§16. Method of Electron Density Measurement with Heavy Ion Beam Probe

Kitazawa, M. (Waseda Univ.),
Fujisawa, A., Shimizu, A., Matsuoka, K.,
Irie, M. (Waseda Univ.)

Potential profile and density fluctuation have been measured with a heavy ion beam probe (HIBP) in CHS. In principle, the HIBP has possibility of simultaneous measurements of electron density, electron temperature, and magnetic field. Now we are developing a method to deduce electron density and temperature profiles from detected beam intensity profile.

The detected beam intensity is the product of a) local ionization rate at the observation point of the HIBP, and b) beam attenuation intergrated on the primary and secondary orbits. That is expressed in the following form,

$$I_{\det}(r) = I_{p0}\frac{n_e S_{12}}{v_{beam}} w_s \times \exp\left(-\int \frac{n_e S_1}{v_{beam}} dl_1 + \frac{n_e S_2}{v_{beam}} dl_2\right) \qquad \text{Eq.(1).}$$

where r, n_e, v_{beam}, and w_s mean the minor radius at the observation point, electron density, beam velocity and beam sample volume. S_1 and S_2 are ionization rate from a singly charged state to the others, and that from a doubly charged state to the others, respectively. I_{p0} and I_{det} are the injected and detected beam intensities, respectively. Subscripts represent ionization process.

The reconstruction of density profile is possible from the detected beam intensity by solving the nonlinear integral eqation described in Eq.(1).

Before trying the density reconstruction on actual data from CHS HIBP, we have tested a numerical method for a set of model orbits based on tokamak-like configuration.

The result is shown in Fig.1. The equation is solved numerically using iteration processes. Figure1-(a) is for low line-averaged density regime ($5*10^{12}cm^{-3}$), figure1-(b) for the middle line-averaged density regime ($1*10^{13}cm^{-3}$), respectively. In low and middle line-averaged density regime, the influence of attenuation is small and reconstruction is successfully done. This is because in low line-average density regime, the brightness proportional to local electron density is more dominant in Eq.(1) than attenuation terms; Idet$\propto$ne*A in an extreamly low density. But in the high line-averaged density regime ($5*10^{13}cm^{-3}$), the present method cannot give an appropriate result. In a high density regime, our method needs improvement in its iteration sequence.

The presented reconstruction is based on absolute values of detected beam intensity, which is influenced by the neutral particle at the scrape-off layer. To avoid this problem, another method independent of the absolute values is now being developed. The method uses the local attenuation rate of beam intensity (or normalized derivative of detected beam intensity, i.e., 1/I(dI/dr)). This makes the method more suitable for practical use.

In summary, fine temporal and spatial resolution of the HIBP will prove a new insight to contribute to understanding of detailed plasma dynamics after the method is put into practical use.

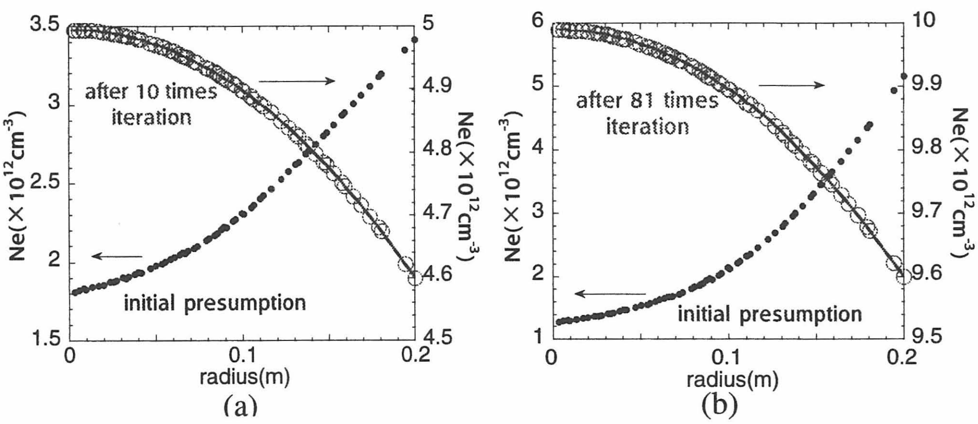

Figure1. Results of calculation for low density (a) and middle density (b). Solid line, dot, and circle represent model density profile, initial presumption, and converged value, respectively.