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Experimental evaluation of Langmuir probe sheath potential coefficient

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Sheath potential coefficient α is a very important parameter in Langmuir probe measurement. It is often used to estimate the plasma potential: Vp=Vf+αTe, where Vf and Te are floating potential and electron temperature respectively.In magnetized high temperature fusion plasmas this coefficient is affected by many factors and may lead to large errors in the inferred electric field and fluid shear. Now a systematic calibration experiment of α were carried out in the HL-2A tokamak deuterium plasmas with the purpose to help to solve this issue.
In this experiment, a multi-functional probe array was used in Ohmic and ECRH L-mode discharges to directly measure sheath potential coefficient. It is comprised of a triple probe array, a flat swept probe, and two poloidal separated Vf probes which can be used to estimate the location of the last-closed- flux-surface (LCFS) by the reversal of turbulence propagation velocity in the poloidal direction.
At first, with the V-I characteristic measured by swept probe and Druyesteyn method, the electron energy distribution function (EEDF) F(ε) can be inferred and the plasma potential Vp can be calculated where the second derivative equal 0 in V-I characteristic.
Then, besides the traditional constant αt==2.8 often used, there are another two methods to infer the α coefficient. We define them as: αp=(Vp-Vf)/Te and αI=ln(|Ise/Isi|).It should be noted that Vp and αp, which are measured from V-I characteristic directly, is the most credible as compared to the others.In our experiment, αp and αI are very different. The former increases from ˜1.2 outside LCFS to ˜2.1 inside LCFS while the latter increases from ˜2.2 to ˜2.8. The potential estimated by αI and αt are both higher than Vp even if their trends are similar. This difference will cause an error (>20%) in electric field calculation and also will lead an ˜5mm error in the estimation of LCFS position where Er=0.
At last, there is another method consider that we should use the first derivative of V-I characteristic, not the second derivative, to calculate EEDF and Vp while the probe is used in magnetic plasma. By using this method, we found that the plasma potential from the first derivative is larger than the one from second derivative but their profile are similar. The α increase from ˜2.2 outside LCFS to ˜2.8 inside LCFS. The detail will be discuss in the further paper.

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