculated (red dotted lines). It is clear that inside LCFS they are both dominated by the low temperature electron.

Reference

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